A COMPARATIVE STUDY OF THE COMPOSITION OF THE
SUNFLOWER AND CORN PLANTS AT DIFFERENT
STAGES OF GROWTH

By R. H. Shaw, Chemist, and P. A. Wright, Assistant Chemist, Dairy Division,
Bureau of Animal Industry, United States Department of Agriculture

INTRODUCTION

The sunflower plant is gaining recognition as a silage crop in certain
of the northwestern States where climatic or soil conditions are not
always favorable for the maturing of corn for silage purposes. In some
sections also there is a growing sentiment that sunflower silage offers a
more profitable feed than corn silage, because of the greater yield that
may be obtained per acre.

The Dairy Division is making an investigation of sunflower silage.
This paper, which is the first of a series, presents the results of a study of
the chemical composition of the sunflower plant at several different and
distinct stages of its growth as compared with that of corn grown under
similar conditions. The purpose of the study is to assist in selecting the
proper stage of maturity for ensiling.

The investigation of the corn plant was made partly as a basis on which
to study the sunflower plant and partly in connection with another in-
vestigation, the results of which will be published in a paper having to do
with the fermentation of corn in the silo.

HISTORICAL REVIEW

Numerous analyses of the sunflower plant have been published from
time to time. In some cases these have represented the whole plant,
but more often only the head or the seed. No record of any study of
the composition of the plant at different stages of growth has been found.
On the other hand, there have been several such studies, more or less
complete, made of the corn plant. Some of these will be briefly reviewed.

Roberts (5) selected periods of growth (1) when the plants were coming
into bloom, (2) when approaching roasting-ear condition, and (3) when
most of the ears were out of the milk. Basing his figures on the dry matter,
he found that the percentage of protein decreased from the first period
to the last, while the percentage of carbohydrates increased.

Ladd (3) concludes that the nitrogen steadily diminishes throughout
the period of growth, while the sugars rise and fall. The starch falls
slightly during the earlier stages and then rises rapidly until the plant
reaches maturity.

1 Reference is made by number (italic) to "Literature cited," p. 792-793.
Morse (4) analyzed samples representing four stages of growth and reached the same conclusions, with respect to the protein and carbohydrates, as the other investigators.

Perhaps the most elaborate study of the subject was made by Jones and Huston (2). Their study included the whole plant as well as the stalks, leaves, and ears taken separately. Unfortunately their figures for the whole plant are based upon yield per acre and so cannot be compared with those of the other investigators or with ours.

EXPERIMENTAL WORK

The crops for the experimental work were grown in a section of the field at the Dairy Division Experiment Farm at Beltsville, Md., usually devoted to silage corn. The preparation of the soil, the planting, and cultivating were done under the supervision of T. E. Woodward, farm superintendent.

The sunflower plants were of the variety known as Giant Russian, and the corn was Boone County White. The sunflower plants thrived well in this soil (Bibb silt loam), reaching a height in many cases of 10 and 12 feet.

In dividing the growing period of the corn plant into stages, more or less arbitrary points must be taken. It is quite useless for the purpose to select plants by their age or height, for it is easily possible to find at any one time within a comparatively small area plants of the same height and age at entirely different stages of maturity. Up to the time of tasseling, however, there are no easily recognized guides except height. From that time until the plant is fully mature there are certain and fairly distinct points that can be selected, based on the condition of the silk and ears.

The task of selecting stages of growth of the sunflower plant offers more difficulty, and it is quite impossible to divide it into anything like as sharply defined stages as in the case of the corn plant. We endeavored to differentiate the stages first by the height and later by the condition of the flower and seed, but at best these points are very arbitrary.

The difficulties in selecting representative samples of whole plants for chemical analysis are obvious. The plan we followed was to go through a small area of the field and select from 6 to 20 plants of the proper stage of growth and as nearly the same size and conformity as possible. These were carefully wrapped in a specially prepared waterproof cloth and taken immediately to the laboratory, where they were cut into 1-inch lengths with a hand-power feed cutter.

A 1-kilogram subsample was weighed out and dried in the steam closet for the determination of starch. The remainder was ground to a pulp in a power meat grinder, and a subsample was taken for moisture, albuminoids, and total-protein determinations. A further subsample
was weighed out, from which the alcoholic extract of the pulp was prepared according to the method described by Swanson and Tague (6). Aliquot portions of the alcoholic extract were used to determine total and reducing sugars according to the gravimetric cuprous-oxid method of Walker and Munsen (7, p. 241).

Moisture was determined on a 5-gm. sample of the pulp by drying to constant weight in a reduced pressure water-jacketed oven. The subsample dried in the steam closet was ground to pass a 40-mesh sieve, and starch was determined on the air-dry sample by the diastase method with subsequent acid hydrolysis (1, p. 110).

