non-ionized quinone-phenolate salt, — $C(:C_6H_4:O)(C_6H_4OK)$, may also be intensely colored, but its concentration is small in dilute solutions.

6. The intense and very sharp color changes in the sulfonphthalein series are far more satisfactory than in the phenolphthalein series because the monobasic salts of the sulfonphthaleins are changed practically quantitatively into the deeply colored quinone-phenolate ion, whereas phenolphthalein gives only about 50% of such deeply colored dibasic ion, the other 50% going over into the colorless lactoidal dibasic ion. The tetrachloro-, tetrabromo-, and tetraiodo-phenolphthalein give only about 1% of the colored, dibasic quinone-phenolate ion, the remainder forming colorless dibasic salts. These facts make the phenolsulfonphthalein series of indicators the best yet discovered. The derivatives described by us, and by Lubs and Clark and one of us, have a wide range of useful *P*H values, show very little of the fading characteristic of the phenolphthaleins and their colors are not greatly disturbed by the "salt effects" which we are studying by the spectrophotometric methods.

MADISON, WISCONSIN.

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[CONTRIBUTION FROM THE PURDUE EXPERIMENT STATION.]

# SOFT CORN—ITS CHEMICAL COMPOSITION AND NITROGEN DISTRIBUTION.

BY GEORGE SPITZER, R. H. CARR AND W. F. EPPLE.

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## Introduction.

The large amount of corn (maize) produced in this country makes one of our greatest and most valuable sources of food, and hence the success or failure of the crop in any year is a matter of great economic importance. The failure of considerable of the corn to mature properly during 1918 led to much speculation as to the feeding value of soft corn, or to state it another way, the question "What is soft corn?" was often asked. One publication[1] has answered the question in part by stating that very soft corn contains 65% of water (rare) and ranges down to 25%, which is low enough to allow the corn to be stored in cribs. whereas old corn usually contains about 12% of moisture. It might be inferred from this that soft corn differs from mature (corn) only in the amount of moisture it contains, but the present writers have found characteristic differences in the carbohydrates, proteins and mineral constituents. The idea is prevalent in some localities that soft corn is worthless for feeding purposes, whereas others have succeeded in feeding the wet and therefore often moldy corn to cattle and hogs with profitable returns, no cases of poisoning from the mold having been reported to our knowledge. Thus, evidently, soft corn has a feeding value that, although not to be considered equal to that

[1] Iowa Expt. Sta., *Circ.* 40 (1917).

of the mature corn, is far too great to be ignored. One phase of the corn problem has centered about the drying out of this excess moisture which causes the corn to spoil before it can be used. The other side of the soft corn question has to do with its nature after the excess water has been removed. It is on this part of the problem that the authors have tried to throw light.

In order to get a better understanding of the composition of mature corn, and especially its nutritive deficiencies which have been extensively studied, it may be well to recall briefly the main points of this deficiency noted in the literature.[1] These are,—a low per cent. of ash which contains a high proportion of magnesia and a low calcium content; a comparatively large amount of potassium and phosphorus; less protein than contained in most other grains, and this is largely made up of certain distinct and characteristic proteins, such as zein, globulin and glutelin. The first named is said to be the most abundant protein, but there are lacking 3 amino acids in its formula, two of which (lysine and tryptophane) seem essential to the growth and development of a young animal. The other two, globulin and glutelin, are said to be complete proteins and to yield on hydrolysis all the essential amino acids, Hence they are capable of producing growth, but it is noteworthy that they are not present in sufficient amount in the corn grain to support growth.[2]

## Procedure.

In response to numerous inquiries as to what is soft corn, the authors have attempted to get some insight into the composition and the nature of its proteins. In order to carry out the investigation, corn was chosen whose previous history was known. In the samples of Series I the corn was chosen because of its extreme softness and failure to germinate, and because the original moisture was known. Another series, II, was obtained from the Botany Department of Purdue University and represents more matured corn capable of germinating, on which certain studies in plant pathology are being conducted. A third series, III, represents an intermediate grade on which only amide nitrogen and acidity determinations were made. All 3 series were based on shelled corn taken from individual ears. It was the purpose of the writers to compare also the nitrogen distribution of these series of corn with that of mature corn,[3] and if possible to secure data on which qualitative classification can be made as to maturity.

## Experimental.

The grain was ground so that the starch, etc., would pass an 80-mesh sieve while the bran layers passed a 40-mesh seive. The method of mak-

[1] *J. Biol. Chem.*, **18**, No. 1 (1914).

