T H E S I S

A C O M P A R I S O N O F T H E M E T H O D S U S E D I N T H E T E S T I N G O F S U G A R B E E T S.

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A COMPARISON OF THE METHODS USED IN THE TESTING OF SUGAR BEETS.

With the development of the beet sugar industry in the United States, there has been a constant dissatisfaction and variance of opinions as to the best methods of testing the beets in the factory. Some chemists and some factories have advocated and adopted one method, while other chemists and other factories have used another. As the number of sugar houses in the country increases, the number of supporters of one method have increased about equally with those of another, and now it can be said that there is no uniformity in the methods used.

At the suggestion of Professor F. S. Kedzie, I began a somewhat exhaustive study of the methods now used in the Michigan factories, and a careful comparison of the same. The purpose of the work was, first, that I might acquaint myself thoroughly with the different methods; and, second, to determine the difference, if there was any, in the results obtained by them, from the standpoint, not of the factory, but from that of the beet grower. The importance of this latter to our farmers should not be overlooked for it is largely upon these factory tests that the profit of the crops depends. If any one method of testing is more accurate than another, or if one is more likely to give incorrect results by careless or indifferent procedure, it is time that attention should be turned that way. It is not

only best for the grower, but also for the manufacturer, to know the truth regarding this. With these ends in view I began the work. The investigation was made in the Chemical Laboratory, under the personal direction of Professor Kedzie during the winter and spring terms of my senior year.

In commencing the work, we wrote to the various sugar companies of the State, asking them the following questions:- (1) What method for testing the beets do you use in the testing room? (2) If it is the sucrose pipette method, what per cent do you allow for marc? (3) What is the basis by which you determine the price to be paid for the beets?

The answers received from these inquiries were very satisfactory both in number and the information contained. Out of the total thirteen factories written to, eight were heard from. Of these, six were using the sucrose pipette method, allowing 8 per cent for marc, and two employed the hot water digestion. None of the houses answering our letters were using the 110 c.c. method, but as it is commonly considered a method worthy of use we decided to admit it for comparison with the other two.

Upon this information we based the experiment. The methods of testing to be compared grouped themselves into three. The juice pipette, the 110 c.c., and the hot water digestion.

We will now notice minutely the method of procedure, and the principles involved in each.

First. The juice pipette method:

The beets are first washed and cleaned with water, then made into a pulp by a machine made for that purpose. There are many devices for this work, but sufficient to say that the beets should be as finely divivded as possible. After pulping, the beets are placed in a press of some kind and the juice extracted. The amount of pressue used does not affect the purity of the juice.

This extracted juice is now placed in a brixing can, and a brix spindle is used to give the per cent solids in the liquid. The graduations upon the spindle are made in relation to the specific gravity of H^2O, and gives the direct per cent of solids in juice. The juice should be at a temperature of 17.5 C. when brixed. If above or below this, a correction must be made. After the brix has been carefully determined, the same number of c.c. are taken with a sucrose pipette, and placed in a test flask. A clarifier is now added, either sub-acetate of lead or "Alumina Cream", and the solution made up to the mark with water. This is now filtered, and the filtrate pladed in a tube and polaized. The polarizing may be done in either length tube, a 200 mm. or 100 mm. If a 200 c.c. test flask has been used and the reading taken from a 200 mm. tube, the direct per cent of sucrose is given by the instrument. If either a 100 c.c. flask or a 100 mm. tube be used, the reading must be corrected. In the first case it must be divided by 2, in the latter it must be multiplied by 2. The per cent purity of the beet is now found by dividing the polariscope reading,

(per cent sucrose), by the degrees brix.

Second. The 110 c.c. method:

Thid manner of testing is thought by many somewhat simpler than the former system, but taken all in all it does not differ very much either in time of operation or in results of test. The juice of the beet is obtained the same as in first method. The brix and temperature are then taken. 100 c.c. are then placed in a 110 c.c. sugar flask and 10 c.c. of lead acetate are added. This is filtered and polarized. 1/10 of reading is added because the volume has been increased by one-tenth. With the correct polariscope reading, and the correct brix, the per cent sucrose is obtained by the use of Shmitz tables. These tables were constructed by experiment and are formed from the relation between the brix and polariscope reading. Purity $= \frac{\text{Per cent sucrose.}}{\text{Brix.}}$

