

Proceedings
of the
North Dakota
Academy of
Science



Volume II — Grand Forks, North Dakota — 1949

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U. N. D.  PRESS

NORTH DAKOTA ACADEMY OF SCIENCE

*Minutes of the Fortieth Annual Meeting**Agricultural College, Fargo, North Dakota***May 7 and 8, 1948**

The Assembly was called to order at 9:10 A. M. May 7th, in Room 204, Chemistry Building, by President Rae H. Harris. He introduced President J. H. Longwell, of the Agricultural College, who welcomed the visitors and cordially invited them to visit and inspect the various activities on the campus.

The program of papers was then introduced, and the seven papers scheduled for the morning session were read and discussed. At the request of its author, paper number 17, scheduled for the afternoon session, was then presented.

Luncheon was held at Ceres Hall, complimentary to visitors, with local members lunching with their guests.

The Academy reconvened at 1:35 P. M. in Room 204, Chemistry Building. President Harris announced the appointment of the following committees: Committee on Resolutions—J. L. Hundley, Chairman; H. B. Hart, E. A. Helgeson; Committee on Nominations—A. D. Whedon, Chairman, A. M. Cooley, J. A. Munro.

All papers scheduled for the afternoon session were presented and discussed. The session adjourned at 4:45 P. M. Average attendance was about 75.

The Academy Dinner was held at 6:30 P. M. in the "Town Hall" room of the Gardner Hotel. 83 members and guests were present. The Guest Speaker was Dr. J. A. Anderson, Chief Chemist of the Grain Research Laboratory, at Winnipeg, Canada. This laboratory is under the direction of the Department of Trade and Commerce and is engaged in the evaluation of the quality of wheat, barley, flax, and other cereals.

Prior to this, Mr. Anderson had served as Biologist for the National Research Council of Canada, at Ottawa. He received his education in England. He has published many papers on his cereal investigations, and he is now associate editor of *Cereal Chemistry*, the official organ of the American Association of Cereal Chemists. He is recognized as an expert on the preparation and editing of scientific papers.

The unique subject of Dr. Anderson's address was "Bridling the Editorial Nightmares." It was a timely criticism of faults so commonly observed in scientific papers. Without "pulling any of his punches," he tempered his criticisms with so much of his genial humor, and sympathetic understanding, that even the most flagrant offender could feel no resentment. Examples of good and bad authorship were projected on the screen and used to illustrate his remarks.

The address was timely, constructive, and very helpful to all authors of scientific and technical papers, and it was received with

enthusiasm and grateful appreciation by all who were privileged to hear it.

On Saturday morning, the Academy reconvened at 9:10 A. M. in Room 204, Chemistry Building, President Harris presiding. All papers scheduled for this session were read by their authors, except Number 25, by William McMillan, which was read in his absence by Wilson M. Laird.

After a brief recess, the Business Session was called. The minutes of the preceding meeting were read by the Secretary, and approved. The report of the Treasurer was then presented and accepted. Dr. J. A. Munro reported informally on the A. A. A. S.

The Committee on Publication of the Proceedings, consisting of Wilson M. Laird, Chairman, Rae H. Harris, Ralph E. Dunbar, and G. A. Abbott, reported the successful publication and distribution of the first number of the Proceedings through the financial assistance of the University and the Agricultural College.

Following the election of new members, the report of the Committee on Resolutions was presented by the Chairman, Dr. J. L. Hundley.

Dr. A. D. Whedon, as Chairman of the Committee on Nominations, presented the following nominations for the officers and additional members of the Executive Committee for the ensuing year.

President	R. B. Witmer, University
Vice President	R. E. Dunbar, Agricultural College
Secretary-Treasurer	G. A. Abbott, University
Additional Members of the Executive Committee:	
H. B. Hart	Jamestown College
L. D. Steinmier	State School of Forestry, Bottineau
Representative in Council of the A. A. A. S.	J. A. Munro

On motion of George C. Wheeler, second, H. L. Walster, these officers were unanimously elected.

The Academy adjourned, at 12:15 P. M. to meet at the University, in May, 1949. Following adjournment the members of the Academy were served luncheon at Ceres Hall.



NORTH DAKOTA ACADEMY OF SCIENCE

Active Members, 1948

1. Abbott, G. A., (Chemistry), University. Charter Member.
2. Addicott, Harold B., (Geog.), State Teachers College, Mayville.
3. Aldrich, Vernice, (Geography), 428 Belmont Road, Grand Forks.
4. Arnason, A. F., (Forestry), Commissioner, State Board of Higher Education, Bismarck. 1939.
5. Banasik, Orville, (Cereal Technology), Agricultural College, 1947.
6. Bavone, A. L., (Sanitary Engineering), Minot. 1947.
7. Beck, Lyle, (Dairying), Agricultural College. 1946.

8. Bolin, D. W., (Nutrition), Agricultural College, 1948.
9. Bolin, F. M., (Veterinary Science), Agricultural College, 1948.
10. Bolley, H. L., (Botany) (Dean Emeritus), Agricultural College, Charter Member.
11. Bosch, Wouter, (Chemistry), Agricultural College, 1948.
12. Brezden, William (Chemistry), State Mill and Elevator, Grand Forks, 1945.
13. Broberg, J. W., (Chemistry), Agricultural College, 1948.
14. Bryant, Clarence, (Public Service Commission), Bismarck, 1946.
15. Bryant, R. L., (Experiment Station), Dickinson, 1948.
16. Burr, Alexander C., (Chemical Engineering), State Research Foundation, Bismarck, 1940.
17. Chetrick, M. H., (Chemical Engineering), University, 1947.
18. Clagett, C. O., (Agricultural Chemistry), Agricultural College, 1947.
19. Cooley, A. M., (Chemical Engineering), University, 1938.
20. Coon, Ernest D., (Chemistry), University.
21. Cram, Sheldon, (Physics), State Teachers College, Dickinson, 1948.
22. Daly, J. J. (Mining Engineering), University, 1948.
23. Davis, Joe, (Biology), State Wild Life Administration, Bismarck, 1938.
24. Dunbar, Ralph E., (Chemistry), Agricultural College, 1938.
25. Dunlap, W. A., (Public Health), Assistant Director, State Public Health Laboratory, Bismarck, 1946.
26. Evanson, Harlow. (Physics), State School of Forestry, Bottineau, 1947.
27. Eveleth, F. F., (Veterinary Science), Agricultural College, 1944.
28. Espe, Dwight, (Dairy Husbandry), Agricultural College, 1947.
29. Facey, Vera, (Botany), University, 1948.
30. Flor, Harold H., (Pathology), Agricultural College, 1932.
31. Fleetwood, C. W., (Chemistry), Agricultural College, 1948.
32. Ford, Kenneth, (Experiment Station), Dickinson, 1948.
33. Fordice, Ira, (Chemistry), Agricultural Supply Co., Grand Forks, 1947.
34. French, Harley E., (Medicine), (Dean Emeritus), University, 1911.
35. French, Leslie A., (Engineering), State Highway Department, Bismarck, 1943.
36. Freier, Herbert E., (Chemistry), University, 1947.
37. Gillette, John M., (Rural Sociology), University.
38. Goldsby, Alice, (Veterinary Science), Agricultural College, 1946.
39. Grimes, Ruby, (Mathematics), Agricultural College, 1946.
40. Grossman, Irving, (Geology), University, 1947.
41. Gustafson, Ben G., (Chemistry), University, 1939.
42. Hagen, Irvin, (State Seed Dept.), Agricultural College, 1946.
43. Hankenson, Kermit, (Mathematics), Agricultural College, 1946.
44. Hanning, Irene, (Mathematics), State Research Foundation, Bismarck, 1945.

45. Harrington, L. C., (Engineering), University.
46. Harris, Rae H., (Cereal Technology), Agricultural College, 1937.
47. Hart, Harry B., (Chemistry), Jamestown College, Jamestown.
48. Helgeson, E. A., (Botany), Agricultural College.
49. Hemphill, Perry V., (Agricultural Extension), Agricultural College, 1937.
50. Henderson, Donald, (Physics), University, 1945.
51. Hill, Glenn A., (Mathematics), Agricultural College, 1946.
52. Hundley, John L., (Physics), University.
53. Hurst, H. J., (Physics), State School of Forestry, Bottineau, 1942.
54. Jensen, C., (Dairy Husbandry), Agricultural College.
55. Johanson, J. F., (Social Science), Carrington, 1939.
56. Johnsgard, Gordon, (Soils), Agricultural College, 1947.
57. Johnston, Jr., James W., (Zoology), Agricultural College, 1948.
58. Kelley, Eunice, (Nutrition), Agricultural College, 1944.
59. Kirk, H. H., (Biology), Supt. of Schools, Fargo, 1938.
60. Kjerstad, C. L., (Psychology), University, 1937.
61. Klosterman, Earl W., (Animal Nutrition), Agricultural College, 1948.
62. Klosterman, Harold, (Chemistry), Agricultural College, 1948.
63. Knight, G. N., (Biology), Jamestown College, Jamestown, 1934.
64. Koons, Melvin E., (Public Health Laboratory), University, 1943.
65. Koth, Arthur W., (Chemical Engineering), University, 1939.
66. Kruschwitz, Earl W., (Physics), State Teachers College, Valley City 1947.
67. Laird, Wilson M., (Geology), University, 1941.
68. Larson, Edith, (Biology), University, 1947.
69. Larson, Kermit, (Chemistry), (On leave, Grad. Student, University of California), 1943.
70. Lauster, K. C., (State Health Department), Bismarck, 1944.
71. Lejeune, A. J., (Agronomy), Agricultural College, 1947.
72. Leraas, Marvin A., (Agronomy), Agricultural College, 1947.
73. Lundy, John L., Mayo Clinic, Rochester, Minn., 1940.
74. McMillam, William, (Chemistry), State Research Foundation, (Working at University), 1947.
75. McKean, William, (Animal Biology), Agricultural College, 1947.
76. Mason, Sewell, (Mathematics), University, 1946.
77. Mattson, Harold, (Horticulture), Agricultural College, 1937.
78. Maher, George, (Agricultural Chemistry), Agricultural College, 1948.
79. Miller, Cap E., (Agricultural Economics), Agricultural College.
80. Miller, C. E., (Pharmacy), Agricultural College, 1947.
81. Moberg, Wenzel, (Geography), Agricultural College, 1943.
82. Moomaw, Leroy, (Experiment Station), Dickinson, 1943.
83. Moran, Walter H., (Chemistry), University, 1928.
84. Moore, C. C., (Chemistry), Agricultural College, 1948.
85. Munro, J. Alex, (Entomology), Agricultural College.

86. Murphy, H. E., (Chemistry), State Teachers College, Dickinson.
87. Nelson, Caspar I., (Bacteriology), Agricultural College.
88. Norum, Enoch, (Soils), Agricultural College, 1948.
89. Nystuen, Peter, (Agriculture), Agricultural College, 1947.
90. Oehler, Mrs. Alma, (Nutrition), State Mill and Elevator, Grand Forks, 1945.
91. Opton, Edward, (Physiology), Agricultural College, 1946.
92. Overby, G. O., (Physics), State Teachers College, Valley City, 1947.
93. Owens, Paul, (Owens Floral), Grand Forks, 1945.
94. Peterson, Hjalmer, (Chemistry), University, 1946.
95. Posin, D. Q., (Physics), Agricultural College, 1948.
96. Post, R. L., (Entomology), Agricultural College, 1948.
97. Potter, Loren, (Botany), Agricultural College, 1948.
98. Promersberger, W. J., (Agricultural Engineering), Agricultural College, 1938.
99. Reid, Russell, (Natural Science), State Normal and Industrial School, Ellendale, 1940.
100. Reiersen, W. T., (Biology), State Normal and Industrial School, Ellendale, 1940.
101. Rhodes, L. D., (Physical Science), State Teachers College, Valley City, 1920.
102. Riley, K. W., (Chemistry), City Chemist, Grand Forks, 1945.
103. Robertson, Ina G., (Geography), State Teachers College, Valley City.
104. Rognlie, Philip, (Mathematics), University, 1946.
105. Rue, Julia, (Geography), State Teachers College, Minot.
106. Saiki, Arthur K., (Pathology), University.
107. Sands, Frederick H., (Chemistry), Agricultural College, 1946.
108. Samuelson, Theodore A., (Pharmacy), State Laboratories, Bismarck, 1943.
109. Saugstad, Stanley, (Entomology), Wild Life Administration, Bismarck, 1939.
110. Schultz, Frederick, (Physics), University, 1947.
111. Schlamb, Kenneth, (Experiment Station), Dickinson, 1948.
112. Schultz, J. H., (Horticulture), Agricultural College, 1948.
113. Shute, Leonard F., (Chemistry), Agricultural College, 1948.
114. Seymour, J. H., (Biology), State Teachers College, Valley City.
115. Sebens, Walter F., (Greater North Dakota Association), Fargo, 1948.
116. Sibbitt, L. D., (Cereal Technology), Agricultural College, 1946.
117. Sinner, Eugene M., (Pharmacy), State Laboratories, Bismarck, 1945.
118. Shepperd, Mrs. Adele G., (Chemistry), 1018 Seventh St. North, Fargo, 1911.
119. Shepperd, Wyman, (Horticulture), East Grand Forks, Minn., 1943.

120. Smith, Glenn, (Experiment Station), Agricultural College.
121. Smith, Grant W., (Chemistry), University, 1948.
122. Stafne, Gilbert J., (Farm Bureau), Fargo, 1948.
123. Staley, R. C., (Mathematics), University, 1946.
124. Stebner, Jack, (State Laboratories), Bismarck, 1943.
125. Steinmeier, L. D., (Chemistry), State School of Forestry, Bottineau, 1947.
126. Stevens, O. A., (Botany), Agricultural College.
127. Stewart, Donald L., (Chemistry), American Beet Sugar Co., East Grand Forks, Minn., 1943.
128. Street, Thomas F., (Biology), State School Forestry, Bottineau.
129. Sudro, W. F., (Pharmacy), Agricultural College, 1911.
130. Svore, Jerome, (Sanitary Engineering), State Health Department, Bismarck, 1943.
131. Taintor, E. J., (Agriculture), Taintor Seed House, Grand Forks, 1945.
132. Thompson, John C., (Mathematics), State Teachers College, Dickinson, 1948.
133. Thompson, Matilda, (Mathematics), Agricultural College, 1946.
134. Treumann, William B., (Chemistry), Agricultural College, 1947.
135. Van Heuvelen, W., (Chemistry), State Health Department, Bismarck, 1945.
136. Varland, Robert, (Chemistry), University, 1947.
137. Voedisch, Fred W., (Geology), Grand Forks, 1935.
138. Waldron, L. R., (Agronomy), Agricultural College.
139. Walster, H. L., (Director Exp. Station), Agricultural College.
140. Wanner, Donald F., (Agr. Economics), Farm Security Administration, Jamestown, 1947.
141. Wardner, Arthur K., (Agricultural Chemistry), Flaas Farms Co., Grand Forks, 1938.
142. Weeks, Oliver, (Bacteriology), Agricultural College, 1947.
143. Wendland, Ray T., (Chemistry), Agricultural College, 1948.
144. Weyer, Albert E., (Chemistry), Agricultural College, 1948.
145. Whedon, Arthur D., (Zoology), Agricultural College.
146. Wheeler, George C., (Zoology), University.
147. Wiidikas, William, (Agronomy), Agricultural College.
148. Winchester, Burl, (Animal Husbandry), Agricultural College, 1947.
149. Winstead, Hulda, (Physical Science), State Teachers College, Minot.
150. Witmer, R. B., (Physics), University.
151. Witz, R. L., (Agricultural Engineering), Agricultural College, 1947.
152. Zarling, Lillian, (Mathematics), State School of Forestry, Bottineau, 1945.

