COMPOSITION OF EGGPLANT FRUIT AT DIFFERENT STAGES OF MATURITY IN RELATION TO ITS PREPARATION AND USE AS FOOD [1]

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INTRODUCTION

To make the most effective use of the eggplant (*Solanum melongena* L.) an understanding of its physical and chemical characteristics is essential. Since the fruit of the eggplant is always eaten in the immature state, it was thought best to study its chemistry at different stages of maturity in order to determine whether it would be a more desirable food at one stage than another. An effort was made to ascertain the cause of the great shrinkage that often occurs in eggplant during cooking, as well as its tendency toward excessive softening which results in an undesirable texture or consistency. A bitterness that sometimes detracts from the quality of the product and the discoloration of material that takes place during the cooking process or when exposed to air were also studied, the table quality and the food value of different varieties were compared, and the effect of differences in stage of maturity upon the palatability of the product was determined.

REVIEW OF LITERATURE

Apparently the composition of the fruit of the eggplant has not been studied extensively. The results compiled by Chatfield and Adams (*4*) [3] show that on an average this fruit is composed of 92.7 percent water, 1.1 percent protein, 0.2 percent fat, 0.54 percent ash, and 5.5 percent total carbohydrate, including fiber; the fuel value is given as 28.2 calories per 100 g. The percentage composition as given by Van Slyke, Taylor, and Andrews (*7*) agrees very closely with the values given by Chatfield and Adams. Yoshimura (*8*) records the presence of the nitrogenous substances adenine, trigonelline, and imidazolylethylamine in the tissues of the eggplant fruit.

Several writers (*1*, *3*, *5*) have described methods of canning eggplant. Collections of recipes for general purposes usually describe methods of preparing and cooking the material but contain little discussion of the difficulties encountered and their causes.

SOURCE OF MATERIAL

The material used in these tests was grown at the Arlington Experiment Farm, Rosslyn, Va., in 1928. The soil was a medium heavy loam of good fertility. Frequent cultivation was given to destroy weeds and

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[3] Reference is made by number (italic) to Literature Cited, p. 717.

to keep the soil in good tilth. The planting included the varieties New York Improved, Long Purple, Maule Excelsior, Black Beauty, Florida Highbush, Chinese Giant, Japanese Round Purple, Ovigerum, and several foreign varieties. The fruits of these varieties differed remarkably in size, shape, and color. Ovigerum has a small white egg-shaped fruit; Long Purple has a medium-sized long purple fruit; and Black Beauty and New York Improved have very large deep-purple egg-shaped fruits.

METHODS OF SAMPLING AND ANALYSIS

To secure material of known age it was necessary to know the date of flowering of each fruit. Therefore the plots were gone over every 2 days and the flowers that had opened on the preceding day or two were tagged with the record of the date. By this method the age of the fruits could be determined within a limit of error of 1 or 2 days. Practically all the samples were collected from fruits that bloomed between August 20 and September 10. The development was therefore in the cooler part of the summer, and the rate of growth was consequently slower than if earlier flowers had been tagged. Each chemical sample was made up of sections from 5 to 10 fruits, except in the case of very young samples, when 20 or more fruits were required. The samples were taken at 5- to 10-day intervals, and sampling was continued until the fruits were 60 to 70 days old. In many cases the oldest fruits were turning yellow and the seeds were brown or black, indicating complete ripeness.

The fruits were picked between 9 and 10 a.m., brought into the laboratory, and analytical samples prepared from the unpeeled fruit by slicing radial sections from each fruit so that each sample included amounts of material from the several fruits approximately proportional to their weights. The slices were then minced finely and duplicate 100-g samples were weighed out. Enough 95 percent alcohol was added to make the concentration in the preserved material 75 to 80 percent. The samples were then heated to the boiling point of the alcohol and stored until the end of the sampling period. They were then extracted with 95 percent alcohol and the extract was made up to volume. From this fraction aliquot portions were taken for determination of soluble solids, sugars, acids, tannins, and nitrate nitrogen. After extraction the residue was dried, weighed, and recorded as the alcohol-insoluble fraction. Portions of the residue were used for the determination of the acid-hydrolyzable material.

The soluble solids were determined by drying an aliquot portion of the alcoholic extract in a vacuum oven at a temperature of 75° C. The determinations were made in triplicate, porcelain milk dishes being used for the drying of the material. The value for total solids was obtained by adding the values of the soluble and insoluble fractions.

