[CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.—NO. 2.]

SOME PRODUCTS OF CASSAVA.[1]

BY E. E. EWELL AND H. W. WILEY.

SOME four years ago one of us[2] described a plant which has been grown in Florida for many years under the name of sweet cassava, the botanical name of which is *Jatropha manihot* or *Aipi*. From the analyses made at the time it was found that the plant was valuable for feeding purposes, being very rich in carbohydrates, although rather poor in albuminoids. Lately the subject has been studied to a much greater extent, with the object of preparing as large a number of products as possible from the plant, with the determination of their chemical properties and food values.

A large quantity of the root was obtained from Florida, the bark separated from the root, and each subjected to analysis with the following results:

	Peeled root. Fresh.	Peeled root. Dry.	Fiber after removal of starch. Dry.	Bark of root. Fresh.	Bark of root. Dry.
Moisture	61.30	....	....	61.30	....
Ether extract	0.17	0.44	0.30	0.66	1.70
Albuminoids (nitrogen × 6.35)	0.64	1.66	1.02	2.29	5.91
Starch (diastase extract inverted with HCl)	30.98	80.06	64.64	....	....
Fiber	0.88	2.26	10.68	3.83	9.89
Ash	0.51	1.31	1.42	2.02	5.23
Undetermined	5.52	14.27	21.94	29.90	77.27
	100.00	100.00	100.00	100.00	100.00

With the starch in the analysis given above is reckoned also the soluble carbohydrates, consisting almost exclusively of cane sugar, and of which in an analysis of another portion of the dry substance as high as seventeen per cent. was found. The undetermined portion consists of the digestible fiber and carbohydrates of the pentose series. The pentosans in the fiber were determined by the furfurol process as modified by Krug, and the amount in the air-dried material was found to be 3.92 per cent., and in the material after the removal of the starch, 5.33 per cent.

[1] Read before the Washington Chemical Society, February 9, 1893.

[2] Wiley, *Agric. Science*, Vol. 2, No. 10, p. 256 *et seq.*

The fresh root was found to contain 38.7 per cent. of dry matter, being considerably more than was found in the fresh sample of the previous analysis. Of this 38.7 per cent., 30.98 consisted of starch and soluble carbohydrates.

Experiments were made to determine the yield of air-dry starch which could be obtained from the roots by laboratory work. Two sets of experiments were made. In the first set the roots were pulped on a Pellet rasp used for preparing beet pulp for instantaneous diffusion. Twelve kilos of the unpeeled root were rasped in this way and the starch separated by washing through a sieve of bolting cloth. The washings and settlings were collected and dried in the ordinary method of starch manufacture. The yield of pure starch was 3105 grams, equivalent to 25.9 per cent. of the total weight of the root. The starch was almost absolutely pure, containing only a trace of nitrogenous matter. In the second experiment ten kilos of the root were ground in a pulping machine used for preparing green fodder for analysis. The pulp was much less fine than that produced by the Pellet rasp. Treated in the same way, the yield of air-dry starch was 2360 grams or 23.6 per cent. One of the striking points in connection with the work is that the residue from the starch, which consisted largely of fiber, as will be seen by reference to the above analysis, contained still a large percentage of starch, showing that by the process employed, the whole of the starch was not secured from the pulp.

The cassava which grows in tropical regions contains a notable percentage of hydrocyanic acid, so great in fact that it can not be used directly as a food. The so-called poisonous cassava is boiled to expel the hydrocyanic acid before being used for feeding purposes. A careful determination was made of the hydrocyanic acid in the fresh root, and the amount was found to be 0.015 per cent. While this shows a considerable quantity of hydrocyanic acid, it is hardly in proportions sufficiently large to be alarming. Nevertheless, any possible danger could be avoided before using the material as a food by subjecting it to a sufficient heat to expel the hydrocyanic acid. The hydrocyanic acid seems to be distributed throughout the pulp, and particularly in the juices, which can be expressed from the pulp. No injurious effect from the hydrocyanic acid has ever been observed in the case of animals fed on cassava in Florida.

The bark of the root was also subjected to analysis, as will be seen by reference to the table. It contained no starch, the undetermined matter being chiefly digestible fiber and pentosans.

The mineral matters extracted from the soil are distributed as indicated in the table. The amount of ash in the root itself is quite low, showing that the cassava plant does not require a soil very rich in mineral constituents. The amount of mineral matter taken from the soil by 100 kilos of the fresh root is approximately only half a kilo. The albuminous matters are also present in small quantities, being only slightly larger in weight than the ash itself. The plant, therefore, is one which seems particularly suited to feed almost exclusively from the air and water, and hence is one which could be recommended on the sandy soils of Florida as a crop which would require the minimum of fertilization.

COMPOSITION OF THE ASH.

The ash of the peeled root and the bark of the root was subjected to analysis with the following results:

ANALYSES OF THE ASH OF CASSAVA ROOT.