NORTH DAKOTA ACADEMY OF SCIENCE

PAST OFFICERS

<i>Yr., Place</i>	<i>President</i>	<i>Vice President</i>	<i>Sec.-Treas.</i>
1908			
Valley City	M. A. Brannon		Lynn B. McMullen
1909 A. C.	M. A. Brannon		Lynn B. McMullen
1910 U. N. D.	M. A. Brannon	C. B. Waldron	Lynn B. McMullen
1911 U. N. D.	C. B. Waldron	Lynn B. McMullen	G. A. Abbott
1912 A. C.	Lynn B. McMullen	H. F. Bergman	G. A. Abbott
1913 U. N. D.	Louis Van Es	A. G. Leonard	G. A. Abbott
1914 A. C.	A. G. Leonard	W. B. Bell	G. A. Abbott
1915 U. N. D.	W. B. Bell	Miss Lura Perrine	G. A. Abbott
1916 A. C.	Miss Lura Perrine	A. H. Taylor	G. A. Abbott
1917 U. N. D.	A. H. Taylor	R. C. Donaghue	G. A. Abbott
1918 A. C.	R. C. Doneghue	H. E. French	G. A. Abbott
1919 U. N. D.	H. E. French	J. W. Ince	G. A. Abbott
1920 A. C.	J. W. Ince	B. J. Spence	G. A. Abbott
1921 U. N. D.	L. R. Waldron	Daniel Freeman	G. A. Abbott
1922 A. C.	Daniel Freeman	Norma Pfeiffer	G. A. Abbott
1923 U. N. D.	Norma Pfeiffer	O. A. Stevens	G. A. Abbott
1924 A. C.	O. A. Stevens	David R. Jenkins	G. A. Abbott
1925 U. N. D.	David R. Jenkins	E. S. Reynolds	G. A. Abbott
1926 A. C.	E. S. Reynolds	J. G. Sinclair	G. A. Abbott
1927 U. N. D.	Karl H. Fussler	H. L. Walster	G. A. Abbott
1928 A. C.	H. L. Walster	G. A. Talbert	G. A. Abbott
1929 U. N. D.	G. A. Talbert	R. M. Dolve	G. A. Abbott
1930 A. C.	R. M. Dolve	Howard E. Simpson	G. A. Abbott
1931 U. N. D.	Howard E. Simpson	Arthur D. Whedon	G. A. Abbott
1932 A. C.	Arthur D. Whedon	George C. Wheeler	G. A. Abbott
1933 U. N. D.	George C. Wheeler	Caspar I. Nelson	G. A. Abbott
1934 A. C.	Caspar I. Nelson	Edgar A. Baird	G. A. Abbott
1935 U. N. D.	Edgar A. Baird	L. R. Waldron	G. A. Abbott
1936 A. C.	L. R. Waldron	John L. Hundley	G. A. Abbott
1937 U. N. D.	John L. Hundley	P. J. Olson	G. A. Abbott
1938 A. C.	P. J. Olson (Resigned)	Ernest D. Coon	G. A. Abbott
1939 U. N. D.	Ernest D. Coon	J. R. Dice	G. A. Abbott
1940 A. C.	J. R. Dice	Frank C. Foley	G. A. Abbott
1941 U. N. D.	Frank C. Foley	F. W. Christianson	G. A. Abbott
1942 A. C.	F. W. Christensen	Neal Weber	G. A. Abbott
1943 U. N. D.	Neal Weber	E. A. Helgeson	G. A. Abbott
1944 A. C.	E. A. Helgeson	Walter H. Moran	G. A. Abbott
1945 U. N. D.	Walter H. Moran	J. H. Longwell	G. A. Abbott
1946 A. C.	J. H. Longwell	A. M. Cooley	G. A. Abbott
1947 U. N. D.	A. M. Cooley	Rae H. Harris	G. A. Abbott
1948 A. C.	Rae H. Harris	R. B. Witmer	G. A. Abbott
1949 U. N. D.	R. B. Witmer	R. E. Dunbar	G. A. Abbott

WHEAT VARIETIES — OLD AND NEW

*L. R. Waldron**Plant Breeder, North Dakota Agricultural Experiment Station*

Two years ago this academy was shown the changing map of common wheat varieties within the state at 5-year periods since 1920. It could be compared to a series of geological maps with the "ages" limited to 5-years. With their passage some varieties moved off the map, became "extinct" as it were, while new varieties "evolved." It was noted that some varieties, such as Marquis or Thatcher, took their last stand in the western areas, the newer varieties making their start in the eastern areas. These variety changes, as we know, have been largely due to the greater resistance to disease shown by the newer varieties. Better adaptation to environmental factors has also played its part.

Changes in Yield

It is my desire now to present, among other things, an estimate of the changes in yield and the consequent income resulting from these variety changes as applied to the common wheats. This estimate is based on a series of plot yields which have been secured at Fargo over a period of years. The variety Power has been grown continuously and as this variety was selected from the variety Red Fife, the two may be treated as equivalent. Red Fife has also been grown at Dickinson for many years but the crops there have lacked the uniformity of performance, due to weather and other conditions, which prevents their use in this discussion. The results from 1916 to 1945 and calculated in 5-year periods are shown in table 1. In this table the average yields of Power (Fife) and those of the newer varieties produced by breeding are shown side by side and from the two the percentage yield is calculated of the Power variety. This percentage yield is then applied to the official state yields which indicates what would have been secured if the new varieties had not been introduced. The respective differences, between the actual and calculated yields, shows the 5-year average gains from plant breeding work.

The gains per pentad shown by the table vary from $\frac{1}{2}$ to 4.64 b. p. a. The gains show an increase through the years but they are not regular. Differences in crop conditions should be cited to explain this lack of regularity but it need only be pointed out that varieties markedly resistant to stem rust have been available for only the last two pentads, where very marked differences are shown. The differences are shown. The differences in b. p. a., applied to the state acres furnish the bushelage increased by plant breeding which totals 450 millions for the 30-year period or an average of 15 millions yearly.

TABLE I.

An estimate of the increased production of common wheat in North Dakota in 5-year periods from 1916 to 1945 resulting from the introduction of varieties developed by plant breeding and based on plot yields secured at Fargo.

Pentad	Yields at Fargo				Estimated Yields			
	New var.	Power (fife)	Power in p'cents	Off'l.	Calc. for Power	Inc.	State acreage (000)	Calc. bu. inc. (000)
1916-1920	19.0	17.9	94.2	8.7	8.20	0.50	28,316	14,158
1921-1925	27.0	20.8	77.0	11.4	8.78	2.62	29,606	77,568
1926-1930	31.7	26.7	84.2	11.1	9.35	1.75	31,370	54,898
1931-1935	27.6	21.9	79.3	7.0	5.55	1.45	26,196	37,984
1936-1940	24.0	11.5	47.9	8.9	4.26	4.64	26,196	121,549
1941-1945	27.0	20.8	77.0	18.0	13.86	4.14	34,856	144,304
<i>Bushels per year</i>								15,000,000

One criticism of this table would be that the yields from Fargo cannot properly be used to measure state-wide differences. This criticism is somewhat justified but yields from Langdon and Dickinson serve as a partial reply for the comparisons available from those two stations show a marked advantage for the new wheats though the differences are somewhat less than shown by the experiments at Fargo. If it were possible to compile a table showing the entirely accurate gains for the new wheats they would certainly be enormous and if a promise of such gains had been given at the start of the breeding program it might well have sounded fantastic.

Comparison of Present-Day Varieties of Common Wheat

It has been shown that a new and superior variety of wheat rapidly replaces the old variety. This suggests that the wheat grower is alert to the comparative value of two or more wheat varieties and generally is unmindful of any sentimental values which may be attached to an older variety. This seems to be generally true. In evaluating a variety of wheat the grower must be mindful of a number of characters which he is able to observe upon the farm and in the elevator. Means are provided for him to obtain information as to the baking characters of flour. From this one sees how it is that one variety may rapidly follow another in our spring wheat area. As an example of the above I wish to cite results secured from varieties developed by our own experiment station. Any hesitancy I might have in presenting these results is offset by the knowledge that their production has been strictly cooperative, not only at this experiment station, but with other centers as well.

Rival wheat was distributed in 1939 and the Mida variety had its release five years later, in 1944. The named spring wheat varieties commonly grown in the three states of Minnesota and the two Dakotas number seven and these perhaps cover 98 percent of the common wheat acreage. Only Thatcher was grown previous to the introduction of the Rival variety while the other four are either coeval with, or later than, Rival. These seven have been grown in field plots at various stations in these three states since 1944, when Mida was introduced. Yields are available continuously from four Minnesota stations but not continuously from three stations in South Dakota and seven in this state. The comparable experiments number 51.

Table II shows the difference in yield and in consequent potential production, based on state-wide acreages of Rival and Mida compared with five other named varieties, if one group had been grown instead of the other. In this table the experimental yields, which are relatively high, have been reduced by appropriate correction factors to reduce them to the official estimated yields.

TABLE II.

To show the total potential state-wide harvest differences in bushels between 2 groups of wheat for the years 1944 to 1947 with a total of 51 comparable experiments. Yields from the experiments are reduced to accord with the official estimating yields.

	No. of trials	Correction factor—%	RIVAL, MIDA		FIVE OTHERS		Difference	Acreage (000)	Excess bu. (000)
			Experiment	Statewide	Experiment	Statewide			
			b. p. a.		b. p. a.				
N. Dak.	24	55.5	28.6	15.9	26.2	14.7	1.2	31,682	38,018
S. Dak.	11	62.3	25.4	15.8	22.2	13.8	2.0	12,185	24,370
Minn.	16	64.9	30.4	19.7	27.3	17.7	2.0	4,437	8,874
		Av.	28.6		25.7		Tot.	48,304	71,262
			<u>+ .17</u>		<u>+ .10</u>				

From this table it is evident that the Rival and Mida definitely exceed the other five wheats in yield. The over-all yields of Rival and Mida are almost identical as they differ only 0.1 bushel. Also the excess of yield of these two varieties, as averages for the three states, are very uniform for each of the five varieties. The difference is below one bushel in only one instance in the 20 possible comparisons. Associated with this uniformity of yield superiority one may consider the standard errors of the two sets of total yields. Estimates

had to be made for five standard errors as only 46 of the 51 are available but one may be certain that such estimates are approximately accurate. The appropriate standard errors are shown in the table and with a difference of 2.9 bushels the t value equals 14.5 The odds that such a value, expressed statistically, is of significance is of the order of 10^{47} . Such a value is far beyond comprehension and no doubt exceeds the number of atoms in the universe.

Proper correction coefficients were applied to the experimental yields to reduce them to the official estimates. Doing this and applying the corrected yields to the total acreages of the four years the difference in bushels is seen to be $71\frac{1}{4}$ million.

Mention should be made of one area where these differences do not hold, the northwestern portion of North Dakota where Thatcher shows high yields. The limits of this area are not too well defined but evidently the Minot region is not included.

Leaf Rust Effects

The two parasitic fungous diseases, stem and leaf rust, have been of serious import in the production of wheat and other cereals. For the past several years our stem rust losses of spring wheat have been reduced to nearly zero by the development of varieties resistant to this disease. This relationship should remain unless rust races virulent to our present varieties should invade and increase in our spring wheat area. It is too well known how race 56 increased rapidly some 15 years ago and devastated the fields of Ceres wheat in 1935. The Ceres variety, however, was at best only semiresistant.

Very recently one or more forms of leaf rust have developed, or perhaps only increased, until now serious losses affect our main varieties which previously were held to be resistant. In earlier years opinions upon losses from leaf rust were divided due to difficulties in measurement. Johnston¹, in greenhouse experiments, found losses to lie above 50% when young plants were inoculated and losses above 20% were observed in a resistant variety, due probably to flecking rather than to pustulation, which was absent. A loss of 8% was found in the field where the check plots were sulphur-dusted at two-day intervals. Greaney² reports upon sulphur dusting experiments extending over three years. In 1932 leaf rust was abundant while the crop escaped severe damage from stem rust. The use of sulphur every other day at 45 lbs. per acre reduced leaf rust readings from 75% on the check plots to 2% on the treated grain while yield of grain increased from 31 b. p. a. on the check plots to 47 on the plots sulphur-dusted, an increase of 55%. Part of this gain must be laid to the sulphur effect on the stem rust present while dusting may have been beneficial by holding some of the minor diseases in check.

¹ Johnston, C. O., Jour. Am. Soc. Agron. 23 (1): 1-12. 1931.

² Greaney, F. J., Sci. Agric. 14 (9): 496-511. 1934.

Measurements from Durum Yields

In North Dakota, durum varieties, grown for many years in plots comparably with common wheat, furnish a criterion for measuring leaf rust damage as these wheats are highly resistant to leaf rust. It is possible to secure data from three localities, Fargo, Langdon, and Dickinson. Results for certain years have been grouped depending upon leaf rust damage to common wheats. Also those years have been omitted when stem rust injured durum yields. In these comparisons the Thatcher variety has been susceptible to leaf rust while the varieties Mida, Rival, and Pilot have showed marked susceptibility only since 1944 or 1945.

In Table IV, showing Fargo results, Thatcher shows two phases, with slight and heavy leaf rust injury, and the same is true with the Mida-Rival-Pilot average but the two sets are not the same as to time. All references to rust signify leaf rust.

TABLE III

Common and durum wheats compared in bushel and percentage yields at Fargo in two phases, light and heavy rust injury, for two sets of common wheats.

Rust injury: Years:	Slight		Thatcher heavy		All common heavy	
	1939, '40, Yield	'43, '44 %	1938, 1941, 1942 Yield	%	1945 - 1947 Yield	%
Thatcher	22.3	105	30.3	79	25.3	81
Mida-Rival-Pilot	22.0	103	37.5	97	25.7	82
Durums	21.3	100	38.6	100	31.2	100

In the four years when leaf rust injury lacked importance the common wheats outyielded the durums nearly one bushel per acre. For the three years when Thatcher showed susceptibility and when leaf rust was prevalent the Thatcher yield was 8.5 bu. below the durums while the three other common wheats yielded 1.1 bu. below. It is evident these three were injured somewhat. For the last three years, when all common wheats had high leaf rust readings, their yields were essentially equal and about 18% below the durums.