The sugars were determined by the volumetric permanganate modification of the Munson-Walker method as given in Methods of the Association of Official Agricultural Chemists (*2*).

The acids were determined by titration with N/10 sodium hydroxide and calculated as citric acid.

The total astringency was determined by the modified Procter-Loewenthal method, and the acid-hydrolyzable polysaccharides were determined in the residue after extraction with alcohol by boiling with hydrochloric acid. Both are described in Methods of the Association of Official Agricultural Chemists (*2*).

The total nitrogen was determined by the method recommended by Ranker (*6*) for determining total nitrogen including nitrate nitrogen. For this test a separate sample was dried in a special drying chamber with a strong current of air directed against it by an electric fan.

RESULTS OF ANALYSES

Table 1 shows the results of the analyses.

SOLIDS

It is evident from the percentage of total solids that the water content of the tissues of the eggplant is high, generally between 91 and 93 percent. The percentage of total solids in the developing

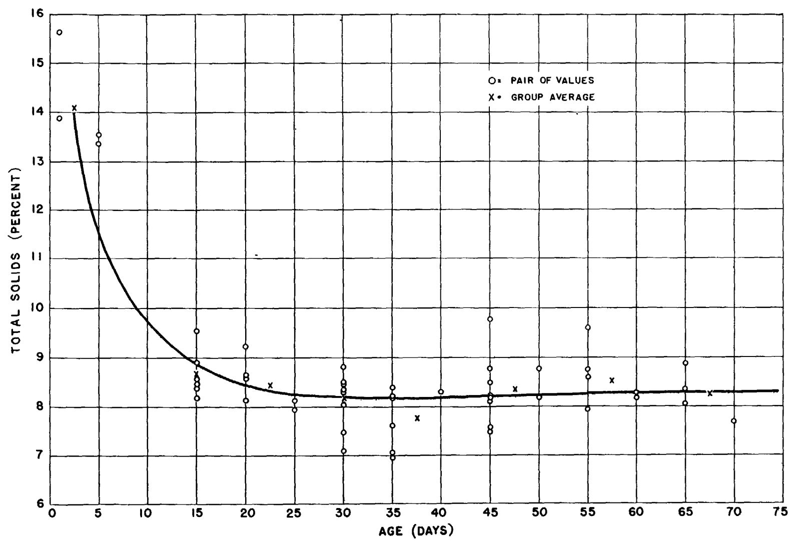

Figure 1.—Relation of percentage of total solids to age of eggplant fruit. Plotted from table 1; all varieties at all stages of maturity included.

fruit is largest at the time of flowering, when the values may be as high as 15 percent. They decrease rapidly for several days, but by the time the fruits are 15 to 20 days old a rather constant level has been reached. During the remainder of the developmental period there is no consistent tendency for the total solids either to increase or to decrease (fig. 1). From these results it is apparent that at any stage of maturity at which the fruits are likely to be used in cooking the difference in age will scarcely account for any significant difference in the solids content of the fruit.

In the 10 varieties studied there seem to be no consistent or significant varietal differences in solids content. There are striking differences in size, shape, and color of the fruit, but these do not seem to influence materially the moisture content.

TABLE 1.—*Composition of fruit of different varieties of eggplant at different stages of maturity*