[2] Ohio Expt. Sta., *Bull.* **255**, Jan., 1913.

[3] THIS JOURNAL, **37**, 1778 and 2762 (1915).

ing the analysis was as follows: 3 g. of the air-dry ground corn was placed in an alundun shell No. R. A. 98. It was dried for 5 hours at 100° and then weighed for moisture. The shell was next placed in a Soxhlet tube and the fat extracted and weighed. The shell and contents when free from ether were extracted with hot 95% alcohol. This extraction continued for 5 hours. The residue from the alcohol extraction was dried and weighed and the nitrogen determined by the Kjeldahl method (zein). After the alcohol extraction the sample was treated with cold water for 24 hours, a stirring machine being used part of the time to extract more thoroughly all of the soluble starch and dextrin. The sample was next boiled to get the starch in solution and a solution of diastase of malt added to convert the starch to sugar—a correction being made for the starch in the malt. The starch was determined as follows: An aliquot of the invert sugar solution was boiled with an excess of Fehling's solution and after cooling, filtered through an asbestos filter; washed with distilled water and the filtrate titrated with standard sodium thiosulfate solution according to modification of Low's method. The weight of dextrose multiplied by 0.90 gives the weight of starch, from which the per cent. was calculated.

After removing all of the starch which was water soluble and converted by diastase, the samples still in the filter shells were next refluxed for 30 minutes with 1.25% sulfuric acid, washed and then boiled for the same length of time with 1.25% sodium hydroxide solution. Washing and filtering by this means was simpler than by the official method. This method also prevents a possible loss in filtering. The fiber was then dried and weighed, burned and the shell[1] weighed again. The ash determinaion was made on the original sample.

A new sample was taken on which the degree of acidity was determined.[2]

Another 5 g. sample of each corn was hydrolyzed for 16 hours with 20% hydrochloric acid and treated according to the Van Slyke method for the determination of acid-insoluble melanin, lime melanin, ammonia nitrogen, monoamino acids, and diamino acids.

The results of the analysis of Series I are given in Table I.

The data for the more mature corn (Series II) are given in Table II.

## Amide Determination.

Mature corn has usually been considered nearly free from amides, but this could hardly be expected to be true of soft corn. The method used in making the determinations was a modification of the Stutzer process as developed by Blish.[3]

One part of finely ground corn and 20 parts of water were shaken frequently for 12 hours. Fifty cc. of the filtered solution was then taken and 25 cc. of 0.1 *N* sodium

[1] The shells mentioned are very porous and filtration takes place rapidly.

[2] Dept. Agr., Bur. Plant Ind., *Bull.* 102, Jan., 1913.

[3] *J. Biol. Chem.*, 33, 55 (1918).

TABLE I.
Composition and Nitrogen Distribution of Corn. Series I.