Third. Hot water digestion:

This is the third method that is now in general factory use. This is the direct extract of the juice from the pulp or cossettes by the application of hot water. The principle involved is the same as that which exists in the cells of the diffusion battery. A normal weight, (26,048 gr.), of the pulp is taken and placed ina 201.2 c.c. flask in which about 10 c.c. of lead acetate or other clarifier has been run. Now water is added in such quantity as to nearly raise the liquid to the mark. This is now placed in a hot water bath and heated at a temperature of 80 C. for about 45 minutes. After thoroughly digested, cool,

add 1 to 2 c.c. acetic acid, fill to mark and filter. Take polariscope reading in 2 mm. tube Multiply scale reading by 2 because 200c.c. flask was used with only one normal weight of pulp. If 100 c.c. flask is used the reading is direct. In this method the per cent purity of the beet is not determined by the factory chemist.

This last method of testing takes the longest to operate and admits of the greatest amount of inaccuracy. It is very difficult to obtain fair samples of the cossettes. The sampler is liable to get that that has lost some of its juice or some whose juice content is increased. In this method it is also difficult to have the pulp fine enough. Every cell in the beet should be broken so that the juice may be easily extracted. A coarse cut pulp does not give up all its sugar in the operation. For these reasons it is only with the greatest care that a true and satisfactory test is obtained. In both the juice pipette and the 110 c.c. methods an allowance must be made for marc, or the insoluble matter of the beet that is left after all the sucrose has been removed. The majority of the factories use 8 per cent for the deduction of this marc, although 5 per cent has been found more nearly correct. This is taken from the first per cent of sucrose found and lowers the test of the beet. In the hot water method no allowance need be made for marc, as the pulp itself has been taken, and there is no correction to be made except for the volume. This correction is made in the capacity of the flask, it holding 201.2 c.c. H O instead of exactly 200 c.c.

In making the comparison of the tests made by the above methods we employed a series of three duplicates for each sample, in each of the three different forms. These were for a check upon each test. As many different samples of beets were used for the work as it was possible to obtain at that time of year. The results of the tests are tabulated in three different tables. The first contains a list of the samples, with the test reading of each, together with the per cent purity of each; the second is a table arranged simply for comparison and contains only the per cent sucrose, as taken from the preceding table; the third table shows the final per cent sucrose of the beet as figured by the factory after allowing 8 per cent for marc. This was computed to show the results as obtained from the various tests. The figures are the per cent sucrose as held on the books at the factory. It will be noticed by table No. II that the per cent sucrose as found by the three methods do not agree, that of the first two varying but little while that of the hot water digestion falls below by from .2 to .6 per cent per sample. These results stand with no correction for marc. Table No. III shows the per cent of the allowance, for marc has been deducted. Here the tests made by the juice pipette and the 110 c.c. methods are from .1 to .27 lower than those of the hot water digestion. However, from the results of the above work one can say that there is very little difference in the methods of testing, the final per cent sucrose is about the same, and there is little advantage given the farmer by any of the three. The greatest difference in the test lies in the method of

procedure, and this is simply a factory option. The lessons of this comparative work do not advocate a change in any factory method, but only substantiates the fact that in what ever form used the chemist must be more than careful and painstaking if he would obtain the most accurate results.

Table No. I.

Tests Made.