Variety	Diameter	Age	Soluble solids	Insoluble solids	Total solids	Reducing sugar	Sucrose	Total sugar	Titratable acidity	Total astringency	Acid-hydrolyzable substances	Nitrate nitrogen	Total nitrogen	Specific gravity of flesh
	Cm	*Days*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
Florida Highbush	0.6- 0.9	1	5.27	8.62	13.89	0.51	0.72	1.23	0.207	0.288	1.256	0.	0.694	------
	1.0- 1.2	5	5.16	8.21	13.37	------	------	1.29	.772	1.076	------	0.	.602	------
	4 - 5	15	4.13	4.76	8.89	1.50	.42	1.92	.240	.516	1.31	.00014	.260	0.654
	6 - 8	25	4.10	3.82	7.92	2.38	.37	2.75	.169	.202	1.10	.00026	.186	.638
	9 -11	30	4.04	3.05	7.09	2.49	.46	2.95	.137	.098	.92	.00039	.158	------
	10 -12	35	4.06	3.55	7.61	2.48	.18	2.66	.133	.158	.99	.00040	.160	.681
	10 -12	45	4.26	3.87	8.13	2.48	.63	3.11	.131	.120	1.13	.00028	.149	.577
	11 -12	55	4.46	3.47	7.93	2.68	.60	3.28	.174	.118	1.12	.00017	.117	.640
New York Improved	.6- .8	1	6.61	9.01	15.62	------	------	1.22	.661	.913	------	0.	.721	------
	1. - 1.5	5	5.26	8.28	13.54	------	------	.65	.610	1.093	2.85	0.	.595	------
	3 - 4	15	3.78	4.58	8.36	.96	.40	1.36	.273	.468	.92	.00040	.412	------
	4 - 6	20	3.92	4.63	8.55	1.79	.40	2.19	.208	.250	1.13	.00070	.247	------
	7 - 8	30	4.14	4.32	8.46	2.19	.29	2.48	.182	.243	1.29	.00094	.211	.598
	8 -11	35	4.10	4.05	8.15	2.50	.16	2.66	.127	.120	1.21	.00091	.191	.614
	14 -16	45	4.30	3.19	7.49	2.52	.65	3.17	.116	.112	.91	.00096	.158	.580
	16 -18	55	4.76	3.97	8.73	2.48	1.09	3.57	.162	.193	1.16	.00051	.186	.658
Black Beauty	3 - 4	15	3.73	4.72	8.45	.99	.45	1.44	.260	.432	1.04	.00040	------	------
	4 - 5	20	4.36	4.86	9.22	1.56	.57	2.13	.292	.443	1.07	.00056	------	------
	6 - 8	25	4.26	3.85	8.11	2.12	.58	2.70	.196	.212	1.02	.00070	------	.626
	8 -10	30	4.80	3.67	8.47	2.88	.53	3.41	.176	.184	1.04	.00055	------	.612
	15 -18	45	4.20	3.37	7.57	2.65	.44	3.09	.130	.105	.90	.00155	------	.583
	18 -20	60	4.18	3.99	8.17	2.12	.64	2.76	.208	.126	1.06	.00197	------	.560
Chinese Giant	3 - 4	15	4.26	3.81	8.07	2.10	.50	2.60	.172	.204	.98	.00078	------	------
	5 - 7	20	5.04	3.57	8.61	2.45	.64	3.09	.240	.359	1.13	.00092	------	------
	8 -11	30	4.92	3.12	8.04	2.92	.83	3.75	.156	.081	.96	.00144	------	.776
	9 -11	45	4.82	3.30	8.12	2.65	.89	3.54	.140	.112	1.06	.00195	------	.700
	10 -11	65	4.58	3.46	8.04	2.36	.70	3.06	.205	.079	.84	.00227	------	------
Long Purple	4 - 5	20	4.06	4.06	8.12	2.01	.69	2.70	.215	.118	1.16	.00097	------	------
	4 - 6	30	4.48	3.82	8.30	2.66	.27	2.93	.156	.252	1.27	.00012	------	------
	5 - 6	35	4.44	3.93	8.37	2.63	.03	2.66	.130	.272	1.24	.00023	------	.696
	5 - 7	45	4.16	4.04	8.20	2.46	.27	2.73	.156	.202	1.23	.00014	------	.659
	5 - 7	65	3.72	5.14	8.86	1.71	.77	2.48	.175	.091	1.18	.00161	------	------
Maule Excelsior	8 -10	30	4.74	2.75	7.49	2.81	.71	3.52	.162	.126	.64	.00027	------	------
	10 -11	35	4.48	2.45	6.93	2.67	.45	3.12	.172	.105	.65	.00048	------	.563
	10 -12	50	4.88	3.87	8.75	2.21	1.02	3.23	.240	.191	1.15	.00029	------	------
Japanese Round Purple	2.5- 3.5	15	5.34	4.18	9.52	3.18	.50	3.68	.169	.239	1.21	.00057	------	------
	5 - 7	30	5.02	3.29	8.31	3.20	.86	4.06	.120	.098	.99	.00071	------	------
	6 - 7	40	5.34	2.95	8.29	3.31	.59	3.90	.127	.144	.90	.00195	------	.723
	6 - 7	45	5.22	3.55	8.77	2.84	1.15	3.99	.127	.175	1.31	.00184	------	------
	6 - 9	55	5.48	4.11	9.59	2.91	.86	3.77	.195	.130	1.01	.00124	------	------
	9 -10	65	3.96	4.37	8.33	1.81	.66	2.47	.223	.128	1.02	.00124	------	------