If the first phase is compared with the last phase the loss due to leaf rust is evidently 22% which would be the net loss, assuming that with no leaf rust the common wheats outyielded the durums.

Results at Langdon

For five years at Langdon, 1930, 1931, and 1934 to 1936, little leaf rust was in evidence and for that period Thatcher and the durums yielded 21.4 and 20.5 bushels, respectively. This was an excess for Thatcher of 5 percent. Only stem resistant durums were used in the comparison.

In table IV only two phases are shown and comparisons start with 1935 when yields of Rival and Pilot become available. Leaf rust was rather severe from 1935 to 1943 on Thatcher but as in Fargo, Rival

and Pilot showed resistance. For the four years from 1944 Rival and Pilot showed resistance. For the four years from 1944 Rival and Pilot showed susceptibility. The race or races virulent toward these two varieties were in evidence at Langdon one year earlier than at Fargo.

TABLE IV.

Common and durum wheats compared in bushel and percentage yields at Langdon in two phases, light and heavy leaf rust injury, for two sets of the common wheats. 1939 omitted because of crop injury.

	1935 to 1943		1944 to 1947	
	Mean	Percent	Mean	Percent
Thatcher	22.5	80	30.9	75
Rival-Pilot	28.4	101	34.1	83
Durums	28.2	100	41.0	100

At Langdon Rival and Pilot yielded as well as the durum as long as they remained resistant but at Fargo these two wheats, with Mida, evidently suffered during the three years 1938, 1941, and 1942. The net difference of 1.8 bushels is significant. From Table IV, in a comparison of Rival and Pilot for the two phases, the loss due to leaf rust was 18% in comparison with the durum yields. If the 5-year period, 1930, 1931, 1934 to 1936, were compared with the 4-year period 1944 to 1947, considering only Thatcher, its loss would be 30%, or 25% using the yields of 1935 to 1943.

Losses at Dickinson

Leaf rust has been of minor importance until recently but since 1945 readings have been such as to indicate probably damage. This is borne out when comparable yields are considered between the two classes of wheats, common and durum. These are shown in Table V.

TABLE V.

Common and durum wheats compared in bushel and percentage yields at Dickinson in two phases, light and heavy rust injury. The years 1936 and 1941 omitted because of crop injury.

	1935 to 1944		1945 to 1947	
	Mean	Percent	Mean	Percent
Thatcher-Rival-Pilot	16.5	108	21.6	89
Durums	15.2	100	24.4	100

Present Work

The present condition, with respect to leaf rust, is similar to that in 1935 when Ceres lost out in competing with stem rust race 56. At that time Thatcher became rapidly available to replace the Ceres acreage. There is no variety now ready for distribution to replace those which are now susceptible to the newly increased races of leaf

rust but active work is under way. The Minnesota Experiment Station has a variety developed from crossing Hope with an experimental variety Timstein which has shown promise in the field plots and the flour has relatively good quality when one considers its parentage. This variety, Minn. 2776, is being grown in the milling trials in 1948 and in plot trials at many of the stations. Many crosses have been made with this wheat. The cereal breeding laboratory at Winnipeg and the U. S. D. A. are both at work on the problem, using different initial sources of rust resistance.

Work at Fargo

The writer of this paper outlined the work now under way at the North Dakota Experiment Station before the Wheat Conference held at St. Paul early in February in a paper which will appear in the mimeographed report of the Conference. Our initial attack differs from most of the others with regard to the basic parents. Dr. E. R. Sears of the Missouri Experiment Station crossed the well-known emmer *Triticum Timopheevi*, discovered in the Caucasus Georgia in 1923, with a wild grass native to the Near East, *Aegilops squarrosa*. The 14 (haploid) chromosomes combined with the 7 from the aegilops produced a necessarily sterile plant but this was remedied by applying a colchicine solution to the young tillers of the hybrid plant thereby causing a doubling of the chromosomes and resulted in a fertile plant with 21 pairs of chromosomes, the same number as found in our common wheats. Dr. Allard of Madison made two crosses with the new amphiploid and a few seeds, in 1944, were sent to Dr. Glenn Smith who divided his material with the writer.

Plants from this divided portion, seeded in the 1944 nursery, were crossed with a Fargo-bred wheat and F_2 plants from this cross were crossed with Newthatch in 1945. Sixteen F_2 rows were planted in the nursery in 1946 which segregated as to presence and absence of leaf rust. In 1947 material was on hand to grow 54 F_3 families in 129 8-foot rows and 39 F_4 families in 119 8-foot rows, a total of 338 rows. Conditions were favorable for a severe leaf-rust epidemic in 1947 and segregation was observed among and between the families with 16 of the families showing complete freedom with respect to the rust races prevalent during the epidemic. Previous to any selection work the families were critically examined to eliminate those plants carrying leaf rust. Then over 2000 unit plants were selected and the balance of the families harvested in bulk units. From the large number of plant units of the present crop enough material will be available for a wide range of data. If a suitable variety should be developed an illustration will be at hand of some rather bizarre initial breeding work, obviously "impractical," leading finally to some very worth-while results.

SUMMARY

The average accrued production resulting from growing wheat

varieties developed by plant breeding during the period 1916 to 1945 has amounted to 15 million bushels annually for North Dakota alone.

The potential difference in production for the three states, Minnesota and the two Dakotas, during the four years 1944 to 1947 between the two varieties Rival and Mida, developed at the North Dakota Experiment Station, and five other named varieties commonly grown, is shown to be 71¼ million bushels.

Comparisons of yield between durum varieties, resistant to leaf rust, and Thatcher, a susceptible variety, and three other varieties, susceptible since 1944, from data taken at three localities in North Dakota, show that losses from leaf rust in 1947 may be estimated at about 20%. Such a loss would have entailed a reduction of about 25 million bushels in production.

Breeding work now under way promises to provide new varieties resistant to those races of leaf rust now virulent upon our present varieties. At the Fargo station the basic parent furnishing resistance is the amphiploid *T. Timopheevi* x *Ae. squarrosa* produced at the Missouri Experiment Station.



TRANSGRESSIVE SEGREGATION FOR EARLINESS IN DURUM WHEAT CROSSES

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SUMMARY

Lateness of maturity has always been a characteristic of durum wheats. From a farmer's standpoint this is not desirable because it increases the weather hazards, such as hail and lodging. Earliness perhaps also has an advantage where drouth is concerned.

This study also has importance for other crops. Many crops are not grown in North Dakota because they are not adapted. This simply means that prevailing varieties are too late, for example, soybeans, certain types of barley, flax, corn, sorghum, Sudan grass, potatoes and especially fruits and vegetables.

Wheat is one of the crops with which pioneer work has been done, both breeding and genetics. The success of research improvement with newer crops in many cases depends upon basic information learned from such crops as wheat, barley and corn. This, then, is another reason for studying earliness in wheat. The knowledge gained should be useful, not only with wheats but in "remodeling" other crops to suit our peculiar climate.

This present study is only an exploratory report suggestive of what may be accomplished in breeding earlier durum wheats.

The results may be summarized as follows: Thatcher and Mida, standard varieties of hard red spring wheat, are from three to five days earlier than Mindum, the standard variety of durum. The first step in producing earlier durum is Vernum, which is two to three days earlier than either of its parents, Mindum and Vernum. Apparently this is an example of transgressive segregation. More striking results have been obtained from crosses with Heiti and Khapli (emmer), which are about 5 and 10 days earlier than Mindum, respectively. Selections from crosses between the early Heiti and the late Stewart have given selections ranging up to 7 days earlier than Mindum. A number of the medium earlier selections from Heiti X Stewart, when crossed with Vernum have given progenies 3 or 4 days earlier than either parent. Most striking has been a progeny from Vernum X LD270, which is 10 days earlier than Mindum, a striking increase in earliness over either parent and a synthetic variety as early as Khapli (emmer). More complicated crosses involving three early parents have given progenies as much as 13 days earlier than Mindum.

These results may tentatively be explained by the assumption of different genes for earliness being carried by the various parents. When such parents are crossed it is possible to recover progenies carrying more genes for earliness than either parent. Such progenies will show transgressive segregation for earliness.

Presumably these genes for earliness may control the release of certain enzymes or hormones or physiological processes indirectly related to earliness. Eventually it would be desirable to attempt to establish what physiological processes the more important genes for earliness control.

It is generally considered that earlier wheats are lower in producing ability. However, if the effects of different genes were established it might be discovered that certain physiological processes related to earliness might give increased yields.



A NEW SYNTHESIS OF 3,5-DINITROBENZOATES OF ALCOHOLS AND PHENOLS

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3,5-Dinitrobenzoates, as alcohol derivatives, have previously been prepared by refluxing the acid chloride with primary and secondary alcohols¹, or preferably by a similar technic including the addition of dry pyridine². The latter modification is also applicable to tertiary and aromatic alcohols as well as some phenols. A modified Schotten-Baumann Reaction for the preparation of like deriva-

¹ Malone and Reid, *J. Am. Chem. Soc.*, 51, 3424-7 (1929).

² Phillips and Keenan, *J. Am. Chem. Soc.*, 53, 1924-8 (1931).

tives involves the addition of aqueous potassium hydroxide and potassium or sodium salts³.

Metallic sodium reacts with dry primary, secondary and tertiary aliphatic alcohols, aromatic alcohols and phenols to form the corresponding oxides. These oxides will then combine with the acid chlorides to form the desired derivative.

In the procedure here reported, the sodium was added in small quantities to 1 ml. portions of the several alcohols at room temperature. The addition of sodium was continued until no further reaction could be observed, but care was exercised to prevent the addition of an excess of sodium. In those instances where the reaction failed to start or was extremely slow, heat was applied at 60 degrees C. In the event that an extremely solid oxide was obtained or an objectionable excess of sodium was present, a small amount of the original alcohol was added to obtain a semi-liquid mass with which the acid chloride could react. The solid alcohols and phenols employed were first dissolved in an inert solvent such as ether and then the sodium was introduced.

Approximately 0.5 g. of 3,5-dinitrobenzoyl chloride was then added and the contents of the test tube were carefully mixed. In most instances where the reaction proceeded spontaneously and readily, a light colored, nearly white ester was obtained. In other instances dark purple substances were first produced which became white or light yellow upon further mixing or addition of more 3,5-dinitrobenzoyl chloride. The reaction mixture was carefully watched for excessive heating, and any evidence of charring was counteracted by external cooling. Ten ml. of water was then added to the ester reaction mixture, and the whole was vigorously agitated. Upon cooling the esters separated as solids. The liquid was decanted, and the solid esters were washed with approximately 10 ml. of 2% sodium carbonate solution. The prepared derivatives were then recrystallized several times from acetone. Where acetone failed to give satisfactory results the ester was recrystallized from ethanol. Here, however, care must be exercised to prevent trans-esterification if heat is applied or if the derivative is allowed to remain in the ethanol for long periods.

Table I includes a tabulation of thirty-three different alcohols and phenols so characterized, together with observed and reported boiling points and melting points.

Thirty-three different alcohols and phenols have been converted into the corresponding 3,5-dinitrobenzoates and these esters have been conventionally characterized. The method reported gave equally satisfactory or better results than previously reported methods of preparation. A decided advantage of this method is its application to a wide and varied group of hydroxy compounds such as aliphatic alcohols, aromatic alcohols, glycols, and phenols.

³ Lipscomb and Baker, *J. Am. Chem. Soc.*, **64**, 179-80 (1942).

TABLE I.

3,5-DINITROBENZOATES OF ALCOHOLS AND PHENOLS WITH EXPERIMENTAL AND REPORTED^{4, 6} PHYSICAL CONSTANTS

ALCOHOL or PHENOL	Boiling or Melting Points °C.		3,5-dinitrobenzoates Melting Point °C.	
	Exp.	Rep.	Exp.	Rep.
LIQUIDS (B. P.)				
Methyl.....	63.9-65	64.65 ⁴	106.5	107.5 ⁴
Ethyl.....	77.8-78.8	78.325 ⁴	92.2	93 ⁴
n-Propyl.....	96.7-97.8	97.15 ⁴	72.5	73 ⁴
Isopropyl.....	81.7-82.8	82.4 ⁴	121.5	122.1, 123 ⁴
n-Butyl.....	117-118	118 ⁴	62	62.5 ⁴
Isobutyl.....	106-107	108.1 ⁴	86	86.5 ⁴
ter-Butyl.....	82-83	82.50 ⁴	141	141.5-142.5 ⁴
n-Amyl.....	136-138	138.0 ⁴	46	46.4 ⁴
ter-Amyl.....	101-102	102.35 ⁴	115	116 ⁴
2-Methylbutanol-1.....	128-129	128.9 ⁴	69.5	70 ⁴
3-Methylpentanol-3.....	122-123	122.9 ⁴	96	96.5 ⁴
Hexanol-1.....	157-157.8	157.5 ⁴	57.5	58.2 ⁴
Hexanol-2.....	138.9	139.8 ⁴	38	38, 38.6 ⁴
Ethylene Glycol.....	197-198	197.85 ⁴	167	169 ⁴
Diethylene Glycol.....	244-245	244.5 ⁴	147.5	149 ⁴
Furfuryl.....	169-170	170 ⁴	79	80-81 ⁴
Tetrahydrofurfuryl.....	176-177	177 ⁴	83	83-84 ⁴
Benzyl.....	204-206	205.45 ⁴	111.5	113 ⁴
Cinnamyl.....	256-258	257 ⁴	119.5	121 ⁴
Cyclohexanol.....	160-162	161.1 ⁴	110-111	112-113 ⁴
2-Methylcyclohexanol-1.....	163-164	cis 165.3 ⁴ trans 167.4 ⁴	82-88	85-90 mixed ⁴
3-Methylcyclohexanol-1.....	170-171	cis 173-4 ₇₆₀ ⁴ trans 174-5 ₇₆₃ ⁴	78-84	80-85 mixed ⁴
4-Methylcyclohexanol-1.....	168-170	cis 173-4 ₇₅₀ ⁴ trans 174-4.5 ₇₄₅ ⁴	125-131	125-130 mixed ⁴
Guaicol.....	203-204	205 ⁴	138-139	142.2 cor. ⁴
Eugenol.....	252-253	253 ⁴	128-129	130.8 ⁴
SOLIDS (M. P.)				
d-Borneol.....	203-204.5	204.5-205.5 ⁴	152.5	154 ⁴
para-Nitrophenol.....	113	114 ⁶	186	188 ⁶
4-Hydroxy-1,2-dimethylbenzene.....	61-62	62.5 ⁶	180	181.6 cor. ²
Resorcinol.....	108	110 ⁴	199-200	201 ⁴
Orcinol.....	104-106	106.5-108 ⁴	188.5	190 ⁴
Pyrogallol.....	132	133 ⁴	202	205 ⁴
alpha-Naphthol.....	92-93	94 ⁴	214-215	217.4 cor. ¹
beta-Naphthol.....	122.5	123 ⁴	208	210.2 ⁴

⁴ Huntress and Mulliken, "Identification of Pure Organic Compounds, Order I," John Wiley and Sons, Inc., New York, N. Y., 1941, pp. 201-272, 398-481.⁶ Hellbron, "Dictionary of Organic Compounds," Volume III, Oxford University Press, New York, N. Y., 1943, pp. 217-218.⁶ Lange, "Handbook of Chemistry," Sixth Edition, Handbook Publishers Inc., Sandusky, Ohio, 1946, p. 664-665.