No. of sample.	Degree Brix	Temp. of juice		Juice Pipette Method			110 c.c. Method			Hot H2O Dig.	
			Tests.	Pol. R.	% Sucrose	% Purity	Pol. R.	% Sucrose	% Purity	Pol. R.	% Sucrose
I.	15.8	17.5	1.	5.5	5.5	34.8	20.4	5.42	31.4	5.22	5.2
			2.	5.4	5.4	34.1	20.0	5.39	33.8	5.1	5.1
			3.	5.5	5.5	34.8	20.3	5.53	34.8	5.2	5.2
II.	16.2	15.5	1.	6.8	6.8	41.9	25.4	6.8	41.9	6.45	6.4
			2.	6.6	6.6	40.8	24.8	6.6	45.8	6.2	6.2
			3.	6.6	6.6	40.8	24.4	6.5	40.8	6.5	6.3
III.	17.4	17.	1.	11.6	11.6	66.6	43.4	11.5	66.2	5.5	11.1
			2.	10.9	10.9	62.6	41.3	11.0	62.6	5.1	10.2
			3.	10.5	10.5	60.3	39.9	11.6	66.6	5.0	10.0
IV.	17.1	20.	1.	5.4	5.4	31.6	24.6	6.5	37.2	5.0	5.0
			2.	7.6	7.6	44.3	28.7	7.6	44.3	6.8	6.8
			3.	6.2	6.2	36.0	26.7	6.3	36.4	5.8	5.8
V.	14.6	17.	1.	10.3	10.3	70.6	38.6	10.4	71.2	4.8	9.6
			2.	10.2	10.2	70.1	38.2	10.2	70.1	4.9	9.8
			3.	10.6	10.6	72.4	39.4	10.6	72.4	5.0	10.2
VI.	15.2	19.	1.	8.4	8.4	55.2	31.0	8.3	54.8	4.0	8.0
			2.	8.6	8.6	56.5	31.8	8.5	55.9	4.1	8.2
			3.	8.6	8.6	56.5	31.6	8.4	56.5	4.0	8.0
VII.	16.9	21.	1.	11.0	11.0	65.0	41.8	11.2	66.3	5.4	10.8
			2.	11.6	11.6	68.1	43.4	11.6	68.1	5.5	11.0
			3.	11.4	11.4	67.2	41.8	11.2	66.3	5.4	10.8
VIII.	15.	19.	1.	6.6	6.6	44.0	23.8	6.4	42.6	6.2	6.2
			2.	6.8	6.8	45.3	24.9	6.9	49.0	6.1	6.1
			3.	6.2	6.2	41.3	23.5	6.3	42.0	6.0	6.0
IX.	14.	18.	1.	7.2	7.2	51.4	27.1	7.3	52.1	7.0	7.0
			2.	7.3	7.3	52.1	26.4	7.1	50.8	6.8	6.8
			3.	7.1	7.1	50.8	26.8	7.2	51.4	6.9	6.9
X.	16.2	20.	1.	9.3	9.3	51.2	34.4	9.2	51.0	9.0	9.0
			2.	8.1	9.1	50.0	34.1	9.15	50.1	8.9	8.9
			3.	9.1	9.1	50.0	34.2	9.18	50.1	8.8	8.8