| Yellow dent variety. Sample No. | Total nitrogen. %. | Insoluble melanin. %. | Lime melanin. %. | Ammonia nitrogen. %. | Monamino acids. | Diamino acids. | Protein. % N × 6.25. | Moisture. | Fat. | Water sol. starch. Dextrin. %. | Normal starch *via* diastase. | Total starch *via* acid hydrol. | Pentosans, etc., by difference. | Crude fibre. %. | Ash. %. | Acidity. Degrees. | Water loss from ear. %. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1.74 | 0.099 | 0.059 | 0.188 | 0.997 | 0.199 | 10.97 | 8.81 | 2.27 | 2.03 | 38.07 | ... | 31.40 | 4.35 | 2.10 | 64.8 | 62.50 |
| 3 | 1.59 | 0.090 | 0.061 | 0.185 | 1.10 | 0.179 | 9.93 | 9.22 | 1.96 | 2.64 | 38.09 | ... | 32.49 | 4.29 | 1.90 | 54.4 | 58.33 |
| 4 | 1.55 | 0.092 | 0.051 | 0.179 | 1.03 | 0.210 | 9.62 | 8.95 | 1.44 | 1.70 | 46.62 | ... | 24.17 | 5.43 | 2.07 | 61.2 | 56.25 |
| 5 | 1.94 | 0.101 | 0.048 | 0.274 | 1.36 | 0.145 | 12.13 | 9.03 | 1.83 | 2.03 | 37.09 | ... | 32.37 | 3.45 | 2.20 | 41.6 | 53.33 |
| 6 | 1.45 | 0.087 | 0.078 | 0.213 | 0.99 | 0.104 | 9.06 | 8.09 | 2.00 | 2.22 | 49.05 | ... | 22.13 | 5.25 | 1.89 | 58.8 | 52.85 |
| 7 | 1.63 | 0.117 | 0.068 | 0.241 | 1.09 | 0.135 | 10.19 | 8.90 | 2.02 | 2.04 | 47.34 | ... | 21.32 | 6.20 | 2.14 | 44.0 | 52.38 |
| 8 | 1.75 | 0.101 | 0.089 | 0.230 | 1.05 | 0.157 | 11.00 | 8.46 | 3.49 | 1.04 | 42.71 | ... | 27.03 | 4.13 | 1.68 | 48.8 | 50.00 |
| 9 | 1.33 | 0.082 | 0.089 | 0.170 | 0.963 | 0.090 | 8.31 | 8.23 | 2.53 | 3.88 | 39.04 | ... | 30.75 | 5.58 | 2.19 | 54.4 | 44.40 |
| 11 | 1.65 | 0.070 | 0.089 | 0.260 | 1.04 | 0.202 | 10.33 | 8.02 | 3.33 | 1.62 | 41.73 | ... | 26.30 | 6.48 | 1.65 | 36.0 | 42.85 |
| 12 | 1.41 | 0.080 | 0.089 | 0.179 | 0.903 | 0.208 | 8.79 | 7.53 | 3.20 | 3.84 | 43.45 | ... | 26.68 | 4.86 | 1.90 | 53.2 | 42.80 |
| 13 | 1.37 | 0.078 | 0.087 | 0.176 | 0.908 | 0.179 | 8.53 | 7.40 | 2.38 | 4.16 | 49.30 | ... | 21.12 | 5.21 | 1.92 | 33.2 | 42.80 |
| 14 | 1.32 | 0.070 | 0.068 | 0.200 | 0.870 | 0.204 | 8.27 | 7.33 | 3.20 | 3.44 | 42.46 | ... | 28.72 | 4.66 | 2.11 | 66.4 | 41.66 |
| 15 | 1.54 | 0.063 | 0.068 | 0.260 | 0.963 | 0.179 | 0.963 | 8.93 | 2.22 | 2.42 | 50.52 | ... | 20.26 | 3.91 | 2.22 | 60.8 | 40.92 |