THE USE OF SYNTHETIC PLANT GROWTH STIMULANTS IN CEREAL INDUSTRY

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Certain plant growth stimulants may prove to be useful tools in cereal protein studies. They can be employed as neutral sodium salts, thus reducing hydrolytic action to a minimum, and increasing their solubility. It has been found that 5.0% to 10.0% solution of the sodium salt of naphthyl or phenyl acetic acid had a very marked dispersive action, and could be employed for securing dispersions of cereal proteins. At extremely low concentrations these substances had a coagulative effect on the protein. Other stimulants were also examined; however, their effectiveness was greatly decreased by the low solubilities of their sodium salts.

The plant growth stimulants can also act as protein precipitating agents. At a concentration of 0.14%, the sodium salt of naphthyl acetic acid removed 98.0% of the dispersed protein from N/10 acetic acid dispersions of gluten.

Plant growth stimulants strongly affect dough mixing requirements, as shown by mixogram patterns. The degree of effect varies with the particular compound employed and the strength of the effect tends to be related to the physiological activity of the compound. The character of the dough may be completely altered by the addition of growth stimulant. It might be possible to increase the strength of a flour with weak mixing properties, or a flour with too strong mixing requirements may be toned down by a heavier treatment. It is of course impossible to employ these stimulants for increasing the baking quality of flour because of their unfavorable effects on yeast activity.

GEOLOGY OF THE SODIUM SULPHATE DEPOSITS OF NORTH DAKOTA

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Our knowledge of the "alkalai lakes" of northwestern North Dakota goes back to the time of the Lewis and Clark expedition, but the first scientific study of the deposits began in 1934-35 when a group of engineers, chemists and relief workers under Professor Irvin Lavine outlined three groups of lakes estimated to contain reserves of 20 million tons. In 1947, in response to renewed interest in the subject, the North Dakota Geological Survey assigned a field party to the area to search for new deposits and to ascertain the origin of the Sodium Sulphate.

These investigations resulted in the discovery of a new group consisting of three lakes, but the inordinate precipitation made all augering impossible and, with one exception, no reserve estimates are yet possible. White Lake was augered in the preliminary survey (1934-35) and isopach lines drawn on the basis of the recorded data indicate reserves of about 2,500,000 tons of Mirabilite ($\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}$).

Water samples were collected from the other lakes and the analytical work is proceeding with the kind cooperation of Dr. Abbott. It is believed, however, that these analysis will at best yield only approximate minimum figures on the much thinner intermittent bed. It is quite possible that the samples taken from the lake shores may represent only a layer of relatively fresher rain water floating above a layer much richer in salts with a higher specific gravity.

The new deposits resemble the others in their location with respect to the terminal moraine and to the close control by glacial valleys.

It is postulated that all of the deposits fill initial depressions of two types.

1. Shallow depressions in the undulating topography of the terminal moraine and ground moraine.
2. Steep-walled depressions formed by the melting of huge buried ice blocks. The richest deposits in North Dakota appear to be of the ice-block type.

The question of the source of material for the Mirabilite and Thenardite cannot be answered in full as yet. There is little doubt that the Sulphate radical was derived from the Gypsum ($\text{CaSO}_4 \cdot 2 \text{H}_2\text{O}$) which abounds in the bedrock Fort Union formation and in the glacial till. The Sodium may have come from some of the little-known clay minerals which may yet be revealed by microscopic analysis.

SODIUM SULPHATE STUDIES. I. THERMODYNAMICS OF SODIUM SULPHATE AND ITS SOLUTIONS

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The current shortage of sodium sulphate has aroused national interest in the natural deposits of this material in the State of North Dakota. In order to recover sodium sulfate from the natural deposits of Glaubers salt, it is of the utmost importance that the physical and thermodynamic properties of this material be made available.

It is the purpose of this paper to review and collate the thermodynamic properties of sodium sulfate, its hydrates, and its solutions. After careful consideration of all available information in the literature, the best values were selected and correlated. Included are solubility data and phase relationships, specific heats, vapor pressures, heats of formation, entropies, and standard free energies for both Na_2SO_4 and its decahydrate, $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$. It is believed that such a set of relationships are of considerable value in indicating directions of future experimental work and in clarifying subjects of technical interest upon which direct experimental information is difficult and expensive to obtain. On the basis of this data, illustrations of thermodynamic methods are given for the calculation of useful properties, such as heats of decomposition of Glaubers salt and their reaction temperatures.



SODIUM SULPHATE STUDIES. II. THE DRUM DRYING OF SODIUM SULPHATE

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The inverted solubility of sodium sulfate in water has introduced many difficulties in the dehydration of Glaubers salt, $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$, by ordinary methods. Many intricate processes, involving special equipment have been proposed in the past for the drying of sodium sulfate. However, all of these methods have limitations, and in general have not been too satisfactory.

The feasibility of dehydrating Glaubers salt by a double drum drier has been investigated. This paper presents results obtained, using a 6 inch diameter x 8 inch face Atmospheric Double Drum Drier. The effect of the operating variables on the performance of the machine and on the quality of product have been carefully investigated and are summarized.

On the basis of this pilot plant data, a preliminary design of a proposed plant to manufacture 25 tons of sodium sulfate per day has been made. Included are a flow sheet of the proposed process, a cost estimate of the plant, and predicted operating costs.

SOME REACTIONS OF SPRING WHEATS TO SALTS, AMINES AND ESTERS OF DICHLOROPHENOXYACETIC ACID

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Sachs, Pfetfer and others proposed the idea as early as 1850 that plant responses were regulated by special growth substances produced within the plants themselves. In 1910 Boysen-Jensen demonstrated the movement of natural growth regulators within plants. Went worked out a plant assay method for testing growth regulators in 1928. During the period 1931-34, Kögl and associates isolated and identified several natural growth regulators and prepared a number of compounds having similar action. From 1934 to date over a thousand compounds of phenoxyacetic acid and others of similar character have been tested as growth regulators or as weed killers.

Work at North Dakota has shown that annual weeds in spring wheats can be controlled by the use of various compounds of 2, 4-dichlorophenoxyacetic acid without harm to grain if properly applied. All varieties of wheat tested reacted in a similar manner. Detrimental effects were obtained when grains were treated in the boot and flowering stages whereas treatment in the tiller stage appeared free from such undesirable reactions.



HERBICIDAL ACTION ON PLANT ENZYMES

1. 2-4 Dichlorophenoxy-acetic Acid Inhibition of Lipase.

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The discovery of the chemical composition of Auin A and B led to considerable interest in the study of the effect of various organic compounds on plant growth. The first interest along these lines was directed towards growth stimulation studies (Thimann, Zimmerman). More recently, with the discovery of selective action of the various compounds a major portion of the emphasis has shifted to studies concerned with herbicidal action. Present studies are largely empirical with no information available on physiology of the selective action. Since growth of the plant is involved, the enzyme systems regulating growth must be affected. The oxidative enzymes do not appear to be affected by 2-4 dichlorophenoxy-acetic acid (2-4 D) in invitro studies. Preliminary studies have shown that certain hydrolytic enzymes are affected. Diastase was inhibited to some extent. Lipase inhibition appeared to be proportional to concentration. This inhibition was selected for further study since the action on lipase may have a direct bearing on the use of 2-4 D in weed control in flax production. Data will be presented to show relation of substrate and inhibitor concentration to inhibition of lipase from castor bean meal.

EFFECT OF THREE HALOGEN SUBSTITUTED PHENOXY COMPOUNDS ON MILLING AND BAKING QUALITY

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A short summary is given here of the investigations undertaken at the North Dakota Agricultural Experiment Station of the effect of three halogen substituted phenoxy compounds on the milling and baking quality of hard red spring wheat. The field treatments will be described by Dr. Helgeson, Chairman, Botany Department, in a preliminary paper.

Five varieties of hard red spring wheat were treated at the "tiller" growth of the plant with the three compounds:

- (1) Sodium dichlorophenoxy acetate.
- (2) Amine of 2, 4-dichlorophenoxy acetic acid.
- (3) Butyl ester of 2, 4-dichlorophenoxy acetic acid.

One variety (Mida) was treated with these three substances at four different stages of plant growth. These stages were as follows: (1) Tiller; (2) Boot; (3) Bloom; (4) Soft dough.

Results are given for wheat protein content, flour yields, loaf volume, and crumb color. Mixogram curves were obtained on three of the varieties, and at the "tiller" and "soft dough" stages of application.

The means of the variety trials show that the sodium salt has no effect on the protein content or the milling and baking qualities. The amine and butyrate improved the wheat protein significantly over the check samples. This increase was reflected in a significantly larger loaf volume. Flour yield and crumb color were not affected.

In the study conducted on the effect of time of application of the inhibitor, no change in protein content was noted. Loaf volume and crumb color, however, were increased considerably when the treatment was applied at the "tiller" stage.

Mixogram patterns showed no significant changes, but exhibited the usual varietal characteristics.

From these data it is apparent that treatment at the "tiller" stage by the three halogen substituted phenoxy compounds has no deleterious effect on wheat quality. When the amine and butyl ester were used a definite increase in protein content and loaf volume resulted.

A CASE OF RIGHT AND LEFT SUPERIOR VENA CAVA

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and Evan L. Otto

Normally, the superior vena cava is located on the right side of the mid-line of the body. It is formed by the left innominate vein, draining the left arm and the left side of the head and neck; and, the right innominate draining the corresponding structures of the right side. The right superior vena cava thus formed empties the blood into the upper part of the right atrium. (Figs. I and II).

A cadaver dissected at the University of North Dakota Medical School showed a rather rare deviation from the usual pattern. The subject was female, age 56, on whom no clinical history was available. The veins of the right arm and neck joined together normally to form the right innominate vein which continued down along the normal course of a right superior vena cava; however, the veins of the left arm and left side of the neck did not form a left innominate vein. Instead, they joined together at the left sterno-clavicular articulation to form a left superior vena cava which then proceeded vertically downward, united with the coronary sinus, and emptied into the right atrium above and to the left on the inferior vena-caval opening, (Figs. III and IV). Muculloch, from the University of Michigan reported one such case in 700 dissections; Adochi ("Das Venen system der Japaner") observed four cases in 821 subjects and stated that this anomaly was more common in the female.

A consideration of the embryological development of the venous system makes it clear how such a case can exist.

The earliest form of venous return for the somatic circulation is effected by the anterior and posterior cardinal veins on each side of the body which empty into the sinus venosus. (Fig. V). At about a 16mm. foetus, the two anterior cardinal veins each send a thymico-thyroid branch medialward in the region where the thyroid gland will later develop. These branches, then, grow together to form the left innominate. (Fig. VI). With the further development of the foetus, the left anterior cardinal vein below the left innominate degenerates, and the parts of it that remain are: the left highest intercostal vein, the oblique vein of the left atrium, and the vestigial fold of Marshall (the fold of paricardium). (Fig. VII).

Therefore we see that, in this case, nature forgot to anastomose the thymico-thyroid veins; and, as a consequence, we have a case of a right and left superior vena cava.

THE EFFECTS OF ABSORBED MOISTURE, HUMIDITY AND TEMPERATURE ON THE RATE OF FLOW OF SOAPSTONE

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An investigation was made of the powdered mineral pyrophyllite ($\text{Al}_2\text{O}_3 \cdot 4 \text{SiO}_2 \cdot \text{H}_2\text{O}$, Soapstone¹ by trade name) in relation to its use as a dusting powder in rubber plants. Soapstone is used in powder form for lubricating uncured stock at various stages in the processing of rubber. One such use is that of dusting extruded innertubes to prevent sticking of the inner wall upon its collapse preparatory to the curing process. Air injection type machines using 35 lbs. pressure were formerly used to introduce the dust within the extruded tube. Little attempt was made to control the rate of flow in these machines. In the Fleetwood low pressure dusting machine, the rate of flow was, for the most part, quite uniform. However, in periods of extreme cold or high humidity the rate of flow became irregular. This was thought to be due to the adsorbed moisture content of the soapstone. In order to test this assumption, the adsorption of water vapor by soapstone was investigated. A correlated study of moisture content, relative humidity and temperature was made, to determine how these factors affect the rate of flow of soapstone from a vibrating hopper and feeder² of the type used in the low pressure dusting machine.

The amount of adsorption on solids is affected by temperature, pressure of the adsorbed vapor (or relative humidity in the case of water vapor), nature of the adsorbent, and the nature of the adsorbed material. Around 1910 the belief was generally held that adsorbed vapor existed as an atmosphere surrounding the adsorbent, analogous to the earth's atmosphere. Since then adsorption has been studied rather extensively in connection with colloidal materials, catalysis, filtering, purification and separation. It now seems more proper to consider the formation or building up of monomolecular³ or multimolecular⁴ layers on the surface of solid materials. The film formed on the surface may be held by physical or chemical adsorption. On plane surfaces the film is uniform and investigations have shown that it is usually one molecule thick at maximum adsorption.⁵ On porous adsorbents, the vapor may condense in capillary pockets at higher humidities and result in formation of a film several molecules thick.⁶

¹ Furnished by the Gillette Plant of the U. S. Rubber Co., Eau Claire, Wisconsin.

² Furnished by Phil Maynard and Sons, Minneapolis, Minnesota.

³ Langmuir, *Chem. Rev.*, 13, 147 (1933).

⁴ Frazer et al, *J. Phys. Chem.*, 31, 897 (1927).

⁵ Cohan, *J. Am. Chem. Soc.*, 66, 98 (1944).

⁶ Latham, *J. Am. Chem. Soc.*, 50, 2987 (1928).