Tables I and II give the results of the chemical work on the whole plants. The figures for total protein, albuminoid protein, reducing sugars, nonreducing sugars, and starch are based on the dry matter.

**Table I.—Composition of sunflower plant at different stages of growth**

<table>
<thead>
<tr>
<th>Stage of maturity</th>
<th>Moisture in fresh material</th>
<th>Dry matter</th>
<th>Moisture-free basis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per cent.</td>
<td>Per cent.</td>
<td>Total protein</td>
</tr>
<tr>
<td>3 feet high</td>
<td>84.87</td>
<td>15.13</td>
<td>8.59</td>
</tr>
<tr>
<td>6 feet high</td>
<td>86.02</td>
<td>13.98</td>
<td>8.01</td>
</tr>
<tr>
<td>First flower</td>
<td>84.58</td>
<td>15.91</td>
<td>7.04</td>
</tr>
<tr>
<td>Rays ready to fall</td>
<td>83.90</td>
<td>16.10</td>
<td>9.44</td>
</tr>
<tr>
<td>Rays dry and partly fallen</td>
<td>75.58</td>
<td>24.42</td>
<td>6.80</td>
</tr>
<tr>
<td>Rays all fallen</td>
<td>74.37</td>
<td>25.63</td>
<td>7.03</td>
</tr>
<tr>
<td>Seeds hard and mature</td>
<td>69.68</td>
<td>30.32</td>
<td>5.90</td>
</tr>
</tbody>
</table>

**Table II.—Composition of corn plant at different stages of growth**

<table>
<thead>
<tr>
<th>Stage of maturity</th>
<th>Moisture in fresh material</th>
<th>Dry matter</th>
<th>Moisture-free basis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per cent.</td>
<td>Per cent.</td>
<td>Total protein</td>
</tr>
<tr>
<td>3 feet high</td>
<td>84.21</td>
<td>15.79</td>
<td>11.14</td>
</tr>
<tr>
<td>4½ to 5 feet high</td>
<td>85.14</td>
<td>14.86</td>
<td>9.42</td>
</tr>
<tr>
<td>Just tasseleting</td>
<td>81.65</td>
<td>18.35</td>
<td>9.96</td>
</tr>
<tr>
<td>Just silking</td>
<td>81.56</td>
<td>18.44</td>
<td>8.95</td>
</tr>
<tr>
<td>Kernels forming</td>
<td>81.20</td>
<td>18.80</td>
<td>8.99</td>
</tr>
<tr>
<td>Milk stage</td>
<td>77.60</td>
<td>22.40</td>
<td>8.97</td>
</tr>
<tr>
<td>Silage stage (one half milk, one-half glazed)</td>
<td>68.69</td>
<td>31.31</td>
<td>7.31</td>
</tr>
<tr>
<td>All glazed</td>
<td>64.22</td>
<td>35.78</td>
<td>6.32</td>
</tr>
<tr>
<td>Ready to shock</td>
<td>59.79</td>
<td>40.21</td>
<td>7.09</td>
</tr>
</tbody>
</table>
DISCUSSION OF RESULTS

In studying the tables it should be borne in mind that the figures represent percentages based on the plants themselves and have no bearing on the yield of the various constituents per unit of area. For example, the protéids decline in percentage as the plant grows. This does not mean, of course, that the amount of the protéids per given area decreases, but rather that as the plant grows and increases in weight the protéids do not increase in the same ratio.

Too much importance must not be placed on slight differences in composition from stage to stage of growth. Because of the difficulties in sampling whole plants, small differences due to unavoidable errors are to be expected, and conclusions are safest when drawn from the general trend of the results rather than from particular figures.

Considering the sunflower plant first, it will be noted that the dry matter steadily increases as the plant grows older. This, of course, is what would be expected, but the fact is rather surprising that, even after the rays had all fallen and the seeds had become dry and mature, the plant still contained more moisture than the corn contained at the time it was ready for the silo.

The protéids, both total and albuminoid, show a tendency to decline as growth proceeds. This is somewhat contrary to what might be expected from the highly nitrogenous character of the seed.

The reducing sugars rise and then gradually decline. The nonreducing sugars steadily and rapidly decline throughout the whole period of growth. In the first stage there is one and one-half times as great a quantity of nonreducing sugars present as reducing sugars. This relation, however, is quickly changed, and in the last stage there is nearly three times as much of reducing sugars present as nonreducing. The percentage of starch is small, rising and falling with no apparent relation to the change in percentage of the sugars.