| 16 | 1.52 | 0.079 | 0.078 | 0.207 | 0.986 | 0.213 | 0.950 | 8.93 | 2.42 | 2.28 | 39.04 | ... | 29.99 | 5.62 | 2.01 | 47.2 | 37.50 |
| 17 | 1.42 | 0.087 | 0.089 | 0.193 | 0.903 | 0.190 | 8.88 | 8.72 | 2.25 | 2.55 | 46.37 | ... | 24.38 | 4.84 | 1.90 | 49.6 | 37.50 |
| 18 | 1.39 | 0.070 | 0.078 | 0.179 | 0.990 | 0.190 | 8.71 | 8.88 | 2.49 | 3.10 | ... | ... | ... | 3.58 | 1.81 | 41.6 | 36.66 |
| 19 | 1.22 | 0.068 | 0.066 | 0.213 | 0.740 | 0.175 | 7.61 | 8.49 | 2.26 | 3.89 | 44.90 | ... | 26.08 | 4.56 | 1.59 | .. | 33.31 |
| 20 | 1.23 | 0.067 | 0.056 | 0.179 | 0.790 | 0.177 | 7.66 | 8.41 | 2.16 | 3.57 | 52.22 | ... | 20.22 | 4.17 | 2.06 | 43.2 | ... |
| 21 | 1.96 | ... | ... | ... | ... | ... | 12.25 | 8.28 | 2.74 | 3.62 | 43.20 | ... | 22.28 | 5.56 | 1.74 | 70.0 | ... |
| *a* | 1.69 | ... | ... | ... | ... | ... | 10.54 | 7.26 | 4.70 | 0.72 | 50.80 | ... | 15.24 | 2.59 | 1.65 | .. | ... |
| *b* | 1.51 | ... | ... | ... | ... | ... | 9.45 | 7.66 | 3.96 | 1.21 | 50.24 | ... | 23.11 | 2.72 | 2.36 | .. | ... |
| *c* | 1.92 | ... | ... | ... | ... | ... | 11.99 | 7.09 | 3.12 | 0.45 | 49.96 | ... | 20.64 | 4.39 | 2.40 | .. | ... |
| *d* | 2.07 | ... | ... | ... | ... | ... | 13.68 | 11.00 | 2.30 | 0.82 | 46.31 | ... | 18.35 | 5.08 | 2.32 | .. | ... |
| *e* | 1.44 | ... | ... | ... | ... | ... | 8.96 | 10.56 | 1.62 | 1.10 | 48.08 | ... | 26.96 | 2.72 | 2.33 | .. | ... |
| 149 | 1.48 | 0.090 | 0.038 | 0.220 | 0.95 | 0.161 | 9.27 | 5.37 | 3.56 | 4.12 | 51.50 | 76.28 | ... | 3.23 | 1.33 | .. | ... |
| 148 | 1.47 | 0.089 | 0.042 | 0.229 | 0.994 | 0.188 | 9.19 | 5.47 | 3.66 | 3.62 | 50.52 | 75.42 | ... | 2.77 | 1.58 | .. | ... |
| 141 | 2.02 | 0.116 | 0.046 | 0.294 | 1.33 | 0.245 | 13.50 | 0.274 | 3.14 | 1.08 | 51.45 | 76.28 | ... | 2.73 | 1.87 | .. | ... |
| Average | 1.58 | 0.085 | 0.068 | 0.212 | 0.998 | 0.178 | 9.92 | 8.06 | 2.67 | 2.40 | 45.77 | ... | 24.87 | 4.38 | 1.95 | 100.02 (Total) | ... |
| In per cent. of total nitrogen | | 9.68 (insoluble and lime melanin together) | | 13.41 | 63.16 | 11.26 | | | | | | | | | | | |