Constituents.	Peeled root. A.	B.	Mean.	Bark of root. A.	B.	Mean.
Carbon	0.30	0.31	0.31	0.79	0.77	0.78
Silica (soluble in solution of Na_2CO_3)	0.97	0.91	0.94	10.53	11.36	10.94
Silica (insoluble in solution of Na_2CO_3	7.15	7.15	7.15	52.99	52.16	52.58
Ferric oxide (Fe_2O_3)	0.66	0.66	0.66	2.46	2.44	2.45
Calcium oxide (CaO)	10.63	10.64	10.64	6.58	6.65	6.62
Magnesium oxide (MgO)	7.36	7.35	7.36	3.31	3.33	3.32
Sodium oxide (Na_2O)	1.12	1.28	1.20	0.84	1.05	0.95
Potassium oxide (K_2O)	41.72	41.54	41.63	14.73	14.68	14.70
Phosphoric acid (P_2O_5)	15.58	15.59	15.58	2.44	2.46	2.45
Sulphuric acid (SO_3)	3.67	3.80	3.73	1.71	1.71	1.71
Carbonic acid (CO_2)	9.15	9.12	6.14	2.53	2.50	2.51
Chlorine (Cl)	2.76	2.75	2.75	1.41	1.42	1.41
Total	101.07	101.10	101.08	100.32	100.53	100.42
Oxygen equivalent to chlorine	0.62	0.62	0.62	0.31	0.31	0.31
Difference	100.45	100.48	100.46	100.01	100.22	100.11

From the above numbers it is seen that the ash of the peeled root is especially rich in potash, almost one-half of the total weight being composed of this substance. The potash is combined chiefly with carbonic and phosphoric acids. In the ash of the bark, as might be expected, silica is the predominating element, more than half the total weight consisting of this substance.

Assuming a yield of five tons of roots per acre, the weights of the important fertilizing materials removed by such a crop can be readily calculated from the data given.

Since the bark forms approximately 2.2 per cent. of the entire root the total crop would be made up of the following amounts of bark and peeled root, which would contain the amounts of mineral given below:

Peeled root,	9780 lbs.,	containing	49.88 lbs.	ash.
Bark of root,	220 "	"	4.44 "	"
	10,000 "	"	54.32 "	"

The more important mineral matters contained therein are:

	Ash from peeled root. 49.88 lbs.	Ash from bark. 4.44 lbs.	Total ash from 5 tons. 54.32 lbs.
Lime (CaO)	5.31 lbs.	0.29 lbs.	5.60 lbs.
Magnesia (MgO)	3.67 "	0.15 "	3.82 "
Potash (K_2O)	20.77 "	0.65 "	21.42 "
Phosphoric acid (P_2O_5)	7.77 "	0.11 "	7.88 "
			38.72 "

The less valuable mineral plant foods—that is, those which are of so little note as to require no conservation or addition—amount to 17.60 lbs. per acre.

Quite a number of preparations was made from the starch of the root, and among them may be mentioned: First, tapioca. The first portions of starch washed out, especially, produce an excellent article of tapioca when moistened and dried in the proper way. Second, glucose. Both the fresh root and the extracted root yield full theoretical amounts of glucose, and samples of this article were made by the conversion of the starch both by sulphuric acid and diastase. The samples of glucose made from the starch were exceptionally good, especially when diastase was used, the glucose in this case containing large quantities of maltose. Commercially it would be more profitable to make the glucose directly from the fresh root, in which case the considerable percentage of cane sugar contained by it would be saved, whereas if glucose is made from the starch the cane sugar is previously washed out. On account of the presence of the bark, however, the glucose made from the whole root is not so fine in quality as that made from the pure starch. Third, alcohol. The glucose on fermentation affords the usual quantity of alcohol. Fourth, cane sugar. A beautiful preparation of cane sugar was made from the water used in washing out the starch. The amount of cane sugar, however, is not large enough to warrant its extraction on a commercial scale from the waters used for washing. It is, however, present in sufficient quantity to indicate that in making glucose it is better to use the whole root as indicated above.

The general result of the analytical work is such as to establish the fact that the cassava is a plant of high economic value and worthy the attention of those interested in the carbohydrate products of the country.

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AIR DRYING OVEN.

BY DR. G. L. SPENCER.[1]

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THIS oven is made of Russia iron, with double walls, and is cylindrical in shape. The walls are about one inch apart, and the space between them is filled with some non-conducting material; plaster of Paris is very convenient for this purpose. The bottom of the oven is also double, the outer bottom being made of Russia iron and the inner bottom—placed at a distance of one-half an inch from the outer one—is made of copper. The space between the two is filled with air. The object of having the inner bottom of copper is to allow a speedier and more even distribution of the heat, which is imparted from a lamp placed below the outer bottom. The top of the oven is also made double, with perforations sufficiently large to admit

[1] Presented to the Washington Chemical Society, April 13, 1893.