Ronde de Chine	6 - 7	35	4.60	3.58	8.18	2.65	.37	3.02	.159	.279	.97	.00072	-------	----------
	10 -12	50	4.64	3.55	8.19	2.44	.66	3.10	.130	.144	1.09	.00037	-------	----------
	15 -17	70	4.70	2.99	7.69	2.86	.61	3.47	.130	.119	.78	.00121	-------	.670
Noir Hâtive	4 - 5	35	4.44	2.61	7.05	1.60	1.15	2.75	.182	.198	.82	.00124	-------	----------
	4.5- 6	45	4.46	4.03	8.49	1.63	.76	2.39	.241	.225	1.20	.00167	-------	----------
	5 - 6	55	4.34	4.25	8.59	1.39	.68	2.07	.270	.215	1.27	.00153	-------	----------
Ovigerum	3.5- 4.5	15	3.87	4.67	8.54	1.94	.43	2.37	.200	.160	1.55	.00067	-------	----------
	5 - 6	30	3.88	4.92	8.80	1.98	.48	2.46	.195	.174	1.60	.00047	-------	----------
	5.5- 6.5	45	4.44	5.31	9.75	2.04	.50	2.54	.227	.294	1.94	.00124	-------	----------
	5 - 7	60	3.00	5.25	8.25	1.17	.28	1.45	.299	.119	1.31	.00115	-------	----------

On an average, approximately one half of the total solids are soluble in alcohol. The differences in the proportion of soluble to insoluble solids at different ages and in the different varieties appear to be too small to be of any practical importance in relation to the cooking quality. It seems rather remarkable that the soluble materials in this fruit should be so little influenced by the ripening processes. Many of the oldest fruits in the samples were uniformly light yellow and were therefore physiologically mature or ripe, but throughout the entire period of sampling there was very little change in soluble solids.

SUGARS

Table 1 shows that the total sugars ranged mostly between 2.0 and 3.5 percent, which, though quite low as compared with those of other fruits, nevertheless made up a considerable portion of the soluble solids. There were some differences in individual samples,

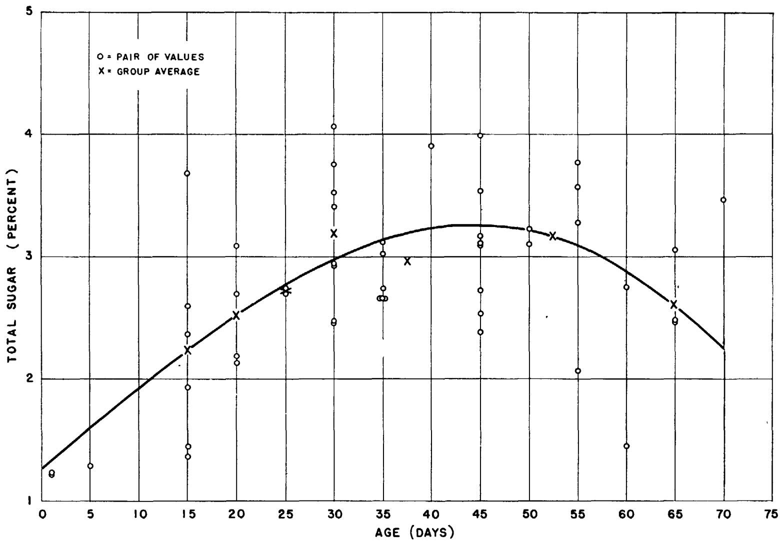

FIGURE 2.—Relation of percentage of total sugars to age of eggplant fruit. Plotted from table 1; all varieties at all stages of maturity included.

but no very marked difference in sugar content was found at any stage of maturity. There was a tendency for the sugars to increase until the fruits were 40 to 50 days old and then to decrease as they became older. This is shown in figure 2, in which the curve represents the average of all the varieties. It may be pointed out that the oldest samples of the varieties New York Improved and Florida Highbush did not decrease in sugars, but it is doubtful whether this fact is significant. The sugar content is lowest at the time of flowering, or immediately afterward, and highest when the fruits are 35 to 55 days old.

There were no very great differences in the sugar content of the different varieties; Japanese Round Purple appeared to average highest in sugar.

The principal part of the total sugars was reducing sugar, although a few samples contained as high as 1 percent of sucrose.