## TABLE II.

Composition and Nitrogen Distribution of Corn of Series II.

| Variety of corn. | Sample No. | Total nitrogen. %. | Insoluble melanin. %. | Lime melanin. %. | Ammonia N. | Monoamino acids. | Diamino acids. | Protein. N × 6.25. | Moisture. %. | Fat. | Water soluble starch. Dextrins. %. | Normal starch via "diastase." | Total starch via acid hydrol. | Pentosans, etc., by difference. | Crude fibre. %. | Ash. %. | Calorific value. Cal./Gm. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 day corn. | 8.03 | 1.35 | 0.077 | 0.049 | 0.196 | 0.943 | 0.095 | 8.44 | 7.80 | 3.65 | 3.20 | 50.11 | ... | 22.99 | 2.53 | 1.46 | ... |
| | 7.97 | 1.62 | 0.082 | 0.053 | 0.234 | 1.107 | 0.157 | 10.13 | 6.37 | 3.92 | 1.67 | ... | 74.03 | ... | 1.82 | 1.55 | ... |
| | 5.05 | 1.89 | 0.095 | 0.042 | 0.266 | 1.28 | 0.207 | 11.81 | 6.53 | 4.84 | .. | 45.97 | 74.03 | 26.95 | 2.47 | 1.43 | 42.67 |
| | 1.51 | 1.98 | 0.107 | 0.053 | 0.267 | 1.22 | 0.242 | 11.76 | 6.96 | 2.27 | 4.69 | 50.64 | ... | 19.70 | 2.37 | 1.66 | .. |
| Leaming. | 8.34 | 1.92 | 0.110 | 0.046 | .284 | 1.23 | 0.225 | 11.99 | 8.03 | 4.30 | 3.35 | 50.50 | .. | 18.17 | 2.36 | 1.30 | ... |
| | 7.05 | 1.82 | 0.098 | 0.053 | 0.252 | 1.23 | 0.213 | 11.37 | 5.75 | 4.55 | 1.08 | 46.35 | 74.13 | 26.36 | 2.70 | 1.84 | 42.04 |
| | 6.83 | 1.76 | 0.082 | 0.053 | 0.250 | 1.24 | 0.180 | 11.03 | 4.75 | 4.68 | 4.39 | ... | 76.28 | ... | 2.63 | 1.42 | .. |
| Yellow dent. | 8.35 | 1.91 | 0.089 | 0.042 | 0.255 | 1.30 | 0.223 | 11.90 | 3.87 | 5.54 | 1.66 | 50.63 | 75.42 | 22.44 | 2.53 | 1.43 | 4354 |
| | 8.19 | 1.64 | 0.084 | 0.042 | 0.220 | 1.17 | 0.158 | 10.24 | 6.96 | 5.08 | 1.74 | 49.45 | 75.42 | 21.65 | 2.17 | 2.71 | 4243 |
| | 8.10 | 1.58 | 0.107 | 0.046 | 0.217 | 1.20 | 0.154 | 9.29 | 6.77 | 4.64 | 1.42 | 46.35 | 73.71 | 27.07 | 2.36 | 1.60 | ... |
| | 8.12 | 1.64 | 0.086 | 0.042 | 0.238 | 1.154 | 0.157 | 10.25 | 6.41 | 3.49 | 1.17 | ... | 77.71 | ... | 2.05 | 1.40 | ... |
| | 1.55 | 1.74 | 0.084 | 0.046 | 0.249 | 1.24 | 0.179 | 10.89 | 5.35 | 5.27 | 2.01 | ... | 75.85 | ... | 1.58 | 1.61 | ... |
| | 6.96 | 1.65 | 0.086 | 0.038 | 0.230 | 1.14 | 0.158 | 10.28 | 7.32 | 3.82 | 1.17 | ... | 79.20 | ... | 1.83 | 1.23 | ... |
| | 7.04 | 1.95 | 0.088 | 0.056 | 0.294 | 1.35 | 0.202 | 12.16 | 4.79 | 5.15 | 4.12 | ... | 73.71 | ... | 2.86 | 1.89 | ... |
| Johnson Co. White | 2.45 | 1.87 | 0.084 | 0.038 | 0.266 | 1.298 | 0.187 | 11.68 | 3.75 | 3.83 | 1.16 | 42.80 | 71.40 | 29.92 | 2.23 | 1.30 | ... |
| | 3.44 | 1.40 | 0.082 | 0.042 | 0.210 | 1.002 | 0.102 | 8.75 | 7.55 | 5.10 | 1.74 | 46.94 | 75.32 | 26.34 | 2.25 | 1.33 | ... |
| | 2.51 | 1.67 | 0.083 | 0.042 | 0.241 | 1.20 | 0.140 | 10.41 | 7.41 | 4.70 | 1.33 | 46.35 | 76.28 | 25.80 | 2.80 | 1.33 | ... |
| | 2.26 | 1.36 | 0.101 | 0.042 | 0.199 | 0.931 | 0.098 | 8.49 | 5.50 | 4.30 | 1.08 | 45.78 | 75.22 | 30.15 | 2.90 | 1.61 | ... |
| Average. | | 1.702 | 0.090 | 0.046 | 0.242 | 1.18 | 0.171 | 10.60 | 6.21 | 4.28 | 2.17 | 47.65 | 75.18 | 24.80 | 2.36 | 1.56— | 99.63 (Total) |
| In per cent. of the total nitrogen..... | | | 8.0 | | 14.23 | 69.41 | 10.58 | | | | | | | | | | |

hydroxide solution was added followed by 27 cc. of 0.1 $N$ cupric sulfate solution. The precipitate was later filtered off and the nitrogen determined in the filtrate by the Kjeldahl method.

In some of the samples the precipitate was also analyzed, but the amount of nitrogen contained was so constant that it was not considered worth while to continue that work.

## Protein Separation.

There seems to be some uncertainty in the literature concerning the amount of the individual proteins making up whole corn. No data on a considerable number of ears of corn have come to the writer's attention. In view of this it was thought best to make a study of the amount of corn protein soluble in some of the various solvents. A 10% solution of sodium chloride was used to extract the globulins, albumens and proteoses. They were allowed to stand 72 hours and frequently shaken.

TABLE III.
PROTEIN DISTRIBUTION, SERIES I.
YELLOW DENT VARIETY.

