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IODINE CONTENT of OKLAHOMA VEGETABLES

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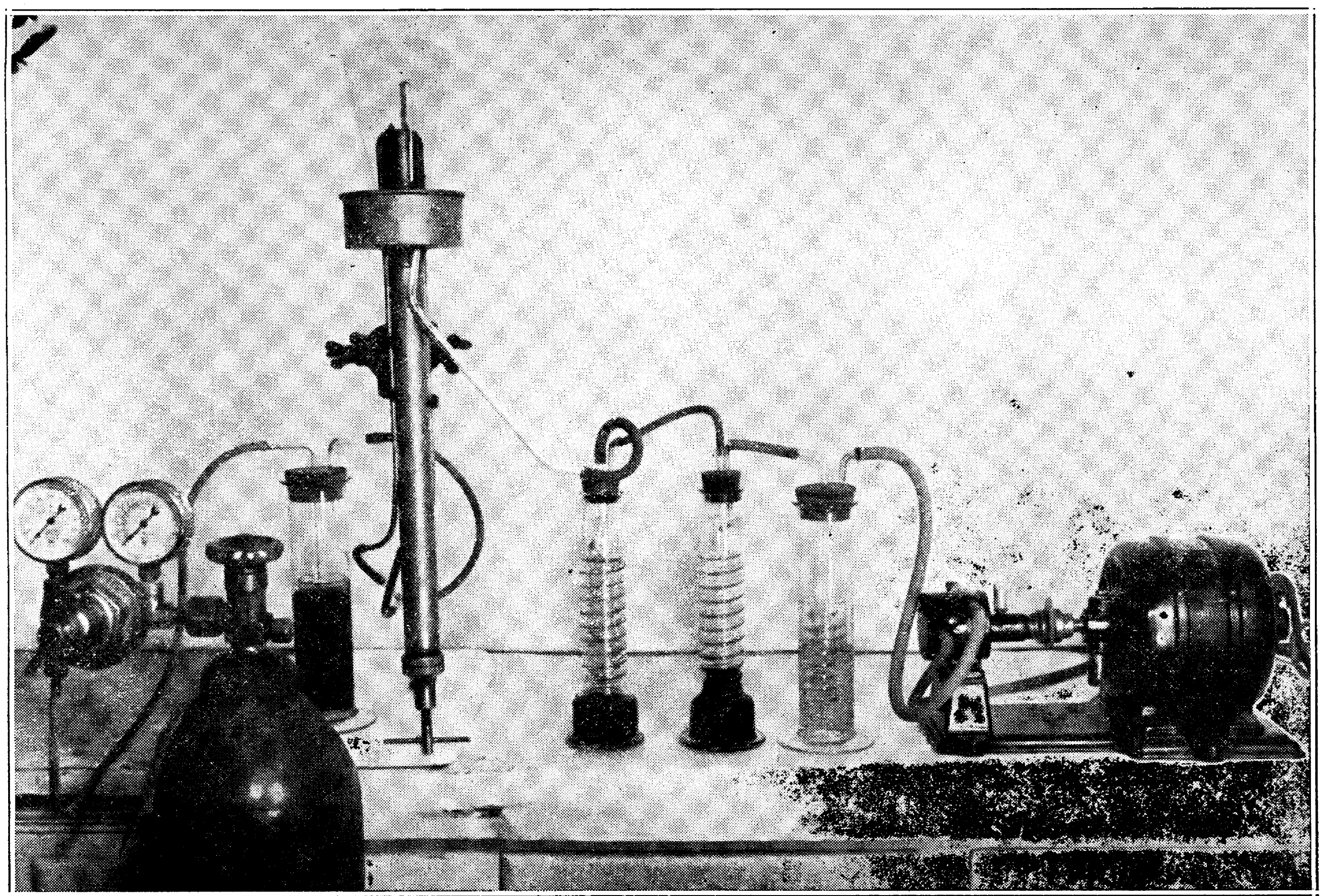

Figure 1.—Combustion torch and absorption flasks used in burning vegetables.