Turning now to the corn plant, it will be noted, as would be expected, that the dry matter steadily increases as the plant grows older. The protéids, both total and albuminoid, decline slowly but quite regularly. The sugars, both reducing and nonreducing, rise and fall but have an upward trend until the kernels begin to mature, when there is a sharp drop, accompanied by a sudden increase in the starch. This is at the stage when the plant is storing starch in the kernels and is the stage usually selected for ensiling. The ratio of reducing and nonreducing sugars changes, but within a somewhat narrow range. The reducing sugars always greatly exceed the nonreducing. The starch rises and falls up to the stage when the kernels begin to mature. Between the milk stage and what may be called the silage stage the starch increased from 2.87 per cent to 24 per cent.

Comparing the sunflower and the corn plants, it will be noted that the chief difference in the constituents studied lies in the amount and char-
acter of the carbohydrates. Although no part of the present experiment, silage was made of the sunflower plant at different stages of maturity, and it was found that silage made from plants at the stage when the rays were dry and partly fallen was excellent in quality. Comparing the plant at this stage with the corn plant at the silage stage, it will be seen that the starch and sugars combined constitute 11.2 per cent of the dry matter in the former, of which only about one-fifteenth is starch, while the combined starch and sugars in the dry matter of the latter constitute nearly 37 per cent, two-thirds of which is starch.

There is no great difference in the percentage of proteids in the dry matter of the two plants, but it is slightly in favor of the corn plant.

In selecting the best stage of maturity of a plant for ensiling, several things must be taken into consideration. In general the stage must be selected that promises the largest yield of food constituents in the silage. This stage is not necessarily the one when the plant itself has the maximum amount of food constituents. The moisture content of a plant, judging by the behavior of the corn plant when ensiled, plays an exceedingly important rôle. When silage is made from the corn plant having a high moisture content there is a downward seepage of the juice, carrying with it valuable food material. If the silo is tight this juice waterlogs the bottom layer, rendering it unfit for feeding. If the silo is not tight the juice leaks out and is lost altogether. Moreover, high moisture in the plant is usually associated with high-acid silage. On the other hand, a plant that has too low a moisture content is difficult to pack closely enough to eliminate the air spaces that cause spoilage. Silage produced from such plants is dry and lacks palatability.

Another point that should not be lost sight of is, of course, the yield per acre. This point, aside from the high moisture content, would bar out the three earlier stages of the sunflower plant. The fourth stage is still too high in moisture. The last stage contains nearly 70 per cent of moisture.

From the moisture content alone the sunflower plant at this stage should make good silage, but here another factor must be taken into consideration. The sunflower plant at this stage has lost some of its leaves. The outer part of the stalk has become so hard and woody that it would be difficult, if not impossible, to pack it closely enough to prevent spoilage. This eliminates all but two stages, the one when the rays are dry and partly fallen and the other when all the rays have fallen. These stages are close together, and judging from the chemical composition there is but little choice between the two.

There is but little difference in percentage between the total proteids and albuminoid proteids in the sunflower plant at these stages and the corn plant at the silage stage. The chief differences, as discussed in another paragraph, lie in the sugars and starch.
SUMMARY AND CONCLUSIONS

A study was made of the chemical composition of the sunflower and corn plants at different stages of growth.

The dry matter in each increased gradually and consistently throughout the entire period of growth.

There is no great difference in the percentage of proteids in the two plants, but it is slightly in favor of the corn plant.

The reducing and nonreducing sugars in the sunflower declined somewhat irregularly but persistently during the growth of the plant. In the first stage there was about one and one-half times as much nonreducing sugars present as reducing sugars. This relation was quickly changed, and in the latter stages the reducing sugars greatly exceeded the nonreducing.

The percentage of starch in the sunflower is small and rises and falls irregularly throughout the growth of the plant.

The reducing and nonreducing sugars in the corn plant rise and fall but with a marked upward trend during the growth of the plant until the stage is reached where the kernels are maturing, when a sudden drop occurs. The percentage of reducing sugars is always far in excess of the nonreducing sugars.

The starch rises and falls until the kernels are maturing, when a sudden rise occurs.

The chief difference between the two plants at the silage stage lies in the amount and character of the carbohydrates.

From the results obtained in this study it would seem that the best stage of maturity for ensiling the sunflower plant is when the rays of the flower have become dry and are falling.

LITERATURE CITED


(2) Jones, W. J., Jr., and Huston, H. A. 1914. COMPOSITION OF MAIZE AT VARIOUS STAGES OF ITS GROWTH. EXPERIMENTS MADE ... 1903. Ind. Agr. Exp. Sta. Bul. 175, p. 595-630, 10 fig., 1 pl. (col.).


(6) Swanson, C. O., and Tague, E. L.