ACID-HYDROLYZABLE POLYSACCHARIDES

The amount of acid-hydrolyzable substances in the fruit of the eggplant was very small and there seemed to be no significant differences caused by stage of maturity or by variety.

NITROGEN

Unfortunately all the samples for the determination of total nitrogen, except those for two varieties, were lost. The total nitrogen in these two varieties indicated that the protein was very low. Total nitrogen was highest in the very young fruits, decreased rapidly for some time, then more slowly, and finally reached a constant level as the fruit approached maturity. However, the differences were too small and the number of samples too few to deter-

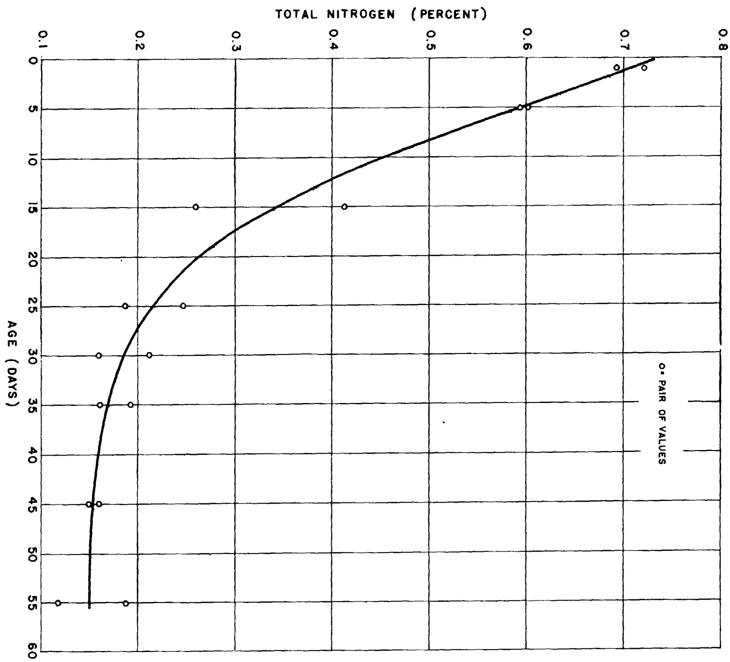

FIGURE 3.—Relation of percentage of total nitrogen to age of eggplant fruit. Plotted from table 1; values of only two varieties are included.

mine with certainty the form of the curve. These data are shown in figure 3.

The percentage of nitrogen was small. If nitrates were present in the fruits at the time of flowering the quantity was too small to be measurable with the methods employed. At all ages from 15 days onward, nitrate nitrogen was invariably present and sometimes was as high as 0.0016 percent. There appeared to be no consistent differences among varieties.

SPECIFIC GRAVITY

The specific gravity was determined for a number of samples, but the results are not complete enough to indicate definitely whether there were differences due to age. It was evident, however, that the specific gravity would be very low at any age at which the fruit would be likely to be used in cooking. The values ranged from 0.56 to 0.77, and the specific gravity of the expressed juice was 1.017, which gave a difference of 0.25 to 0.44. This indicates roughly that there was 25 to 44 percent of air by volume enclosed in the tissues. So large an amount of air in the tissues of a fruit or vegetable is rather unusual, and it might be expected that this feature would influence the behavior of the fruit in cooking.

TITRATABLE ACIDITY

The titratable acidity, calculated as citric acid, generally ranged from 0.1 to 0.2 percent in fruits 15 days old or older, but at the time of flowering a somewhat higher percentage was present. During