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The use of iodine-containing compounds for medicinal purposes was perceived centuries before iodine was chemically isolated or before its physiological functions were known. The Chinese, previous to 1500 B. C., and the Greeks at an early date, are reported to have used products rich in iodine in the treatment of goitrous conditions. Interesting historical references to this subject are numerous, but it has been only within comparatively recent years that the importance in the functioning of the thyroid gland and the control of goiter has been accepted.

During the last score of years scientific workers of the world have devoted much time to theories related to this problem, and hundreds of articles have recorded their findings. Numerous investigators have demonstrated that where iodine is deficient goiter becomes more prevalent, that iodine is not uniformly distributed throughout the surface of the earth, and that iodine content of waters and plant foods found in any region is rather closely correlated with the iodine content of the soils.

The discovery that goiter is controlled by a secretion of the thyroid gland and that this secretion contains iodine was soon announced. The isolation of this active product, the chemical proof of its structure, and finally its preparation in the laboratory, reads like a fairy story to those who are not working in the nutrition field. As a result of these discoveries, more has been done to relieve goitrous conditions in the past ten years than in the active history of medicine previous to this period.

Man has not been the only creature benefitted; as it was proved that man needed iodine, nutrition workers experimenting with domestic animals found that certain difficulties long known could be relieved by iodine administration. Evvard, from the Iowa Experiment Station, has reported a greater growth and an economy of feed by supplementing the hog's ration with a trace of iodine. Hart and Steenbock report that hairlessness of pigs, a condition seriously interfering with the production of pigs, could be eliminated in a similar manner. Goiter in sheep and cattle is frequently reported and is well known by stockmen. Its appearance in the young can be eliminated by feeding the pregnant mother a little iodine. According to many reports, joint ills in colts have been overcome by such supplement, where the condition has been common for years. Chickens seem to respond to iodine feeding, but its exact function is not definitely known. Better growth may be obtained with less feed and certain deficiency diseases may be eliminated if the proper amount of iodine is present.

In the face of these facts, one must expect that vegetables, cereals, and feeds grown where iodine is more abundant are of greater value in nutrition. A further stimulus to these investigations was the correlation between distribution of iodine and the occurrence of goiter in certain sections of the world. It was first thought the deficiency existed in mountainous areas where the soluble iodine salts had been leached away by rainfall, but more careful medical examinations showed certain areas to be more deficient than others. The well known goiter map of the United States, prepared from the study of drafted men during the World War, demonstrates this fact. It is interesting to note that Oklahoma is located in one of the most favorable areas for the avoidance of goiter.

The recognition that goiter is more prevalent in certain sections than in others, and that the iodine content of vegetables and grasses is related to the iodine content of soils and waters has prompted attempts to correlate these figures. Rather complete data have been secured for certain eastern and northern states, but no studies have been made of the southwestern states. The studies in Oklahoma were prompted by the frequent requests for information pertaining to this subject.

Method of Procedure

During the spring and summer of 1933 and again in 1934, vegetables were collected from various sections of the state, particularly from the commercial vegetable growing centers. In every case a record was kept of the variety, the type of soil, the use of fertilizers, the rainfall, and the portion of the plant selected. The material was first carefully washed, separated, and dried in hot air currents. It was ground to a powder, re-dried at 110° and sealed in cans for future analysis.

Results Obtained

The dried samples of the vegetables prepared as previously described were carefully analyzed by the procedure outlined later in this bulletin. Sufficient analyses were completed so that at least five comparable results were obtained for each specimen. The results have been averaged and the iodine content reported in parts per billion in Table 1.