Preliminary studies indicated that adsorbed moisture affected the rate of flow of soapstone from a vibrating feeder. In carrying out the investigation of adsorption on soapstone a constant temperature chamber was used, with an apparatus for exposing dry soapstone to relative humidities between 25 and 90% by means of a system of belts. The adsorption was dynamic since the belts moved the powder through the atmosphere. Seventy-five minutes was found to be the time required for adsorption equilibrium. This period of time was used throughout the investigation. After 75 minutes exposure to the water vapor at constant humidities, samples were removed for moisture content determinations. Values were obtained by the loss in weight after drying at 110° C. for 2 or 3 days. The rate of flow of the soapstone was checked at a constant vibration setting and a constant starting hopper-load at temperatures of 10, 15, 20, 25, and 30° C. At each temperature 5 or 6 humidities were supplied and the information was plotted in graphs, as rate of flow of soapstone against relative humidity, and also against moisture content. It was found the soapstone absorbed small amounts of water vapor and shallow S-curves were obtained when water vapor adsorption in per cent by weight was plotted against the relative humidity. This is in agreement with results obtained by Boyd and Livingston⁷, who studied water vapor adsorption on TiO₂ at 24° C. Relative humidity is related to moisture adsorption. If one then plots the effect of moisture content against the rate of flow, and relative humidity against the rate of flow of soapstone powders, one would expect to obtain similarly shaped curves. This was found to be the case. Comparable curves were obtained at 10, 15, 20, 25, and 30° C. but are omitted here. These curves exhibited rather sharp maxima in the rate of flow of soapstone. The soapstone will flow most freely in a moisture content range of 0.07 to 0.09% water by weight at 30° C. Likewise soapstone in equilibrium with an atmosphere of 55 to 65% relative humidity at 30° C. will flow at a maximum rate. Dry soapstone is subject to a packing effect in the feeder hopper, as is soapstone with a moisture content greater than 0.15%. If one plots the moisture content adsorbed in per cent against the temperature at constant humidities, one obtains constant relative humidity curves. A unique set of curves was obtained when this was done. The general tendency was toward decreased adsorption at higher temperatures, however the curve maxima were not at the lowest temperature (10° C.), but between 15 and 20° c., where the greatest water vapor adsorption occurred. Further work is planned to investigate the continuation of these curves to lower and higher temperatures.

Discussion

A small amount of moisture is desirable since it tends to lubricate the powder. Lubrication may be by contact in which case either

⁷ Boyd and Livingston, J. Am. Chem. Soc., 64, 2383 (1942).

a partial film or a whole film of water acts as a lubricant between soapstone particles. Lubrication may result from occlusion of air by the water film. This could cause some fluffing of the powder or prevention of complete packing of smaller particles within the void space of larger particles during vibration. The surface tension effect of polymolecular films should not be overlooked as a factor in causing particle aggregation at higher humidities or moisture contents. This could possibly cause the decreased rate of flow of soapstone observed at higher percentages of moisture.

Conclusion

1. Considering the range of temperature investigated (10° to 30° C.), the most desirable moisture content falls between 0.07 and 0.12% adsorbed water by weight and the most favorable relative humidity lies between 55 and 75%.
2. Results indicate that a more uniform rate of flow of soapstone can be obtained by controlling the moisture content.
3. The original assumption that moisture content affected the rate of flow of soapstone from a Syntron vibrating feeder and hopper is verified.



IONIZATION IN AIR BY CENTIMETER WAVES

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ABSTRACT

Ionization and sparking in air was studied during the war years at the Radiation Laboratory of the Massachusetts Institute of Technology, in connection with radar performance. Waves of one to ten centimeters in length were used, and their ionization leading to a spark breakdown was investigated in wave guides of appropriate size. The heavy ionization leading to sparking was studied as a function of air pressure within the wave guide, initial ionization provided by a radioactive source, gap height, length of wave pulse traveling down the wave guide, and repetition frequency of the pulses. Results were obtained in the form of graphs and empirical relations relating breakdown to the various parameters mentioned above, and a semi-theoretical analysis was established accounting for breakdown in relation to electron ionization as the ion-generating mechanism, and **electron attachment to neutral molecules** as the ion-loss mechanism. Certain conditions involving the predominance of the former over the latter mechanism leads to a condition of instability ending in a spark.

DETERMINING THE MINIMUM AMOUNT OF WATER NEEDED TO SCOUR WOOL TO MEET A. S. T. M. STANDARDS

Russell Henrickson

Objectives¹

1. To determine the minimum amount of water required for scouring wool in order to have the wool meet the A. S. T. M. standards for clean wool.
 2. To investigate the use of solvents other than water in scouring wool.
 3. To develop the new wool scouring equipment that will improve the efficiency of the process.
- At present only the first objective is being investigated.

Procedure (Condensed)²

The quantity of wool per volume of water is varied at a constant temperature with a concentration of washing chemicals. A washer made by the Easy Washer Corporation, consisting of a washing tub and centrifugal dryer, is used in processing the wool. The agitator was replaced by a suction cup device which is used to move up and down by means of an electric motor pumpjack arrangement. This device is used to avoid roping of the wool. Two tubs of water are used for washing and one tub for rinsing. Seventy-five grams of $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$, 12 grams of Naccanol (a wetting compound and detergent), and twenty-four liters of water at a temperature of 50°C , are placed in each of the first two tubs. A quantity of wool varying from 500-800 grams is introduced into the machine. After five minutes of washing, the wool is removed and spun in the centrifugal dryer. A 40 gram sample is taken and the remainder of the wool placed back into the machine. The second tub of water is run in and the process is repeated. Three 40 gram samples are taken in all. Each sample is dried for twelve hours at 100°C and the loss of weight is noted. By knowing the weight of the wool after each washing, and the weight of the water in the 40 gram samples it is possible to calculate the amount of dry wool present at any time.

The wash liquor; i. e., the water after the wool has been washed, is sampled and portions are evaporated to dryness and are extracted to determine the amount of fat present. However, this subject will not be taken up in this paper.

Treatment of Samples

Each of the 40 gram samples is further sampled to obtain three samples of approximately a gram and one half which are placed in tared alundum extraction thimbles and are accurately weighed and extracted with ether for 10 hours. After drying to constant weight

¹ Henrickson, R. M. "Wool Scouring Report No. 1" Prepared for the North Dakota Research Foundation Jan. 10, 1948.

² Henrickson, R. M. "Wool Scouring Report No. 2" Prepared for the North Dakota Research Foundation April 13, 1948.

to determine the amount of ether extractable material the samples are further extracted with 95 per cent ethyl alcohol and dried to constant weight to obtain the total per cent of extractable material. The per cent of alcohol extractable material is determined by the difference.

The American Society of Testing Materials³ standards state that clean wool accepted for trade must not contain over 1.5 per cent of ether or alcohol extractable material.

Discussion of Results, Source of Error, and Future Work

It has been found in all runs that from 90 to 96 per cent of the dirt is removed in the first washing, 2 to 7 per cent in the second washing, and 1 to 5 per cent by the rinse.

The most significant results are the total per cents extracted after the second washing which are given in Table I.

Quantity of wool per 24 liter of water	number of samples	mean	median	% deviation from mean
800 grams	15	2.25%	2.28%	16.4
700 grams	15	2.02	1.75	23.8
600 grams	9	1.57		2.5

The amount of wool per 24 liter should lie between 500 and 600 grams to attain minimum A. S. T. M. standards; however, since two tubs of water are used to wash the wool, and one tub to rinse, the amount of water required is 72 liter per 500 to 600 grams of wool.

The main error seems to lie in the great variability of the wool used. Despite careful sampling and sorting, it was difficult to obtain wool of a constant grade in fineness and cleanliness. It was necessary to use the analytical balance when working with the extraction thimbles and the small samples of about a gram. It was also necessary to exclude air from the small samples when they were weighed. For this purpose large, ground glass, stoppered weighing bottles were employed.

At present the wool is washed once in the water, and then the water is thrown away. The next step on which work has already been started is to re-use the water after the wool has been washed.

The Procedure Is as Follows

Consider three tubs A, B, C, of which A and B are tubs for washing; and C for rinsing, operating through runs 1, 2, and 3.

After run 1, the water in tubs B and C is saved and the water in tub A is discarded.

For run 2: Tub A contains water from 1 B, and tub B contains water from 1 C. The fresh rinse water is also added in tub C.

For run 3: Tub A contains water from 1 C; tub B contains water from 2 C. Fresh rinse water is added in tub C.

This procedure will greatly reduce the amount of water necessary to meet A. S. T. M. standards for clean wool.

³ American Society for Testing Materials. "Standards of the American Society of Testing Materials." 260 South Broad Street, Philadelphia, Pennsylvania.

THE RATE OF DRYING OF LIGNITE IN HOT OIL AT 315° F

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Occasionally it has been proposed to reduce the moisture content of lignite by conveying it through a bath of hot oil. Since no data relating to the drying time were available, it was decided to determine the rate of drying lignite in hot oil under conditions similar to those which would prevail in a commercial plant.

The constant temperature bath was made from a five gallon oil can. The can was well insulated and placed in a box. Four and one-half gallons of motor oil, SAE 20, was added; giving a bath depth of 11 inches. The bath was maintained at constant temperature by 120 psi saturated steam flowing through a steam coil placed in the bottom of the bath. A thermometer, immersed to a depth of 5 inches, measured the temperature of the hot oil. The vigorous bubbling, caused by the moisture released by the coal, maintained the temperature throughout the bath constant to within two degrees. The heat capacity of the bath was such that no appreciable change in temperature was caused by introducing the coal samples.

The tests were carried out at a temperature of 310 to 320° F. In order to obtain comparative results on the rate of drying as related to the particle size, lignite spheres of 1 inch, 2 inches, and 4 inches diameter, were prepared by grinding lignite pieces, cut from large lumps, by means of a grinding wheel.

In order to prevent any loss of material to be dried, which had been previously measured and weighed, each lignite sphere was put into a gauze bag and fastened to a steel rod by means of a string in

TABLE I.
COMPOSITION OF THE DRIED LIGNITE SPHERES

		<i>Diameter Inches</i>											
		1				2				4			
Sphere No.	Drying Time—Min.	Dry Coal—%	Moisture—%	Oil—%	Drying Time—Min.	Dry Coal—%	Moisture—%	Oil—%	Drying Time—Min.	Dry Coal—%	Moisture—%	Oil—%	
1	2	69.2	29.6	1.2	8	68.8	27.8	3.4	32	71.1	26.3	2.6	
2	4	73.0	25.4	1.6	16	71.0	25.3	3.7	64	71.3	25.9	2.8	
3	8	77.5	17.8	4.7	32	75.7	19.1	5.2	128	79.5	16.0	4.5	
4	16	83.9	12.1	4.0	64	82.2	10.1	7.7	256	88.6	6.2	5.2	
5	35	87.4	6.2	6.4	120	87.4	4.0	8.6	420	91.4	1.8	6.8	

TABLE II.
REDUCTION OF THE MOISTURE CONTENT IN PERCENT
DEPENDING ON THE DRYING TIME.¹

Sphere No.	Diameter Inches					
	1		2		4	
	Drying Time —Min.	Moisture Red.—%	Drying Time —Min.	Moisture Red.—%	Drying Time —Min.	Moisture Red.—%
1	2	13.9	8	14.9	32	28.2
2	4	38.0	16	30.6	64	35.3
3	8	42.0	32	53.0	128	57.3
4	16	63.5	64	78.0	256	85.0
5	35	85.0	120	91.2	420	96.7

¹ Corrections for oil absorption have been made.

such a manner as to allow the piece to be immersed 5 inches deep in the hot oil. The spheres were simultaneously immersed in the heated oil and frequent temperature readings were made in order to obtain a complete record of the temperatures prevailing during the course of an experiment. At set intervals, the rod was slightly lifted and one sphere was removed from the bath. The oil was allowed to drip from the surface of the sphere, whereafter the moisture content was determined, as well as the amount of absorbed oil.

Table No. 1 shows the composition of the dried lignite sphere after the drying experiment. The reduction of the moisture content in percent depending upon the size of the spheres and on the employed drying time, is presented in Table No. 2.

From these tables it can be concluded that:

1. An effective reduction of the moisture content of raw lignite takes place when lignite spheres are immersed in hot oil.
2. The final moisture content of the dried lignite spheres depends on the drying time.
3. The time to dry to equal moisture content is a function of the diameter of the lignite sphere.

Oil is absorbed by the lignite during the drying process. The amount of absorbed oil increases with the drying time. In Figure 2, the percent oil absorbed is plotted against the moisture content of the dried lignite sphere. The general tendency is that the lower the moisture content of the dried lignite, the higher the amount of oil absorbed by the coal. When a lignite lump is immersed in the hot oil, the surface is rapidly heated to the temperature of the oil and the moisture begins to vaporize at and near the surface of the sphere. Small cracks are developed which in a very short time form a network covering the whole surface of the lignite sphere. The escaping

water vapors, which force their way through the outer zone of the sphere, begin to loosen the material. This is sometimes followed by a slight bulging of the surface. Since the center part of the piece remains still cold the "skin," begins to fall apart. Such an initial destruction of the surface becomes greater with an increasing diameter of the sphere. Later on, radial cracks are formed which penetrate the whole sphere and once they reach the center, the sphere falls apart. In addition, separated plates are formed by opening the natural cracks which are already present in the original piece. When the drying process is carried on for an appreciable period of time, regardless of the initial size of the pieces, cubicles of almost equal size are obtained.

The following pictures show the disintegration of the spheres which takes place during the drying process.

1 Inch Spheres:

- (1) Development of cracks at the surface.
- (2) Network of cracks at the surface.
- (3) Beginning disintegration into plates.
- (4) Disintegration into plates, development of radial cracks.
- (5) Complete disintegration.

2 Inch Spheres:

- (1) Surface cracked, loose particles.
- (2) Increased cracking at the surface formation of separated plates.
- (3) Increased disintegration, numerous loose particles, radial cracks about $\frac{1}{2}$ inch deep.
- (4) Disintegration into plates, cracks running almost across the piece.
- (5) Complete disintegration.

4-Inch Spheres:

- (1) Development of cracks at the surface, formation of partly loose particles.
- (2) Increasing disintegration, about 1 inch deep. Formation of a cracked peel which envelopes the center part.
- (3) Surface completely cracked, formation of bulges and radial cracks. Falling apart prevented by gauze bag.
- (4) Complete disintegration into small pieces.
- (5) Complete disintegration into small pieces.

The time which is required to dry spheres of various diameter to equal moisture content is of considerable interest because it determines the size of the drying equipment needed.

Should no disintegration of the piece occur during the drying process, the drying time would be governed by the velocity of the heat flow from the surface to the center of the piece, by the heat units which are transferred from the hot oil to the surface of the piece, and by the time which is required to vaporize the moisture and which is necessary for the water vapors to reach the surface of

the piece. Disintegration of the original lump, which allows part of the hot oil to have direct access to central zones of the lump, reduces the drying time. Since it is almost impossible to compute the drying time with disintegration of the lumps, a mathematical analysis was worked out which indicates the time required to dry without disintegration of the lignite.

The full lines of the lower diagram represent the percent moisture removed plotted against the drying time. It was assumed that the reduction of the moisture content is a hyperbolic function of the drying time, which can be represented by the following equation:

$$\frac{1}{y-a} = \frac{x}{c} - a$$

Where x =drying time in minutes; y =percent moisture removed; a =a constant equal to 100% moisture reduction; and c is another constant. The full lines of the upper diagram represent the expression $\frac{1}{y-a}$ plotted against the drying time. The curves are the rectified full curves of the lower figure. They indicate that besides heating and vaporization another factor, disintegration influences the rate of drying. It was now assumed and confirmed by observations that almost no disintegration takes place during such a period of drying, which is represented by the first two points of each set of experiments. The respective points were connected by a straight line, the dashed lines of the upper diagram which now furnish the theoretical data for the rate of drying without disintegration of the spheres.