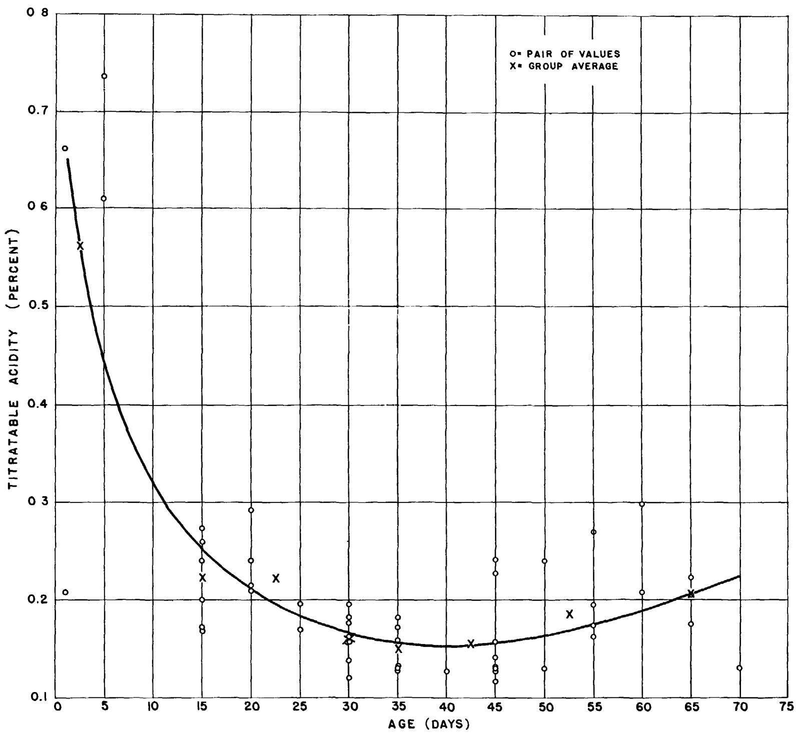

FIGURE 4.—Relation of percentage of titratable acidity to age of eggplant fruit. Plotted from table 1; all varieties included.

early development the acidity decreased slightly, reaching a low point when the fruits were 35 days of age and increasing again as they grew older. The differences, however, did not appear to be significant, at least over most of the developmental period (fig. 4).

TOTAL ASTRINGENCY

The total astringency was somewhat higher than might have been expected in view of the low total solids content. In fruits 15 days old or older total astringency in most varieties ranged from 0.15 to 0.35 percent. The total astringency was highest at the time of flowering; for several days thereafter it decreased rapidly, then more slowly, the decrease continuing throughout the life of the fruit. There was considerable variation in individual samples, but the general trend was fairly significant. Figure 5 shows these features. The difference in total astringency among varieties seemed too small to be significant.

PECTIN CONTENT

The pectin content of the fruit was not determined quantitatively, but a number of qualitative tests were made which apparently were important. A quantity of fresh material was ground in a food chopper; the juice was pressed out immediately and strained through cheesecloth, and a portion was filtered through filter paper. The freshly expressed juice turned brown on standing in the air; it was

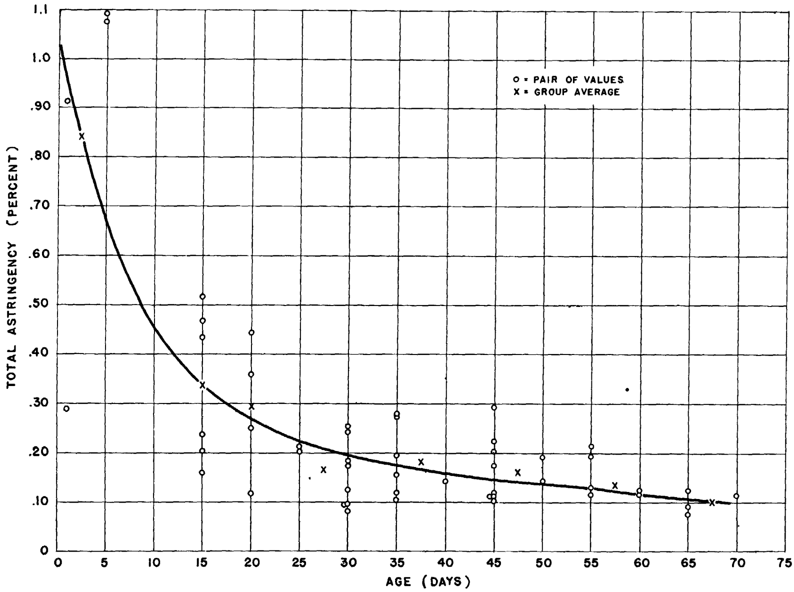

FIGURE 5.—Relation of percentage of total astringency to age of eggplant fruit. Plotted from table 1; all varieties at all stages of maturity included.

slightly viscous and gave a very slight precipitate with alcohol. A portion of the filtered juice was made alkaline with sodium hydroxide, allowed to stand overnight, then acidified with acetic acid and treated with a solution of calcium chloride. Very little precipitate was obtained. Another quantity of material was minced finely and boiled with water, forming a viscous extract which yielded a precipitate with alcohol. After this extract had been made alkaline with sodium hydroxide, allowed to stand overnight, and then acidified with acetic acid and treated with calcium chloride, the solution gave a rather heavy precipitate. Still another portion was extracted in the same way but with dilute citric acid. The extract was very viscous and could not be readily filtered through filter paper unless it was greatly diluted. The quantity of material extracted was much greater than when water was used. The extract gave a voluminous precipitate with alcohol, and when treated with calcium chloride in the manner just described it gave a large amount of precipitate.