TABLE 1.—Iodine Content of Oklahoma Vegetables

(Parts per billion, dry basis)

Vegetable	Variety	Year	Locality of Growth	I_2 Content P.P.B.
Asparagus	Mary Washington	1933	Stillwater	553.
Asparagus	Mary Washington	1934	Sapulpa	1282.
Asparagus	Mary Washington	1934	Mounds	1002.
Beets	Detroit Dark Red	1934	Perkins	300.
Beets	Detroit Dark Red	1934	Okla. City	214.
Beets	Detroit Dark Red	1934	Dewey	221.
String Beans	Stringless Green Pod	1934	Chickasha	315.
String Beans	Stringless Green Pod	1933	Altus	764.
String Beans	Pencil Pod Black Wax	1933	Stillwater	425.
Carrots	Nantes	1933	Haskell	324.
Carrots	Nantes	1933	Quinlan	365.
Carrots	Nantes	1934	Stillwater	531.
Cotton Plant	In Blossom	1933	Stillwater	172.
Cabbage	Copenhagen Market	1933	Stillwater	362.
Cabbage	Copenhagen Market	1933	Perkins	211.
Swiss Chard	Lucullus	1933	Stillwater	515.
Cabbage	Copenhagen Market	1934	Stillwater	394.
Cabbage	Copenhagen Market	1934	Dewey	66.
Lettuce	Black Seeded Simpson	1934	Stillwater	368.
Lettuce	Black Seeded Simpson	1933	Stillwater	737.
Lettuce	Black Seeded Simpson	1934	Bristow	248.
Lettuce	Black Seeded Simpson	1934	Muskogee	281.
Lettuce	Black Seeded Simpson	1934	Okla. City	301.
Lettuce	Black Seeded Simpson	1934	Chickasha	398.
Lettuce	Black Seeded Simpson	1934	Pawhuska	1557.
Lettuce	Black Seeded Simpson	1934	Drumright	452.
Radishes	Early Scarlet Globe	1934	Henryetta	994.
Potatoes	Triumph	1933	Perkins	262.
Potatoes	Triumph	1933	Stillwater	309.

Potatoes	Irish Cobbler	1933	Altus	267.
Potatoes	Irish Cobbler	1933	Woodward	267.
Potatoes	Irish Cobbler	1933	Haskell	154.
Potatoes	Irish Cobbler	1933	Haskell	135.
Potatoes	Triumph	1934	Stillwater	75.
Spinach	Nobel Big Crop	1933	Cushing	226.
Spinach	Nobel Big Crop	1934	Cushing	305.
Spinach	Nobel Big Crop	1934	Muskogee	444.
Spinach	Nobel Big Crop	1934	Pawhuska	1083.
Spinach	Nobel Big Crop	1934	Stillwater	344.
Spinach	Nobel Big Crop	1933	Stillwater	495.
Okra	Perkins Mammouth	1933	Stillwater	1075.
Okra	Perkins Mammouth	1934	Stillwater	603.
Mustard Greens	Southern Curled	1934	Stillwater	952.
Mustard Greens	Southern Curled	1934	Pawhuska	169.
Turnip Greens	Purple Top White Globe	1934	Pawhuska	676.
Beet Greens	Detroit Dark Red	1934	Dewey	815.
Beet Greens	Detroit Dark Red	1934	Chickasha	891.
Beet Greens	Detroit Dark Red	1934	Okla. City	248.
Tomatoes	Pritchard	1934	Perkins	379.
Sweet Potatoes	Porto Rico	1933	Stillwater	87.

These figures. in order to be of value must be compared with the results obtained by other investigators for similar vegetables grown in other localities and a table listing certain vegetables grown in different states is shown in Table 2.

TABLE 2.—Iodine Content of Vegetable Foods From Other Regions

(Parts per billion, dry basis)

Vegetables	South Carolina	Georgia	California	Oregon
Lettuce	761	363		
Summer Squash	716			
Spinach	694	567	32	19.5
Turnip Tops	433	226		
String Beans	429			29.0
Cabbage	336			
Asparagus	285		12.0	
Beets	227		8.0	
Turnips	223			
Carrots	197		8.5	2.3
Sweet Potatoes	98			
Potatoes	211*			

* Other samples showed an iodine content of 86 parts per billion for Minn.; 97 for Mich.; 110, Iowa; and 77.8, Pa.