Without going into details, the dashed straight lines of the upper diagram can be represented by the following equation:

$$y = \frac{ax}{1 + 0.01(ax)}$$

Where x =drying time in minutes, and y =the percent moisture removed. The numerical value for a is 9.28 for the 1 inch sphere, 2.97 for the 2 inch sphere and 0.975 for the 4 inch sphere.

From these assumed rectified curves, the dashed lines of the upper diagram, the theoretical curves without disintegration, the dashed lines of the lower diagram were now computed.

Comparing the curves, the following conclusions can now be drawn:

1. The disintegration of the spheres during the drying process tends to reduce the drying time which would be necessary when no disintegration takes place.
2. The two curves coincide at the beginning of the drying process. Separation of the curves shows beginning disintegration of the lignite lumps.
3. The slope of the curves indicates that the rate of drying decreases with the proceeding drying time.

The before-mentioned equations of the theoretical curves with-

out disintegration can be represented by the general expression:

$$Y = \frac{AX}{1 + 0.01 AX}$$

Where X and Y represent drying time and the percent moisture removed respectively, and A is a constant which depends on the size of the sphere to be dried. Plotting the respective constants against the diameter of the spheres on logarithmic graph paper results in a straight line which indicates that constant A can be represented by an expression which depends on the diameter of the sphere.

The numerical value of the constant:

$$A = \frac{9.28}{D^{1.625}}$$

Where D is the diameter of the sphere.

The general equation, Table 3, which now allows to compute the percentage moisture removal depending on the drying time and on the diameter of the sphere, provided that no disintegration takes place and that the lignite spheres with an initial moisture content of approximately 36% are immersed in heated oil of 310 to 320° F, reads as follows:

$$Y = \frac{\frac{9.28}{D^{1.625}} X}{1 + 0.01 \left(\frac{9.28}{D^{1.625}} \right) X}$$

Where Y and X are the percent moisture removal and the drying time respectively and D represents diameter of the sphere to be dried.

The time required to dry one inch to four inch lignite lumps to any desired moisture content can now be computed by means of this equation.

The actually needed drying time will be shorter due to disintegration of the lignite, however, it can be estimated from the previously presented curves.

TABLE III. GENERAL EQUATION

For Computing The Percentage Moisture Removed Depending On The Drying Time¹

$$Y = \frac{\frac{9.28}{D^{1.625}} X}{1 + 0.01 \left(\frac{9.28}{D^{1.625}} \right) X}$$

Y=Percentage moisture removed.

X=Drying time in minutes.

D=Diameter of sphere.

¹ Without disintegration of the spheres during drying temperatures of oil bath 310-320° F.

THE PRODUCTION OF POTATO FLOUR IN THE ROTO LOUVRE TYPE DRYER

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During the past few years the Red River Valley district of North Dakota and Minnesota has increased the production of potatoes to the point that the surplus and culls provide a source of material for manufacture.

Several materials may be manufactured from potatoes: the material manufactured depends upon the proximity to markets and the supply of water. The cull potatoes in the state of Maine are manufactured into starch, which is used in the textile industry along the Eastern seaboard. Idaho potatoes are manufactured into starch, glucose and potato flour and the manufacture of these by-products has grown to such proportions that during the present season the cull potatoes in Idaho were insufficient for the plant capacity and North Dakota potatoes bought by the Government under the support program were shipped to Idaho for processing.

The December crop estimate for the 1947 season showed 20,100,000 bushels for the Red River Valley district and if the culls amount to 15%, 180,900,000 pounds of potatoes would be available for processing. A large percentage of this total is graded in three localities and the problem of collection is simplified.

The 1947 season was larger by 4,319,000 bushels than the ten year average (1936-45) but the amount of cull potatoes available in an average year is still 142,029,000 pounds. The average potato flour plant of two drying units handles a maximum of 36,000,000 pounds over a 250 day season, consequently, the district can support more by-product manufacturing plants than now exist.

The conventional method of manufacturing potato flour consists in peeling the potatoes in a lye or steam peeler, steam cooking the potatoes and drying them on a single roll steam heated dryer. These dryers are usually about 4 ft. in diameter and 8 to 10 feet long, heated by steam under pressure on the inside of the roll. The cooked potatoes are fed to the roll at the top and are pressed on to the hot metal surface by a series of small unheated rolls rotating one below the other around one side of the roll. A thick layer of potato collects on the top roll and at intervals this is scraped off and falls to the next lower roll. Each roll being in contact with the steam heated roll adds to the thickness of the layer on the heated roll. The heated roll rotates slowly and the dried layer of potato is scraped off by a scraper blade opposite the feed side.

The advantage of this method of making potato flour is that the peeling does not have to be complete since the peelings do not stick to the hot roll in drying and thus concentrate themselves on the cold rolls and may be removed at intervals.

Another important advantage is that blighted potatoes may be used and since they are fully sterilized in the cooking process they do not affect the quality of the finished product.

The disadvantages of the process are that the equipment is relatively costly, it needs an auxiliary boiler plant and it has good capacity only on the high starch types of potatoes.

The Irish cobbler variety is practically the only commercial variety grown in the Red River Valley in commercial quantity which can be processed economically on the roll type of dryer.

Previous experiments in drying of livestock feed from potatoes led to the present process. The process consists in peeling the potatoes by one of the conventional processes, running the peeled potatoes through a hammer mill and set of crushing rolls, addition of sodium sulphite or SO_2 in the mill, pressing in a continuous Davenport press and drying the pressed cake in a Roto Louvre type of dryer.

The Roto Louvre dryer is a double shell dryer in which the heated drying gases are admitted through a series of ports so that these gases pass through the bed of potatoes in the rotating dryer. The advantages of this system is that good contact results between the drying gases and the charge and lower temperature gases may be used than in the single shell type of rotary dryer.

This type of dryer was found to be unsuited to the drying of potatoes having their full moisture contact because of the sticking of the wet potatoes to the metal louvres of the dryer and the rapid gelling of the starch of the potatoes resulting in balling up during drying and poor drying of the lumps.

When the moisture content is reduced by mechanical pressing so that the percentage is less than 70% there is no difficulty from sticking.

The dryer used in this work was 30 inches in diameter by 10 ft. long and was manufactured by the Link Belt Co.

The water was removed from the milled potatoes by means of a Davenport 3A press illustrated in Fig. 3. This type of a press is widely used in the distilling industry to recover spent grains from stillage. It consists of two discs of perforated metal backed by a bronze casting and enclosed in a housing. The discs rotate with their faces at an angle and the distance between the discs is about 6 inches at the top and 1 inch at the bottom. Material fed in on one side is gradually compressed as the discs rotate and the expressed fluid flows through the perforated plates. The feed material to a press of this type must be fibrous, flake or granular. If it is too fluid it will flow from the inlet to the outlet of the press without compression.

In order to provide a feed to the press of the proper characteristics the potatoes were milled in a John Deere 10 inch hammer mill run at 1500 RPM and having a $7/8$ inch screen. Below the screen the material passed between two twelve inch crushing rolls. The

coarsely milled potatoes in passing between the rolls were crushed so as to free the moisture for pressing but the pieces retained a flake form which could easily be compressed in the type of press used.

Sulphur dioxide or sodium sulphite was added during the milling stage to inhibit enzyme action. The amount added was sufficient so that the press cake to the dryer contained 200 ppm of SO₂. This amount was sufficient to keep the potato granules white and practically all of this material passed off during the drying stage.

The drying was accomplished by contact with combustion gases of propane drawn through the dryer by an exhaust fan.

Typical Drying Data

<i>Raw Potatoes</i>	<i>Peeled Potatoes</i>	<i>Pressed Potatoes</i>
2840 lbs.	2410 lbs.	1621 lbs.
Moisture content of raw potatoes.....79		
Moisture content of pressed potatoes.....70		
Solids lost in pressing.....13% of total		
Temperature of gases to dryer.....600° F		
Temperature of gases from dryer.....156° F		
B. t. u. to dryer per hr.....288,000		
Pounds product per hr.....96.0		
Moisture content of product.....12%		

The product from this dryer is whiter than that obtained by the conventional drying process and is essentially a raw product. The drying is so rapid that the starch of the potato is not gelled and the temperature remains so low due to rapid evaporation of moisture that the enzymes of the potato are not inactivated.

The product retains the true potato flavor to a greater degree than does flour from cooked potatoes and the flavor seems to be more stable under ordinary conditions of storage.

The main uses of potato flour are:

1. As an addition to wheat flour in bread making to increase moisture absorption, and improve the flavor.
2. As a thickener in soup mixes.
3. As an addition to pancake mixes.

The flour dried in the Roto Louvre dryer cannot be used as a substitute for cooked potato flour in the usual bread making process. The enzymes are still active and do not reach a high enough temperature in the baking process to become inactivated. The finished loaf consequently is gray in color. Cooking of the potato flour in water before mixing with the wheat flour dough would inactivate the enzymes but this would require an additional step in bread making which would probably not meet commercial acceptance.

The Roto Louvre product would be useful in soup mixes and pancake mixes and seems to be superior to cooked potato flour on account of its better flavor.

The costs of processing flour in the Roto Louvre dryer are considerably less than the costs of the conventional process.

The capacity of commercial size Roto Louvre dryers is high. A 5 ft. diameter by 20 ft. dryer has a capacity of about 1500 pounds of product per hour. No boiler plant is required and the process can be used on all types of potatoes regardless of their original moisture content.



DIBENZOFURAN SULFONIC ACID AS A PRECIPANT FOR SODIUM AND POTASSIUM:

Its Preparations and Properties.

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Dibenzofuran sulfonic acid (diphenylene oxide sulfonic acid) is a strong acid which possesses the advantageous property, unusual for sulfonic acids, of being easily crystallizable from water. It is obtained conveniently by the direct sulfonation of dibenzofuran at 100 C. using 2.0 to 2.5 moles H_2SO_4 per mole of aromatic for a period of 1 to 2 hours. Inevitably the reaction yields also some of the much more soluble disulfonic acid. But the desired monosulfonic acid can be obtained simply by chilling the diluted sulfonation mixture which leads to rapid crystallization of the acid in large shimmering platelets.

Earlier studies of the above acids are those of Hoffmeister¹, Gilman and others², and Zehenter³. Hoffmeister characterized the disulfonic acid (which was the *only* product he obtained by the action of hot concentrated sulfuric acid on the aromatic) as the slightly soluble barium salt mono hydrate. Gilman² prepared the 2-acid (which was not isolated as such but as the sodium salt) using chlorosulfonic acid at low temperature in carbon tetrachloride, and also the 2, 8-disulfonic acid by the directions of Hoffmeister; the 2, 8-orientation in this process was proved by conversion of the disulfonic acid to the known 2, 8-dibromo dibenzofuran. Gilman³ also prepared the 4, 6-disulfonic acid from the 4, 6-disodio-dibenzofuran by way of the established reaction with sulfur dioxide. Gilman and co-

¹ W. Hoffmeister *Annalen* 211 (1871).

² H. Gilman, E. W. Smith, and H. J. Oatfield, *J. Amer. Chem. Soc.* 56, 1412 (1934).

³ H. Gilman and R. V. Young, *op. cit.* 57, 1121 (1935).

workers⁴ likewise prepared the 3-sulfonic acid (by indirect means), and the 1, 2, 3, 4-tetrahydrodibenzofuran-7-sulfonic acid; Zehenter⁵ showed that the action of fuming sulfuric acid on 2, 2-dihydroxy diphenal can be made to yield dibenzofuran-4-sulfonic acid; this was isolated as the slightly soluble sodium salt monohydrate.

The exceptional insolubility of this sodium salt, and also of potassium and amine salts has not previously been capitalized. This knowledge led the authors to undertake the present studies and to propose the use of dibenzofuran sulfonic acid as a sodium and potassium precipitant.

The investigation was aimed at determining two results: (1) the course of the sulfonation reaction, i. e., the amounts of mono and disulfonic acids formed during varying periods of time of reaction between the dibenzofuran and sulfuric acid at 100 C., and (2) the quantitative solubilities of various salts of dibenzofuran monosulfonic acid (here-after abbreviated simply as DBF-MS).

Experimental Procedures

1. Sulfonation of dibenzofuran and isolation of its monosulfonic acid.

The quality of the sulfonic acid was somewhat influenced by the source of the dibenzofuran. The Reilly Tar and Chemical Company product once crystallized from alcohol gave excellent results. The standard procedure for sulfonation employed throughout this work was as follows: A weighed amount of dibenzofuran was put into a loosely stoppered Erlenmeyer flask and melted on the steam bath (m. p. = 88 C.) and concentrated sulfuric acid in the amount of 2.4 moles to 1.0 mole of aromatic was slowly poured in. Steam heating for various times from one to four hours with periodic shaking followed, after which the sulfonation mixture was poured into twice its volume of water. By chilling this solution after filtration, abundant precipitation of the monosulfonic acid occurred. Usually the chilled mixture stood in the ice bath 8-12 hours. The sulfonic acid was filtered off on an all glass funnel and recrystallized from a small volume of boiling water—again at 0 C. This monosulfonic acid after drying in vacuo at 100 C. for 1 to 2 hours assayed 96 to 98 percent pure acid by titration, the remainder being water. To account for the remainder of the monosulfonic acid, the above filtrate was neutralized with sodium hydroxide (phenolphthalein) which precipitated the very insoluble sodium salt. Recrystallization of this from boiling water, chilling to zero C., and oven drying in vacuo at 100 C. for 1-2 hours gave an anhydrous product with the theoretical sodium and sulfur content. To separate the disulfonic acid from the filtrate it was necessary to add barium chloride solution which yielded the

⁴ H. Gilman, E. W. Smith, and Lee Cheney *op. cit.* 57, 2095 (1935).

⁵ J. Zehenter, *J. Prakt. Chemie* 131, 331 (1931).

slightly soluble Ba salt plus barium sulfate from the unreacted acid. These two were readily separated by washing the precipitate on an all glass funnel with boiling water, which dissolved the barium disulfonate of dibenzofuran. This salt recrystallized readily by chilling to zero, and if necessary, concentrating the filtrate by boiling.

The isolation of these products showed that the sulfonation varied with time according to Table I.

TABLE I.

Dibenzofuran occurring as mono and disulfonic acids after sulfonation with sulfuric acid at 100 C.

<u>Reaction Time</u>	<u>Mono Sulfonic acid</u>	<u>Disulfonic acid</u>
1 Hour	75%	17%
2 Hours	54	28
3 Hours	52	29
4 Hours	?	42

————— = expressed as mole percent of dibenzofuran used

It is obvious from Table I that some dibenzofuran remains unaccounted for, altho every bit of it reacted with the sulfuric acid, even during one hour. The remainder undoubtedly was converted to higher sulfonation products which could not be isolated by the procedure employed. It is obvious also that the best yield of the monosulfonic acid could be attained after a one hour sulfonation, hence this period was chosen for the quantitative production of the acid. A shorter reaction period left some of the dibenzofuran unreacted.