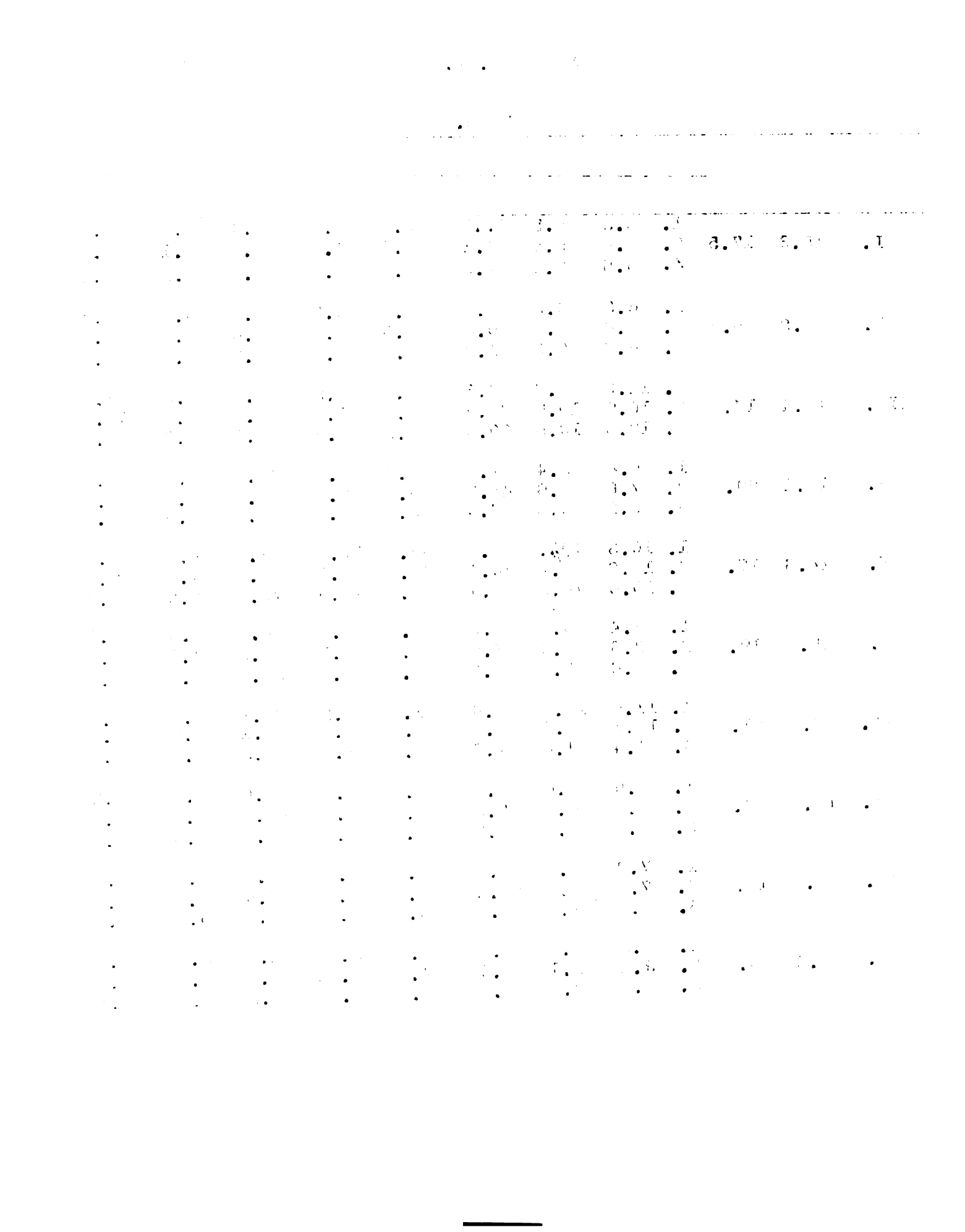

Table II.

Per cent Sucrose.

No. of Sample	Tests	Pipette Method % Sucrose.	110 c.c. Method. % Sucrose.	Hot Water Digestion. % Sucrose.
I.	1.	5.5.	5.42	5.2
	2.	5.4	5.39	5.1
	3.	5.5	5.53	5.2
II.	1.	6.8	6.8	6.4
	2.	6.6	6.6	6.2
	3.	6.6	6.5	6.3
III.	1.	11.6	11.5	11.1
	2.	10.9	11.0	10.2
	3.	10.5	11.6	10.0
IV.	1.	5.4	6.5	5.0
	2.	7.6	7.6	6.8
	3.	6.2	6.3	5.8
V.	1.	10.3	10.4	9.6
	2.	10.2	10.2	9.8
	3.	10.6	10.6	10.2
VI.	1.	8.4	8.3	8.0
	2.	8.6	8.5	8.2
	3.	8.6	8.4	8.0
VII.	1.	11.0	11.2	10.8
	2.	11.6	11.6	11.0
	3.	11.4	11.2	10.8
VIII.	1.	6.6	6.4	6.2
	2.	6.8	6.9	6.1
	3.	6.2	6.3	6.0
IX.	1.	7.2	7.3	7.0
	2.	7.3	7.1	6.8
	3.	7.1	7.2	6.9
X.	1.	9.3	9.2	9.0
	2.	9.1	9.15	8.9
	3.	9.1	9.18	8.8