| Sample No. | Total N. %. | Zein as % of total protein. | Globulins, etc., as % of total protein. | Amide as % of total N. | Prot. sol. in 10% NaCl. % of total protein. | Glutelin as % of total protein. |
|---|---|---|---|---|---|---|
| 2 | 1.74 | 20.00 | 22.64 | 17.70 | 40.34 | 39.66 |
| 3 | 1.59 | 14.68 | ... | ... | 33.85 | 51.47 |
| 4 | 1.55 | 15.00 | 26.47 | 17.29 | 43.76 | 41.24 |
| 5 | 1.94 | 26.68 | 17.54 | 9.00 | 26.54 | 52.78 |
| 6 | 1.45 | 17.37 | 24.29 | 20.08 | 44.37 | 38.26 |
| 7 | 1.63 | 26.32 | 16.56 | 17.17 | 33.73 | 39.95 |
| 8 | 1.75 | 20.91 | ... | ... | 38.56 | 41.53 |
| 9 | 1.33 | 26.88 | 23.64 | 16.82 | 40.46 | 32.66 |
| 11 | 1.65 | 26.00 | 21.99 | 7.96 | 29.95 | 44.05 |
| 12 | 1.41 | 16.15 | 31.47 | 16.48 | 48.95 | 35.90 |
| 13 | 1.37 | 18.39 | 27.35 | 15.50 | 42.85 | 38.76 |
| 14 | 1.32 | 27.27 | 25.63 | 17.80 | 43.43 | 29.30 |
| 15 | 1.54 | 21.51 | ... | ... | 34.94 | 43.55 |
| 16 | 1.52 | 17.17 | ... | ... | 36.94 | 44.89 |
| 17 | 1.42 | 19.36 | 28.62 | 13.40 | 42.02 | 38.62 |
| 18 | 1.39 | 22.80 | ... | ... | ... | ... |
| 19 | 1.22 | 20.00 | ... | ... | 49.89 | 30.11 |
| 20 | 1.23 | 16.76 | 26.54 | 15.55 | 42.09 | 41.15 |
| 21 | 1.96 | 20.71 | ... | ... | 39.39 | 39.90 |
| (a) | 1.69 | 24.05 | 11.68 | 19.47 | 31.15 | 44.80 |
| (b) | 1.51 | 22.80 | 20.98 | 11.56 | 32.54 | 44.66 |
| (c) | 1.92 | 23.33 | 17.56 | 9.25 | 26.81 | 49.86 |
| (d) | 2.07 | 30.24 | ... | ... | 27.13 | 42.63 |
| (e) | 1.44 | 24.00 | ... | ... | 27.62 | 48.38 |
| 149 | 1.48 | 21.11 | 28.12 | 21.28 | 49.40 | 29.49 |
| 148 | 1.47 | 28.57 | 29.80 | 16.72 | 46.52 | 24.91 |
| 141 | 2.02 | 29.81 | 13.93 | 8.35 | 22.28 | 47.91 |
| Av. | 1.58 | 22.14 | 23.04 | 15.08 | 37.52 | 40.63 |

TABLE IV.
Protein Distribution, Series II.

| Variety of corn. | Sample No. | Total N. %. | Zein as % of total protein. | Globulins, etc., as % of total protein. | Amide as % of total N. | Prot. sol. in 10% NaCl. % of total protein. | Glutelin as % of total protein. |
|---|---|---|---|---|---|---|---|
| 90-Day corn | 803 | 1.35 | 23.48 | ... | .. | ... | 34.58 |
| | 797 | 1.62 | 34.87 | 25.77 | 4.83 | 30.60 | 34.53 |
| | 505 | 1.89 | 25.66 | ... | .. | 27.20 | 47.14 |
| | 151 | 1.88 | 22.08 | ... | .. | 30.82 | 47.10 |
| Leaming | 834 | 1.92 | 38.65 | 16.74 | 4.06 | 20.80 | 40.55 |
| | 705 | 1.82 | 35.66 | ... | .. | 28.17 | 36.17 |
| | 683 | 1.76 | 23.07 | 22.50 | 5.70 | 28.20 | 48.73 |
| Yellow dent | 835 | 1.91 | 36.15 | 24.80 | 3.84 | 28.64 | 35.21 |
| | 819 | 1.64 | 38.66 | 21.52 | 5.43 | 26.95 | 34.39 |
| | 810 | 1.58 | 29.49 | 21.52 | 6.40 | 27.92 | 42.59 |
| | 812 | 1.64 | 27.86 | ... | .. | 25.95 | 46.97 |
| | 155 | 1.74 | 32.18 | ... | .. | ... | ... |
| | 696 | 1.65 | 22.91 | ... | .. | 30.05 | 47.04 |
| | 704 | 1.95 | 27.28 | 18.30 | 6.95 | 25.25 | 47.47 |
| Johnson Co. white | 245 | 1.87 | 23.42 | ... | .. | 26.55 | 50.03 |
| | 344 | 1.40 | 27.00 | 21.33 | 5.55 | 26.88 | 46.12 |
| | 251 | 1.67 | 36.64 | 22.03 | 4.67 | 26.70 | 36.66 |
| | 226 | 1.36 | 24.36 | ... | .. | 29.20 | 46.44 |
| Av. | | 1.702 | 29.41 | 21.61 | 5.27 | 27.49 | 42.45 |