2. *Determination of solubilities of sodium and potassium salts of dibenzofuran monosulfonic acid.*

The re-crystallized acid was dissolved in water in various concentrations ranging downwards from 2.0 percent. Such solutions were exactly neutralized by the addition of sodium or potassium hydroxide (phenolphthalein) of known normality, after which the resulting solutions were diluted to a standard volume and chilled in an ice bath. The appearance of a precipitate immediately indicated those mixtures in which the concentration of salt had reached the saturation point. By determining the amount of the precipitated salt, and knowledge of the original amount produced by the neutralization, one can then calculate the solubilities of these salts.

In addition to the sodium and potassium salts, those of other common metals were prepared from solutions of their sulfates or chlorides. The solubilities of these various salts are reported in Table II.

TABLE II.*Solubilities of various salts of dibenzofuran acid at 0 C.*

Cation	Solubility (g./100 mls. water)	Solubility product
Na	0.300	1.25×10^{-4}
K	0.520	3.36×10^{-4}
NH ₄	1.87	49.7×10^{-4}

Ca, Mg, Ba, Cu, Ni, Zn, Sn, Al Chloride or sulfate salts of these gave abundant precipitation at 1% concn. when the sulfonic acid was added.

TABLE III.*Characteristics of the monosulfonic acid of dibenzofuran.*

Melting Point	145 C.
Solubility in g. per 100 mls. H ₂ O at 25 C.	= approx. 8.0
Normality at saturation	= 0.30

Summary

Dibenzofuran mono sulfonic acid has been prepared in good yield (75%) by direct sulfonation of dibenzofuran at 100 C. for one hour using concentrated sulfuric in 2.4/1 molar ration. The acid was readily crystallized from iced solution, and upon drying was found to melt at 145 C. There was always some disulfonic acid formed during the reaction, and the amount of this increased with time at the expense of the monosulfonic acid.

The sodium and potassium salts of this acid have been found to have a very low solubility (Na=0.30 g. per 100 mls. water; K=0.52 g. at zero degrees centigrade). Furthermore, these salts can be completely dehydrated by vacuum drying at 100 C. after which they possess the theoretical content of metal and sulfur. Hence they can be used for the quantitative determination of these alkali metals.

Many other metals, as Ca, Ba, Mg, Cu, Ni, Zn, Sn, and Al, likewise form very insoluble salts with dibenzofuran mono sulfonic acid. The ammonium salt, on the contrary, forms a more soluble salt. Preliminary testing of a variety of organic amino compounds shows likewise that these can be precipitated from aqueous or acid solutions by the addition of the sulfonic acid.

We have demonstrated therefore that we have a general cation precipitant of outstanding usefulness, which has the special advantage of offering a new technique for sodium and potassium determinations.

A RAPID METHOD FOR THE OXIDATION OF ORGANIC MATTER

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A rapid method for the wet oxidation of organic matter is always useful in an analytical laboratory. Sulfuric, nitric and perchloric acids used alone or in combination are the three most common acids used in the oxidation of organic matter. For arsenic determinations, a combination of nitric and sulfuric acids is recommended by the Association of Official Agricultural Chemists. Nitric and perchloric acids have been proposed for the destruction of organic matter in the determination of potassium, calcium, and phosphorus.

In all these proposed methods, the oxidation procedure is usually long and tedious, and it is often difficult to obtain a clear solution, that is, one which is free of all organic matter. Furthermore, considerable quantities of these oxidative acids are required for complete oxidation. The disadvantage in this use of large amounts of the acids lies in the fact that they are sometimes sources of contamination. This is especially true in the case of arsenic determination, as most all acids contain some arsenic.

Bolin and Stamberg¹ have proposed the use of molybdenum as a catalyst for the oxidation of small amounts of organic matter with perchloric and sulfuric acids. They have recommended the use of this procedure for the determination of phosphorus in feeds. Bolin² has extended the use of this procedure to the determination of phosphorus in forages.

In these procedures 500 mg. of material was the maximum amount that was recommended to be oxidized at any one time. The main purpose in proposing the use of small amounts of organic material was to lessen the hazards of explosion. Perchloric acid may produce violent explosions if the proper precautions are not taken and if the proper technique is not used. However, perchloric acid is relatively safe, and no explosions have resulted up to date with its use. All oxidative reactions have proceeded smoothly in the determination of phosphorus in 1,000 or more samples.

Further work at this laboratory has been done to make this method applicable to larger amounts of organic matter. A combination of nitric, sulfuric, and perchloric acids are used in the presence of molybdenum as a catalyst. The method of procedure is essentially as follows:

¹ Bolin, D. W. and Stamberg, O. A., *Ind. Eng. Chem. Anal. Ed* 16, 345 (1944).

² Bolin, D. W., *Proceedings of the No. Dak. Academy of Science*. 1 25-26 (1948).

A ten gram sample is transferred to a 500 or 800 ml. Kjeldahl flask. To the sample is added 5-15 ml. of concentrated sulfuric acid. The amount of sulfuric acid depends upon the type of sample being oxidized. For example, flax seed meal requires more than cereal grains. Sufficient sulfuric acid must always be added so that the sample will not go to dryness.

Add $\frac{1}{2}$ ml. of 20% sodium molybdate and 15 ml. of concentrated nitric acid. Allow the nitric acid to react either at room temperature or by heating very slightly. This oxidation should proceed as slowly as possible since too rapid oxidation will cause the evolution of too much heat, driving off the nitric acid. The efficiency of the nitric acid added will be reduced, and more perchloric acid will be required in the latter stages of oxidation. In order to meet these conditions, with certain samples, cooling in a water bath is sometimes necessary, especially with the first addition of acid. This is again true for flax-seed meal. Add 10-15 ml. additional nitric acid after the first reaction has subsided and cooled somewhat. The total amount of nitric acid needed for any 10 gm. sample is approximately 25-35 ml.

Heat on a microburner until all nitric acid fumes have been driven off, and most of the water has evaporated. Add 1 ml. of perchloric acid, and continue heating until the oxidation of perchloric acid begins. This oxidation will not take place until *all* the water in the sample has been evaporated. It is marked by the formation of heavy, white fumes which ascend into the neck of the Kjeldahl flask. When the reaction has started, it will generally proceed under the heat it generates. Small amounts of perchloric acid are then added as long as the oxidative procedure continues or until a white or clear solution is obtained.

If the material is dark and no white fumes are evolved, it is best to stop adding perchloric acid and to heat again with the microburner. Approximately 5-10 ml. of perchloric acid are required to complete the oxidation after the addition of nitric acid. The exact amount depends upon the type of sample used. The solution remaining is then made up to volume with distilled water.

The danger in the use of perchloric acid for oxidation purposes is in the addition of too much acid in the presence of considerable quantities of organic matter. This danger is eliminated in the use of molybdenum as a catalyst, and if care is taken in the addition of the acid. Under proper conditions and in the presence of molybdenum, perchloric acid is immediately and completely utilized and no accumulation of acid results.

To obtain proper conditions for the addition of perchloric acid there are certain precautions that should be taken; (1) the digestion mixture must be free of water and at the proper temperature for oxidation. Perchloric acid will not oxidize in the presence of water; (2) It is recommended that only 1 ml. of perchloric acid be added,

and the digestion mixture heated until oxidation takes place; thus establishing the proper condition for the addition of more perchloric acid, and eliminating the danger of having too much acid accumulation in the digestion mixture.

To test this method for arsenic determinations, known amounts of arsenic were added to a 10 gram sample of feed previous to digestion. Another sample of the same feed was digested with the same amount of acid and used as a check. The amount of arsenic was determined in both samples by the Gutzeit method and the percentage of recovery determined. Ninety to one hundred percent recovery was obtained.

Summary

A rapid and safe method for the oxidation of organic matter with perchloric acids has been presented.

Its use for quantitative determination of the common inorganic elements in feeds and foods has not been investigated with the exception of phosphorus, arsenic and calcium.

Smaller amounts of oxidative acids are required by this method, thereby lessening the amount of contaminants caused by the addition of these oxidative acids.

Perchloric acid is a good dehydrating reagent for silica; thus silica may be removed quantitatively from the solution by filtration.



EFFECT OF THIOUREA UPON THE CONVERSION OF CAROTENE INTO VITAMIN A IN SHEEP

F. M. Bolin and D. W. Bolin

The effect of thiouracil upon vitamin A values in the liver of the rat has been discussed by Wiese, Deuel and Mehl¹. Body weights of the rats fed the thiouracil were approximately 50% of that of the controls. Both groups were depleted on the vitamin A free diet, likewise each group made the same increase for vitamin A content of the liver when carotene was added to the diet. The range results was greater in the thiouracil treated rats. The thiouracil was either toxic or had an inhibiting effect upon the growth hormone. As to whether the vitamin A in the thiouracil treated rats was usable or not was not determined.

¹ Wiese, C. E., Deuel, H. J., and Mehl, J. W. 1947 Thiouracil and Conversion of carotene to Vitamin A Measured by Liver Storage in the Rat—Proceedings of the Society for Experimental Biology and Medicine, Vol. 66, No. 1, pp. 213-214.

Geiling² has reviewed the literature on thiourea derivatives and related compounds and their anti-thyroid effects. This paper gives the serum vitamin A content of thiourea treated lambs and sheep.

Animals

Sheep No. 233—Vasectomized male. Weight 225 lbs., age 2 years.

Lamb No. 3809—10 months of age, weight 96 lbs.

Lamb No. 7566—10 months of age, weight 57 lbs.

Lamb No. 7567—10 months of age, weight 52 lbs.

These sheep had been kept in an unheated shed during the fall and early winter months. The four sheep were placed upon a vitamin A low diet January 21st, 1948, which consisted of soybean meal, oats, and bright threshed straw for fifteen days. City water was available at all times.

On February 5th the animals were grouped No. 233 and No. 3809 as controls continuing on the same diet while No. 7566 and No. 7567 were likewise continued on the same diet and were given 6 grams thiourea per day by capsule and a balling gun.

On February 17th the last doses of thiourea were given at 8:00 A. M. Citrated blood and serum samples were taken shortly after. A carotene concentrate containing 3,330 I. U. per gram was given at the rate of 1 gram per pound body weight and was administered in water via stomach tube. Blood samples were taken at four hour intervals for the next 24 hours. One sample was taken for each of the following two days.

TABLE I.

WEIGHTS: Pounds at indicated dates.

Sheep No.	2-5-48	2-17-48	2-23-48
233	—	225	215
3809	—	96	90
7566	57	53	36
7567	52	51	37

The weights were taken to determine the dosage of thiourea and carotene, which accounts for the controls not being weighed on February 5th. From physical examination there was very little change in the weights of the controls throughout the experiment. The

² Geiling, E. M. 1948 Pharmacology—Rodenticides—Annual Review of Physiology, Vol. 10, pp. 402-403.

thiourea treated lambs had a continued weight loss amounting to 31 and 27 per cent during the last three days of the experiment. The greatest weight loss occurred after the thiourea was discontinued and followed the administration of the carotene. It was not determined whether the weight loss was due to the thiourea, the carotene, or the handling.

TABLE II.

I. U. Vitamin A per 100 Ml. Serum.

Sheep No.	1-21	2-17 8 A.M.	2 P.M.	6 P.M.	10 P.M.	2-18 2 A.M.	6 A.M.	10:30 A.M.	2-19 10:30 A.M.	2-20 10:30 A.M.
233	188	109	97	118	97	120	102	103	109	123
3809	95	68	68	90	75	88	75	103	103	90
7566	93	35	35	35	55	30	36	36	24	23
7567	93	35	45	35	35	42	42	42	42	35

The vitamin A values of the controls were only slightly below the average normal after being on a vitamin A low diet for 27 days. This compares well with unpublished data of Eveleth³ that long periods of low carotene feeding are needed to deplete older lambs and sheep of vitamin A and to impair their physiology. Following the administration of the carotene there was a gradual rise in the vitamin A content of the blood serum in the control sheep.

In sheep on six grams thiourea for 12 days there was a marked drop in the vitamin A content of the blood serum. There was no rise in the vitamin A values in three days following the administration of the carotene.

A repeat of this experiment was attempted, the animal used was the pig. The data is not included because no significance was found. Failure of the experiment was attributed to vomiting of the thiourea treated pigs within minutes after administration of the thiourea.

Summary

1. The effects of thiourea upon serum vitamin A in sheep have been presented.

2. Failure of a twin experiment in pigs is attributed to early vomiting of the animals after the thiourea was administered.

³ Eveleth, D. F. Unpublished data—North Dakota Agricultural Experiment Station.

GROWTH RESPONSE STUDIES OF CHICKS WITH THE ADDITION OF METHIONINE TO THEIR RATION

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Chick feeding experiments have been conducted during the past year with different rations to which methionine has been added. The purpose of these feeding trials was to determine what feeds are low and what ones are high in methionine content. The results of a feeding experiment are presented here to show that pea and meat meal proteins are low and whole egg proteins are high in methionine.

Procedure

Four lots each containing 20 one-week old chicks were placed on the following ration for two weeks:

Lot No. I was placed on a ration containing 15 percent pea-meat meal protein to which all other known nutrients were added.

Lot No. II was placed on the same ration as *Lot No. I* except that 0.3 percent methionine was added to their ration.

Lot No. III. Six percent of the pea-meat meal protein in the ration fed *Lot No. I* was replaced with six percent whole egg protein.

Lot No. IV was given the same ration as *Lot No. III* except that 0.3 percent methionine was added to their ration.

All chicks were weighed at the start and finish of the experimental feeding trial and the total amount of feed consumed recorded.

Results

The initial and final weights of chicks and the total feed consumption for a two week feeding period are presented in Table I. From these results, the average gain in grams of feed required per gram gain, and the grams gained per gram of protein were calculated.

Discussion of Results

Chicks in *Lot No. I* made very poor gains, required a large amount of feed per gram of gain, and showed a very poor utilization

of the protein in the ration. Chicks in Lot No. II were given the same ration with the exception that methionine was added to this ration. These chicks in Lot II made very good gains, required less feed per gram gain and made good use of the protein in the ration.

TABLE I.

Data obtained from feeding one week old chicks for two weeks on two different rations with and without the addition of methionine.

Lot No.	Initial Weight	Final Weight	Average Gain	Average Daily Gain	Grams of Feed per Gram Gained	Grams Gained per Gram Protein	Average Total Food Consumed
I	59.0	80.0	21.0	2.3	8.28	0.80	168
II ¹	62.0	166.0	104.0	6.1	2.52	2.65	276
III	62.0	140.0	28.0	5.1	2.75	2.42	207
IV ²	62.0	158.0	96.0	5.8	2.45	2.72	261

¹ Ration the same as for Lot I except .3% methionine was added.

² Ration the same as for Lot III except .3% methionine was added.

The results obtained from Lot I and II would indicate that pea-meat meal proteins are a poor source of methionine but very good sources of other essential amino acids. The chicks in Lot II made approximately five times the rate of gain as those in Lot I. If other essential amino acids were limited, it would have been impossible to obtain this increased rate of gain for chicks in Lot IV by the addition of methionine.