A quantity of material was boiled with dilute ammonia; this resulted in almost complete disintegration of the tissues and gave a viscous solution. Some precipitate was obtained when the solution was neutralized, and an insoluble compound was formed on treatment with calcium chloride.

These tests strongly indicate that there is a considerable amount of pectinlike material in the tissues of the fruit of the eggplant. It appears to be mostly in the form of protopectin, very little true water-soluble pectin being present.

In the course of the investigation fruits from several varieties of eggplant at various stages of maturity were steamed, boiled, or fried, in order to determine what changes take place in the cooking process. The fruits were washed, peeled, and sliced. Certain lots were salted and pressed; others were cooked without this treatment. In some recipes it is stated that salting and pressing the slices removes bitter substances. In no variety and at no stage of maturity was an objectionable bitterness found in the material used in these tests; therefore it did not seem necessary to extract the juices with salt or to soak the pieces in salt water before frying. However, the practice may have some merit, since the moisture content is very high and some of the water of the fruit may be rapidly extracted by salt or by soaking in salt water. There may be some difficulty in frying the pieces of the untreated material so that they will remain intact until served, whereas the pieces from which a part of the water has been removed will have a heavier consistency and hence a greater tendency to remain intact. The protopectin, which is largely responsible for the consistency, is not removed by the salting and pressing treatment. Of course some sugars and salts are lost, but the principal substance removed is water. If bitter substances are present they also may be partially removed. This treatment also expels a considerable portion of the air that is enclosed in the tissues.

When steamed or boiled in water the slices of the eggplant fruit became very soft and partly or wholly lost their original shape, showing considerable shrinkage. These changes were apparently due to the peculiar chemical and physical characteristics of the fruit. The softening was the result largely of the changes that occurred in the structural constituents of the tissues or to the change of protopectin into pectin as a result of heating. The high moisture content and the low starch content apparently resulted in a watery consistency which caused the material to readily lose its original shape. The shrinkage was probably due to the driving out of a large amount of the air enclosed in the tissues, which, as already stated, makes up from 25 to 44 percent of the volume of the fruit. It is evident that if water is extracted or escapes from the tissues during preparation for cooking, shrinkage results from this cause also.

The stage of maturity of the fruit seems to be of no particular importance from the standpoint of its cooking qualities. In varieties like Black Beauty and New York Improved the seeds become noticeable at the age of 35 to 40 days from the date of blooming, but even at 50 days they were not particularly objectionable. In early varieties like Ovigerum and Noir Hâtive the seeds mature considerably earlier than in such varieties as Black Beauty and New York Improved. In these tests, fruits about two thirds grown appeared slightly superior when all points were considered. The age at which this size is reached varies with the earliness of the variety, but it was generally between 25 and 40 days under the climatic conditions under which this material was grown.

The cooking quality of the different varieties did not differ markedly and no variety seemed outstanding as compared with the others. Long Purple, Black Beauty, and New York Improved, because of the agreeable flavor and the tender quality of their flesh, were considered slightly superior to Florida Highbush and Chinese Giant. It was expected that some of the varieties would exhibit the bitterness that is cometimes complained of, but such was not the case. Since the varieties studied include those most generally grown, it seems that this trouble must be due not to the variety but to seasonal conditions or to the method of cooking. However, it must be remembered that individuals differ in their sensitiveness to unpleasant flavors. The persons judging this material were necessarily restricted to members of the writers' laboratory force. Extended tasting tests might have revealed some individuals to whom the bitterness even in this material was noticeable.

If the fruits were allowed to stand in the air after they were peeled and sliced they became somewhat brown, but the addition of salt prevented this to some extent. In practically all the cooking tests the material showed a tendency to darken, which increased somewhat when it was exposed to the air after cooking. The darkening was not sufficient to be objectionable, however, unless the material had come in contact with iron. Fruits cooked in an iron kettle became quite badly discolored. In a few tests a quantity of material that was boiled with a small amount of iron filings became greatly discolored. The discoloration was apparently due to a reaction between the iron and the tannin or other hydroxybenzene derivatives. The compounds formed promptly turn dark because of the oxidizing action of the air. The chemical analysis shows a significant amount of tannin compounds in all varieties. The low acidity also favors these reactions. The pH values of the juice ranged from 5.0 to 5.79 for the various varieties; the titratable acidity generally ranged from 0.1 to 0.2 percent. It is obvious that in order to prevent this discoloration the material must be kept from contact with iron or iron salts. The behavior of similar oxidation systems in other materials suggests that the addition of a little vinegar or lemon juice might aid in preventing any objectionable discoloration.