TABLE V.
Amide Nitrogen and Acidity Content, Series III.

| Sample No. | Total N. %. | Amide N as % of total N. | Degree of acidity. |
|---|---|---|---|
| 41 | 1.52 | 8.80 | 30.4 |
| 42 | 1.46 | 9.58 | 23.2 |
| 43 | 1.79 | 11.70 | 37.2 |
| 44 | 1.65 | 8.12 | 22.8 |
| 45 | 1.33 | 5.88 | .. |
| 46 | 1.61 | 7.64 | 22.8 |
| 47 | 1.69 | 8.71 | 37.1 |
| 48 | 1.29 | 10.40 | 22.4 |
| 49 | 1.76 | 8.54 | 41.8 |
| 50 | 1.34 | 8.58 | 19.6 |
| 51 | 1.59 | 9.17 | 35.6 |
| 52 | 2.05 | 5.17 | 35.6 |
| 53 | 1.51 | 6.66 | 34.8 |
| 54 | 1.54 | 9.09 | 32.8 |
| 55 | 1.25 | 9.02 | 30.4 |
| 56 | 1.56 | 8.27 | 15.2 |
| 57 | 1.68 | 15.60 | 36.0 |
| 58 | 1.73 | 6.12 | 27.2 |
| 59 | 1.58 | 8.17 | 30.4 |
| 60 | 1.53 | 6.20 | 31.6 |
| Average | 1.57 | 8.57 | |

TABLE VI.

Summary of Tables.

| | Normal corn. | Series I. | Series II. | Series III. |
|---|---|---|---|---|
| Protein: % N × 6.25 | 10.1 | 9.92 | 10.60 | 9.81 |
| Per cent. of total melanins | 9.78 | 9.68 | 8.00 | .. |
| Ammonia N, % of total N | 12.53 | 13.41 | 14.23 | .. |
| Monoamino acids, % of total | 63.43 | 63.16 | 69.41 | .. |
| Diamino acids, % of total | 15.86 | 11.26 | 10.58 | .. |
| Zein, % of total | 41.00 | 22.14 | 29.41 | .. |
| Globulins, etc., % of total | 22.00 | 23.04 | 21.61 | .. |
| Amide nitrogen, % of total | ... | 15.08 | 5.27 | 8.57 |
| Glutelins, % of total | 31.00 | 40.63 | 42.54 | .. |
| Moisture, % | 10.50 | 8.06 | 6.21 | .. |
| Fat | 5.00 | 2.67 | 4.28 | .. |
| Water-soluble starch and dextrine | 3.38 | 2.40 | 2.17 | .. |
| Normal starch by diastase | 42.50 | 45.77 | 47.65 | .. |
| Total starch by acid hydrolysis | 71.95 | .. | 75.18 | .. |
| Pentosans, etc., by diff | 24.87 | 24.80 | .. | .. |
| Crude fiber, % | 2.00 | 4.38 | 2.36 | .. |
| Ash, % | 1.50 | 1.95 | 1.56 | .. |

The amides were also extracted by this solvent but were deducted in calculating the globulin, etc. Determinations were made of the per cent. of the total protein soluble in 0.05 *N* sodium hydroxide solution after standing at room temperature for 72 hours with frequent shaking, and also after heating for one hour in an autoclave at 115 pounds, pressure, to rupture the cells. It was found that about 8% failed to go into solution previous to heating. The salt solution was heated under pressure in the same way but no increase in soluble nitrogen could be detected. The portion of the protein soluble in alcohol (zein) was determined as previously described. This protein was found present in smaller amount than has been reported by others, and much less was found to be present in the soft corn than in the more matured of Series II. The results of this work are recorded in Table III for Series I and Table IV for Series II.