Method of Analysis

The analysis of dried vegetables for iodine is a tedious procedure and requires an experienced and careful technician. The methods followed are nearly identical to those developed and used by previous workers. Iodine is present in vegetables in only minute traces, which requires the burning of large amounts of the sample. The fact that iodine is volatile at higher temperatures forbids the usual procedure for ashing and for this reason the samples were burned in a closed system. The von Klonitz, Harry, and Remington, Roe E., apparatus was selected (4). This method was thought to be an improvement over the earlier procedure devised by McClendon (2), and by Karns (1).

Very briefly stated, this procedure consists in placing rather large samples of dried vegetables to be analyzed in cellophane tubes which in turn are placed in a long metal tube and mechanically fed into a closed chamber where the organic matter is burned in a stream of oxygen. A detailed diagram of torch and absorption flasks as well as a picture of the entire apparatus is given in figures 1 and 2. A continuous suction carries the gases produced into a series of specially built Friedrich absorption flasks where the iodine vapor is absorbed by and chemically combined with alkalies in the absorbing solutions. The dissolved iodine is finally recovered and estimated colorimetrically as outlined in detail in the original article cited.

Chemical Reactions Involved

Titrimetric, gravimetric, and colorimetric methods have been developed and recommended by various workers. In these tests a micro-colorimetric procedure has been adhered to. In the burning of the sample, other conflicting compounds often interfere with the results; nitrites especially are formed and must be removed. In the work done in this laboratory the gases from the oxygen combustion are conducted into a train of three specially built Friedrich absorption bottles partly filled with water and containing two pellets of sodium hydroxide and five milligrams of sodium sulfite. Chemical reactions may be explained as follows:

$$I_2 + NaOH = NaI + NaIO$$

$$HIO_3 + NaOH = NaIO_3 + H_2O$$

After combustion is completed, the solution from the absorption bottles, the ash, and the wash waters from the torch are evaporated slowly to dryness and ashed at 400° C. until the residual carbon is oxidized.

The ash is extracted three times with alcohol and the insoluble substances are removed by filtration. The alcoholic filtrate is again evaporated to dryness without boiling and the salts are redissolved in 15 ml. of water. This is done as the iodine is to be released by sodium nitrite and extracted from the water with carbon disulfide, and sodium nitrite is only sparingly soluble in alcohol. Also, the carbon disulfide is partially miscible with the alcohol.

The salts are redissolved in water, 1 milligram of sodium azide and 8 drops of 6% sulfurous acid are added. The azide removes nitrites, as

$$N_3H + HNO_2 = N_2 + N_2O + H_2O$$

The sulfurous acid reduces iodates to iodides:

$$3H_2SO_4 + HIO_3 = 3H_2SO_4 + HI$$

The solution is acidified with 85% phosphoric acid, brom-phenol blue paper being used as an indicator and 5 to 10 drops in excess acid are added. The sample is boiled until the volume is about 7 ml. which removes SO_4 and CO_2. It is then transferred to a 15 ml. centrifuge tube. The beaker is washed with water bringing the total volume to 10 ml. The sample is now cooled to room temperature and 1 ml. of carbon disulfide and 1 mg. of sodium nitrate are added. The sample is shaken two hundred times. Care must be used in adding the sodium nitrite as an excess will produce a yellow color that collects in the carbon disulfide and interferes in the comparison of colors.