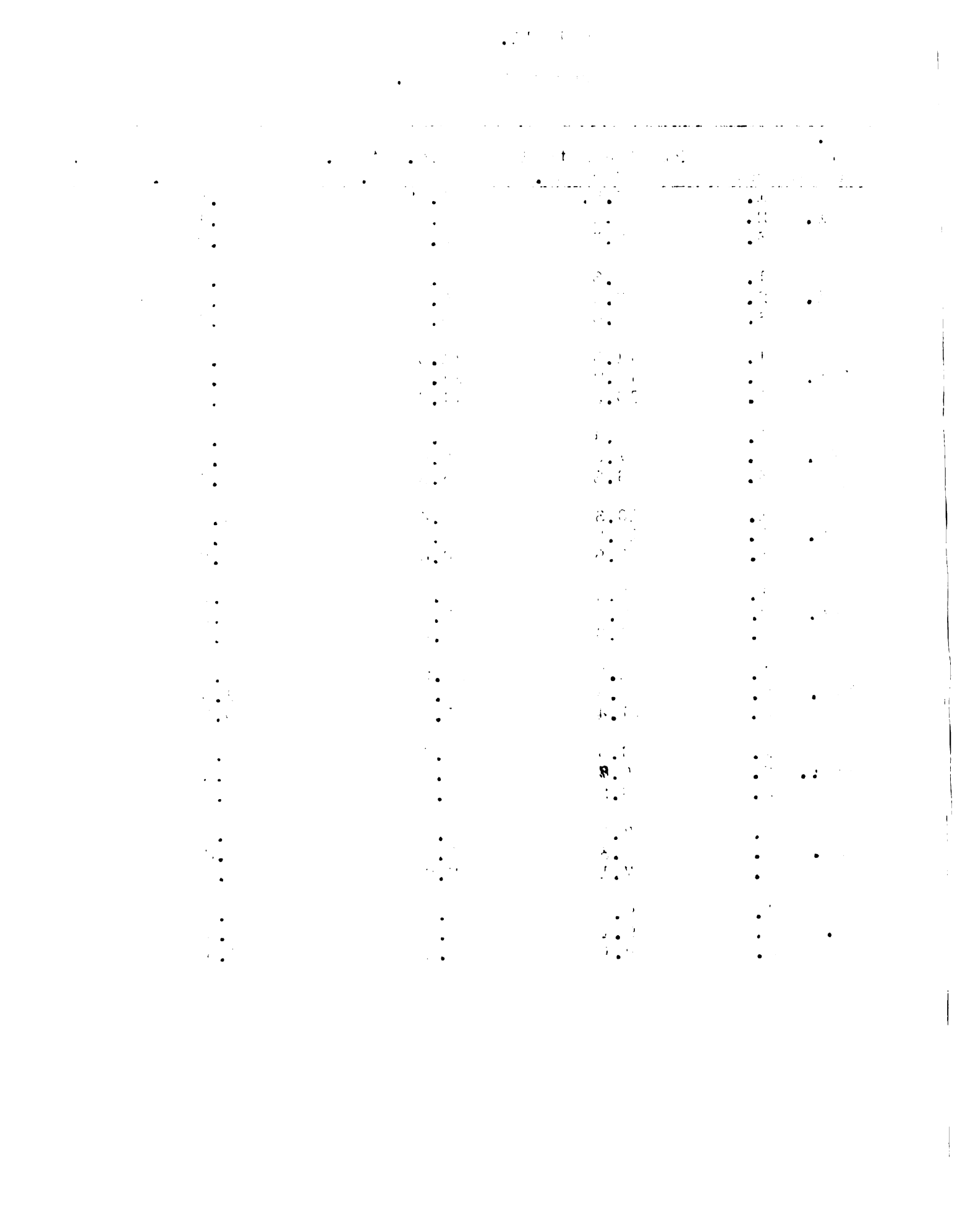

Table No. III.

Per cent sucrose as figured by factory, allowing 8 % for marc.

No. of Sample	Tests	Juice Pipette Method	10 c.c. Method.	Hot Water Digestion.
		% Sucrose	% Sucrose	% Sucrose
	1.	5.1	5.0-	5.2
I.	2.	5.0	4.9-	5.1
	3.	5.1	5.1-	5.2
	1.	6.3	6.3	6.4
II.	2.	6.1	6.1	6.2
	3.	6.1	6.1	6.3
	1.	10.7	10.6	11.1
III.	2.	10.1	10.2	10.2
	3.	9.7	10.7	10.0
	1.	5.0	6.0	5.0
IV.	2.	7.0	7.0	6.8
	3.	5.8	5.8	5.8
	1.	9.5	9.6	9.6
V.	2.	9.5	9.5	9.8
	3.	9.8	9.3	10.0
	1.	7.8	7.7	8.0
VI.	2.	8.0	8.0	8.2
	3.	8.0	7.8	8.0
	1.	10.2	10.3	10.8
VII.	2.	10.7	10.7	11.0
	3.	10.5	10.5	10.8
	1.	6.1	5.9	6.2
VIII.	2.	6.2	6.3	6.1
	3.	5.8	5.9	6.0
	1.	6.7	6.8	7.0
IX.	2.	6.8	6.6	6.8
	3.	6.6	6.7	6.9
	1.	8.8	8.8	9.0
X.	2.	8.7	8.8	8.9
	3.	8.8	8.7	8.8