## Discussion.

It will be noted from the tables that there is a wide range of corn classed as soft corn and that the composition varies considerably among both mature and immature ears. Much of the soft corn of 1917 had been planted 130 days or more and so had had time to mature, but did not advance because of the lack of warm weather during the summer. The composition of the corn is therefore somewhat different from that taken for analysis in the milk, glaze, dented and maturity stages as previously reported from this station.[1]

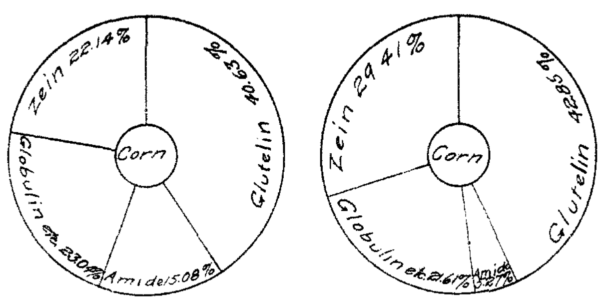
Referring to the summary, Table VI, Series I which represents the most immature corn, shows that the nitrogen content is not greatly af-

[1] Purdue Expt. Sta., *Bull.* 175 (1914).

fected by degree of maturity, as it differs less than 0.2% from that of normal corn. A considerable part of the nitrogen in soft corn is present as amide, however, and evidently has been formed almost entirely at the expense of the zein. There are few data available on the amount of zein in widely selected samples, while that reported is on corn very high in nitrogen (2.33%) and hence may not represent the normal distribution of proteins. Zein is of much interest from a feeding standpoint, because it is an incomplete protein and its presence makes a corn less desirable from a nutritional standpoint. From the analysis of all the samples it would seem that glutelin is the most abundant protein in corn, with zein next and globulin last. The amide or non-protein nitrogen content, and the acidity in soft, moldy corn are quite high, as might be expected, and from data presented on the 3 series it would appear the amide nitrogen can be taken as a basis on which maturity may be determined averaging 5.27 to 8.57 to 15.08 for Series II, I, III, respectively. These figures actually approximate the correct grading of the three lots as to maturity.

Considering now the other deficiencies in soft corn as shown in Table VI the low fat content of Series I is the most noticeable feature for it is only about half that of normal corn. It was believed that the amount of true starch as determined by the diastase method would show a considerable deficiency in Series I but this did not prove to be the case. As

Series I. Series II.




Soft Corn. Mature corn.

Protein Distribution.

expected the amount of crude fiber was found to be large and the ash content high. Some combustion determinations were also made and it was found that the difference between the best and the poorest samples was less than 200 calories. Hence, no further work was done in determining the calorific value of the different grades of corn.

## Summary.

1. The percentages of normal starch and nitrogen-free extract appear to be higher in soft than in mature corn.

2. The formation of protein and carbohydrates apparently go on un-

interruptedly during the growth of corn, while the fat seems to be formed last.

3. The calorific determination is of little service in determining the value of corn for feeding purposes.

4. The acid-hydrolyzed proteins do not reveal any unusual features. The diamines are lower than results reported by others, whereas the monoamines of nearly matured corn are higher, but this is not significant in the present research.

5. The total nitrogen of soft corn is only slightly lower than that of mature corn, but the amide nitrogen is much higher.

6. The amide nitrogen, together with the degree of acidity, may serve as a basis for grading corn. Moldy corn contains a large amount of nitrogen in the amide form.

7. Glutelin is the most abundant protein in corn, zein is next, and globulins, albumens, etc., are present in smallest amount.

8. Since zein appears to be present in smaller amount in soft than in mature corn, and since glutelin, globulins, albumens, etc., are present to about the same per cent. in both mature and soft corn, it would seem that zein is formed last, and amide is formed at the expense of zein.

LAFAYETTE, INDIANA.

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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE COTTON COLLEGE, GAUHATI.]

## DIKETOHYDRINDENE. III.[1]

BY ANANDA KISORE DAS AND BROJENDRA NATH GHOSH.

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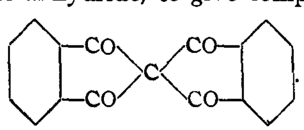
It has been shown by one of us with Sastry[2] that the methylene hydrogen atoms in 1,3-diketohydrindene are very reactive, since they condense readily with aromatic aldehydes giving benzylidene derivatives. This led us to think that diketohydrindene could readily condense with anhydrides, such as phthalic anhydride, to give compounds of the type




(I)

Preliminary experiments were therefore conducted, and it was found that the compound obtained was different from the ones noted in the literature. Thus it was noted that Carmelo Marchese[3] had condensed phthalic anhydride and diketohydrindene in the presence of acetic anhydride, and

[1] For Parts I and II see *Trans. Chem. Soc.*, **107**, 1442 (1915) and **109**, 175 (1916).

[2] *Trans. Chem. Soc.*, **107**, 1442 (1915).

[3] *Gazz. chim. ital.*, **37**, 303–309 (1907).