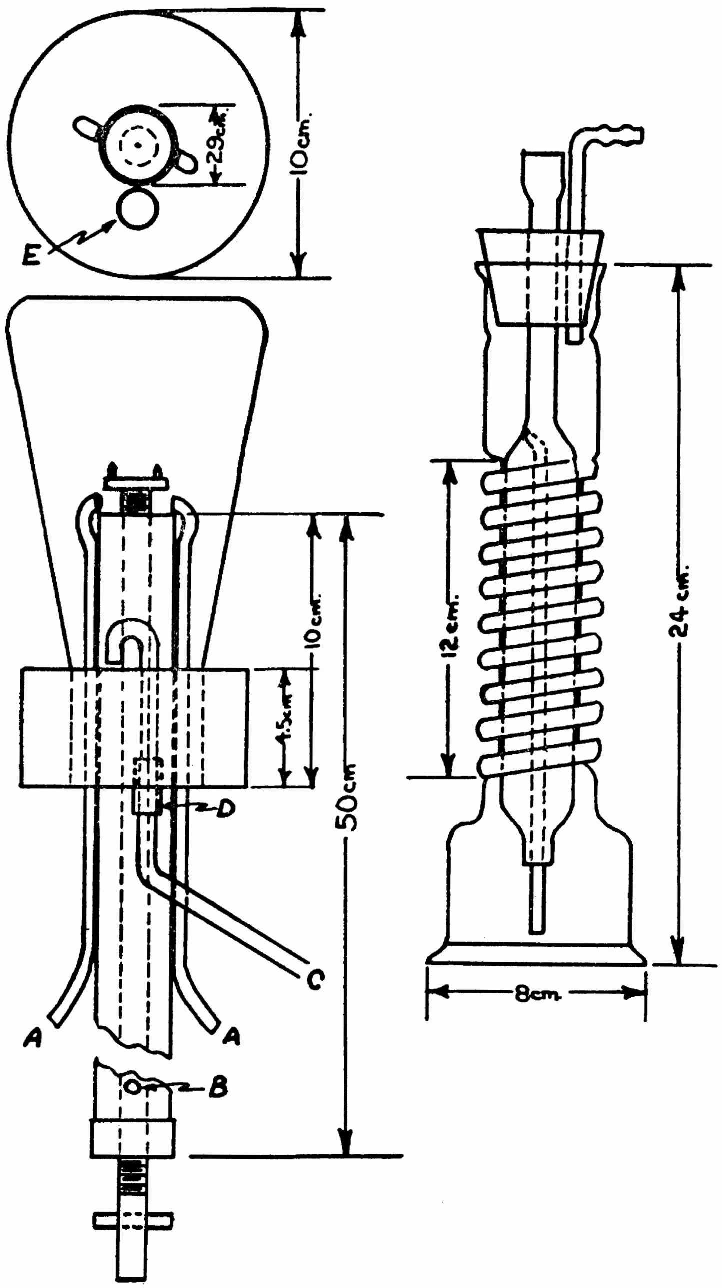

Figure 2.—Cross sectional diagram of the combustion chamber and the Friedrichs absorption flask.

After shaking, the sample is centrifuged and the carbon disulfide solution is removed by means of a micro-pipette. The colors produced are compared in a Klett colorimeter to that of a standard which has been simultaneously and similarly prepared as suggested by McHargue and others (3) rather than as outlined in the original method. The iodine content is calculated in parts per billion of the original dry sample and reported in the preceding tables.

Conclusions

1. Typical samples of commonly grown vegetables have been secured from various parts of Oklahoma during two succeeding years and analyzed for their iodine content.
2. The results indicate that Oklahoma vegetables are very well supplied with iodine and compare favorably with the better regions.
3. The iodine content is not so much dependent on the variety as it is on the place of growth. It is especially noticeable that where salty waters are used in irrigation, or where these waters normally occur, the iodine content of the vegetables produced is often doubled.
4. Iodine is more plentiful in those parts of the plant where the green coloring matter is most intense. It has been observed that the young green leaves always contain more than the ethiolated leaves; that there is more in the leaves than in the stem, and the least amount is present in the storage roots. However, if the stem is green and rapidly growing, as the asparagus, it may be an excellent source. Likewise, the pod of the okra has proved to be very rich in iodine in the samples analyzed.

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