Data obtained from the gains made by chicks in Lot III and IV would also verify the statement that pea-meat meal proteins are a good source of other amino acids with the exception of methionine. Chicks in Lot II made equally or slightly better gains than those in Lot IV. Since methionine was added to both rations for Lots II and IV, the addition of other essential amino acids with the whole egg protein did not increase the rate of growth. Whole egg proteins are known to be a good source of essential amino acids.

Comparison of data between Lot I and Lot III show that whole egg protein is a good source of methionine. Chicks in Lot III made approximately four times the gains made by those in Lot I. Addition of methionine to the ration fed the chicks in Lot IV gave a small additional increase in rate of growth over those in Lot III. This

would indicate that 6 percent egg protein was slightly deficient in supplying adequate methionine to the pea-meat meal proteins for maximum growth response.

It should be noted that when methionine was not supplied in sufficient amounts to the ration, chicks made very poor use of other essential amino acids. For chicks in Lot I, one gram of protein gave 0.8 gram gain whereas in Lot II one gram of protein gave 2.65 grams of gain. Chicks in Lot III made better use of their protein. This was due to the methionine present in the whole egg protein. From these results it can be said that methionine has a sparing action on other essential amino acids.

Summary

Pea-meat meal proteins are a very poor source of methionine but a good source of other essential amino acids. Whole egg proteins are a good source of methionine. In the absence of methionine other essential amino acids are poorly utilized.



HIGH NITRATES IN DRINKING WATERS, AND THEIR TOXICITY TO INFANTS

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Physicians long have recognized the occurrence of a congenital heart defect in new-born infants. It slows down the circulation of the blood, causing a serious deficiency of oxygen. In such cases, the blood acquires a dark color, and the skin shows marked cyanosis, leading to the popular designation of such infants as "blue babies."

Recently, many cases of infant cyanosis have occurred throughout the middle west; but only a very few cases could be traced to congenital heart conditions. The diagnosis was not clear until Dr. Hunter H. Comly, Pediatrician at the University of Iowa, in 1945, traced it to the effects of nitrates in the well waters used in preparing the milk diets. He reported two typical cases in which these well waters were found to carry 619 and 530 parts per million of nitrate respectively.

Following this announcement, other Iowa physicians reported similar cases of "blue babies," and the Iowa State Hygiene Laboratory reported five cases accompanied by high values of nitrate in the drinking waters. Data obtained in the Iowa Water Survey, made in 1935-36, showed that in 2000 water samples analyzed, nitrates varied from 0 to 125 parts per million in domestic and municipal wells, while farm wells frequently showed much higher values.

From these studies, the recommendation was made that well waters used in preparing infant diets should not exceed 10 parts per million, or at most 20 parts per million of nitrate. Later the same laboraotry found that of 91 water samples submitted by their owners, 18 samples, or about 20 per cent showed values as high as 287 parts per million; while 56 per cent carried as much as 44 parts or more. All but one of these samples came from shallow dug wells. Usually bacterial contamination and organic pollution accompanied the high nitrate values.

Similar observations have been made in Illinois, Missouri, Minnesota and other states in the middle west. In Minnesota, infant cyanosis due to nitrates has been shown to be fairly common and endemic in certain areas, particularly in the densely populated farming district in the southeastern part of the state. Not all of the wells involved were of the shallow dug type. Some were bored wells from 100 to several hundred feet deep.

It seems probable that the deep wells may have defective casings that permit the entrance of shallow waters contaminated from nitrate-bearing soils; but some sanitary engineers have expressed their doubt that all of these cases can be explained in this way. They suspect that some of these wells may acquire their nitrates from deeper geologic horizons. If this could be established, it would present an interesting geo-chemical problem whose solution might reveal information about organic conditions prevailing during past ages.

The toxyty of nitrates results from their reduction to nitrites, by the intestinal bacterial flora, and the absorption of the nitrate ion by the blood, where it acts to oxidize hemoglobin to methemoglobin, which cannot carry oxygen from the lungs. The change to methemoglobin consists in the oxidation of the ferrous iron atom in the molecule of the hemoglobin to ferric iron. This reaction is reversible, which explains the spontaneous recovery of mild cases when given nitrate-free water. But without prompt treatment, severe cases may prove fatal. The usual treatment consists in injecting proper doses of methylene blue, which quickly reduces the methemoglobin back to normal hemoglobin, and recovery is generally immediate and complete.

Interest in this nitrate problem is now wide spread. Naturally we in North Dakota are concerned about conditions in our own state. Fortunately, considerable reliable analytical data on the nitrate contents of North Dakota ground waters are already available; for the complete mineral analyses made in the state-wide survey of municipal waters included the determination of nitrate. Also numerous analyses of private wells have been made. The newly established

State Health Laboratory, at Bismarck, is now rapidly accumulating further data in its sanitary examination of waters throughout the state.

Data from the State Municipal Ground Water Survey, made at the University,¹ show nitrate (NO₃) values ranging from less than one part per million to several hundred parts per million. A few values exceed 400 parts per million, while single values of 500 and 708 parts were found.

As anticipated, shallow wells account for most of the high values. Most of these wells obtain their water from the quaternary drift, alluvial deposits, and lacustrine beds; but some of them tap the Pierre Shale, the lignite-bearing Fort Union Shale, and a few penetrate the Lance and other geologic horizons. The character of the aquifer appears to make little difference, as surface or shallow soil pollution seems to be the determining factor in most cases.

Data from 151 dug wells show that about half of them exceed 10 parts per million of nitrate. The distribution is as follows:

10 to 30 parts per million.....	30 wells
50 to 100 parts per million.....	16
100 to 200 parts per million.....	15
200 to 300 parts per million.....	2
300 to 400 parts per million.....	none
More than 400 parts per million.....	3

After the dug wells, the bored wells of moderate depth show the greatest nitrate contamination.

Of the bored wells, 37 exceed 10 parts per million.

10 to 50 parts per million.....	19 wells
50 to 100 parts per million.....	8
100 to 200 parts per million.....	5
354 parts per million.....	1
500 parts per million.....	1
708 parts per million.....	1

Some very deep wells show high nitrate values. A few artesian wells that tap the Dakota Sandstone show values between 22 and 31 parts per million. Normally such waters contain less than 10 parts. This suggests the probability that the exceptions may be wells with faulty casings, or in some cases wells from which the

¹ Bulletin 11, North Dakota Geol. Survey, 1938.

casings have been withdrawn, thus permitting surface contamination. These individual wells will doubtless be checked by sanitary engineers. If found free from surface pollution, such wells would present a very interesting problem.

This examination of available data makes it clear that there is a serious nitrate problem in North Dakota. This is substantiated by actual cases of infant cyanosis brought to the attention of the author by physicians, who deserve commendation for correctly diagnosing these cases and promptly applying the proper treatment in time to save the lives of the infants involved. Usually, parents become alarmed and consult a doctor only when infants show acute cyanosis. This suggests the possibility that harmful effects may result in milder cases from the continued use of nitrate-bearing waters. Older persons seem able to tolerate larger amounts of nitrates, possibly because their intestinal flora may be different from that of very young infants, and may be able to destroy nitrates formed before they can seriously affect the blood.

The State Health Department is alert to this problem, and sanitary surveys, now underway, should soon result in marked improvement in water supplies throughout the state.



WATER SUPPLY STUDY AT CAVALIER, NORTH DAKOTA

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In the fall of 1947 the State Geologist was called to Cavalier to investigate the possibility of obtaining an underground water supply for the city. Upon arriving and completing the necessary preliminary data it was found that the water table is relatively near the surface in that area and that most of the water occurs in a sand blanket extending from the town of Cavalier westward for a distance of over seven miles. This sand body in the city of Cavalier itself is apparently covered by a blanket of clay. The whole sand body is underlain by glacial lake clay. The sand is apparently a phenomenon associated with glacial Lake Agassiz and probably is an off-shore bar or a spit of some kind associated with the Pembina delta to the west. Upon completion of the preliminary geologic work, ground water contour maps were prepared and test drilling was done. It was found that a fairly adequate supply for the city could be obtained in the vicinity of Akra, which is about six miles west of Cavalier. The sand there is the thickest and apparently contains the most water. As yet no pump tests have been done in it to determine the actual capacity to the aquifer, but it would appear that wells in this formation should yield from 50 to 150 gallons per minute.

NOTES ON A NORTH DAKOTA MUSKRAT COMMUNITY

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Methods for obtaining a reliable estimate of the population of residents among amphibious mammals are still in an early stage of development. In view of the widespread need of an empirical method of censusing the muskrat, and the plain fact that North Dakota's characteristic form, *Ondatra zibethicus cinnamominus*, has been neglected as an object of ecological investigation, a characteristic large marsh in southern Bottineau County was selected during the summer of 1947 as the locale for an intensive sampling of a stable and undisturbed community. This marsh had not been trapped for the three succeeding open seasons and was protected from interference by man and livestock at all times.

The well known small animal technique of live-trapping, marking and releasing for subsequent recapture was employed. Thirty National Live Muskrat Traps, baited with sliced carrots, and monel metal ear-tags were used. Each muskrat was tagged in both ears to insure a comparative permanency of marking. The traps were baited in the evenings and inspected before the sunshine became too hot the following morning, the traps being closed during the daytime, since muskrats are most active from twilight to dawn. Furthermore, marsh birds are likely to enter the traps during the daylight and thus interfere with the sampling. In disposing the traps on the study area, an effort was made to trap and mark every individual living in bank burrows on both sides of a low, narrow island within an area of .38 acre. This operation lasted from July 12 to August 25. Then the area was gradually expanded by moving the traps outward from the center of the locality, but rather than place them within a conventional square or circle area, considerable reliance was placed upon fresh signs of travel and feeding. Thus, the final area of sampling assumed an amorphous shape which enclosed 1.1 acre and was that portion of the marsh adjacent to the original bank burrows which was actually used by the muskrats for obtaining food and expressing their innate societal behavior. Trapping was concluded on September 10.

While there seems to be little question but that the sampling was of a large proportion of the resident individuals and that it was very intensively carried out over a significant period, determining the actual residents by other than statistical means would prove rather fruitless because of several unknowns that affect the deduction. Therefore, a simple principle for estimating a population of

animals in a natural habitat was tried which had been developed over a number of years by C. H. N. Jackson, with the help of Dr. R. A. Fisher and Mr. W. L. Stevens (Jackson, 1939). In brief, when "a random sample of individuals is marked and at some later time a random sample is caught and examined, either the initial marking or the later catching being done evenly over the area selected for study," then the population is equal to

$$\frac{\text{total marked and released} \times \text{total caught when recapturing}}{\text{recaptures}}$$

when subject to certain conditions as follows: environmental factors not exceedingly inconstant, the "proportion of marked to unmarked individuals will decrease in a fairly regular way with the passage of time after the marking date."

As the data were gathered by trapping every few nights, in order to satisfy the requirement of a marking interval followed by 6 subequal (or equal) recapture intervals, the data were consolidated by determining the cumulative trap-nights from July 28, the day after the arbitrarily selected marking interval. Thus the 6 subequal recapture intervals were No. 1—97 trap-nights, No. 2—116, No. 3—98, No. 4—94, No. 5—97, No. 6—109. This arrangement gave 26 muskrats marked and 6 dead from human interference by July 27, No. 1 interval with 23 total captures of which 16 were recaptured marked individuals; No. 2 gave 49 and 11; No. 3 gave 54 and 7; No. 4 gave 68 and 2; No. 5 gave 76 and 3; while No. 6 gave 96 and 3.

By substituting the numerical values for the several concepts embodied in Jackson's refinement of the above empirical formula, a resident population estimate was determined as 3.66 percent, a very significant estimate on the basis of Mr. Stevens' mathematical determinations when "K" = 6 (recapture intervals). However, the natural ratio, during the marking interval, of actual population density to the number marked and released was disturbed by the trapping mortality of 6, so therefore it seems reasonable to assume that the number marked, $26:26 + 6 = 19$ (the estimate) : X, when "X" = the estimate corrected for the mortality. This gives an adjusted estimate of 23.38 resident muskrats per acre.

Reference

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PRELIMINARY STUDY
USE OF THE GOLDEN HAMSTER IN THE
LABORATORY DIAGNOSIS OF TUBERCULOSIS

by

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The shortage of guinea pigs for use in diagnostic laboratories during the war lead the Division of Laboratories to search for a substitute experimental animal. At the time our attention was drawn to the many articles about the golden hamster which appeared in popular magazines. Since they were apparently highly recommended for use in the diagnosis of tuberculosis, it was decided to run a series of comparative tests. The original purpose of our study was to determine the feasibility of using the hamster, with the thought in mind that it might replace the guinea pig and give us quicker results. This will mean an extensive comparative study over a long period of time, using routine specimens submitted to the Laboratories, one-half of such specimens being inoculated into a hamster and the remaining portion into a guinea pig. However, at first it was decided to test the hamster with a known positive specimen containing virulent tubercle bacilli.

Several control studies were initiated using known positive sputum specimens in various concentrations. These specimens were inoculated subcutaneously in the inguinal region and were checked at weekly intervals, beginning two weeks after the initial injection. A total of eighty hamsters and twenty guinea pigs (as controls) were used in the first two studies.

The second phase of the study included a comparison of routine specimens received in the laboratory for diagnosis; one portion of each specimen was inoculated into a hamster and the remainder into a guinea pig. To date only fifty-eight of these cases have been studied, with seven pigs positive and two hamsters positive. This phase of the problem has to be continued for another six months before definite information can be obtained.

An interesting observation has been that in no instance did we find a hamster with a generalized infection. All positive animals at autopsy have shown a characteristic lesion at the site of inoculation. Also we have noted a progressive "drying up" of these nodes beginning about the fourth week after inoculation. Because of this a third control study has been initiated with no results to date.

In the transformation of the aortic arches into the anomaly the change takes place in the IVth arch on the right side. Instead of becoming detached distally, the proximal part becomes separated leaving the distal segment still attached to the main stem of the permanent aortic arch. This distal segment is to become the anomalous right subclavian.

Due to the abnormal position of the Right Subclavian artery there is a displacement of the Right Recurrent branch of the Vagus nerve. Normally the Vagus nerve on the left side gives off a Recurrent branch which passes down behind the aortic arch, and on the right side the Recurrent branch descends behind the Right Subclavian. The reason for this is that during the descent of the heart and great vessels, the Recurrent nerves were dragged down. In the anomaly, however, the Right Recurrent nerve is not dragged down but, like the Superior Laryngeal nerve, descends behind the carotid arteries to the larynx.

The anomaly that we have just shown you is only one of several variations to which the aortic arch is subjected. The more common variations are:

- (1) The left vertebral arising from the arch between the left carotoid and subclavian arteries.
- (2) A Thyroidea ima branch which ascends in front of the trachea to supply the thyroid gland.

Our anomaly is mentioned as being a rare occurrence in several Anatomy texts. Grant, Professor of Anatomy in the University of Toronto, lists it as being present in about 1% of the cases. It is the third anomaly of this type that our professor, Dr. H. E. French, has seen in some 600 or more bodies at North Dakota and other Medical Schools.

Bibliography

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