CANNING TESTS

No extensive canning tests were undertaken, but several lots of fruits of the varieties Black Beauty, New York Improved, Florida Highbush, and Long Purple were packed in various ways. The fruits were peeled and cut into circular disks one fourth of an inch thick and of the same diameter as the can. One lot was blanched in steam for 1 minute, packed in cans without preheating, exhausted 3 minutes, and then sealed. Another lot was prepared by thoroughly cooking the material, then pulping it and packing it while hot into the cans. In one lot the circular disks were sprinkled with salt and allowed to stand until about one third of the weight of the juice had been removed; they were then packed in no. 2 cans, exhausted 3 minutes, and sealed. The juice likewise was poured into cans, exhausted 3 minutes, and sealed. All cans, regardless of their previous treatment, were processed for 1 hour at 240° F. and cooled in the air.

In several instances the product was fairly satisfactory, but on the whole the possibility of obtaining a highly attractive pack was not promising. The most satisfactory product was obtained when the material was blanched in steam and then exhausted before processing. All lots showed a tendency to darken, which seemed to be due, as already pointed out, to the presence of tanninlike compounds which reacted with the metal of the can. The reaction was favored by a very low acidity. The shrinkage was excessive unless the air was removed by pressing or exhausting. The material generally became too soft to hold its form properly. Further work would be required to develop the best method of handling the product.

There was considerable corrosion of the can similar to that caused by pumpkin. The tin was removed or dissolved, exposing the iron, which turned dark. The air or oxygen in the tissues may have been responsible for the corrosion, but the presence of nitrates may also have been an important factor. The fact that the juice alone caused practically as much corrosion as the fruit itself indicates that oxygen was probably not the only factor involved.

SUMMARY

A study was made of the composition of the fruit of the eggplant (*Solanum melongena* L.) at different stages of maturity, in relation to its behavior in cooking. The results obtained are as follows:

The total solids were low, or the moisture content high, at all stages of maturity at which the fruit would be likely to be used in cooking. The total solids generally ranged from 7 to 9 percent of the fresh green weight. They were highest in the material at the time of flowering but decreased rapidly for a few days thereafter. This decrease ceased when the fruits were 15 to 20 days old, and for the remainder of the developmental period there was usually very little change in solids.

The total sugars, which in general ranged from 2.0 to 3.5 percent of the fresh green weight, made up a substantial portion of the soluble solids. The percentage of sugar was not greatly influenced by the stage of maturity, although there was a tendency for sugar to be highest in fruit about 40 days old, or about the time when it is generally picked for table use.

The starch or other material converted into sugar by acid hydrolysis was very small in amount and differed little with stage of maturity or variety.

The percentage of total nitrogen in the material was low. It was highest in the very young fruits, decreased rather rapidly for several days, then more slowly, and appeared to reach a constant level about the time the fruits would be picked for table use. A small but significant amount of nitrate nitrogen was present at all stages of development except the very earliest.

The specific gravity of the fruits was very low; the difference in the specific gravity of the intact tissues and that of the expressed juice indicated the presence of 25 to 44 percent of air (by volume) in the tissues.

The titratable acidity was quite low at all stages of maturity. Except in the earliest stages, there was little correlation between differences in acidity and differences in age. There was a tendency for the acidity to be lowest in fruit 35 to 45 days old, or about the time when it would be used for cooking.

There was a rather significant quantity of astringent materials present in the tissues of the fruit. These were highest at the time of flowering and decreased rapidly for a few days, then more slowly until the fruit was completely mature. During the period at which the fruit would be likely to be used on the table, its age is correlated with only very small differences in the percentage of astringent materials.

The differences in the composition of the varieties studied seemed too small to be of any practical significance.

Chemical and cooking tests indicated that the failure of the material to hold its form was due to the high moisture content of the material, associated with the change of a considerable part of the protopectin into pectin during cooking. This resulted in a product that was very soft in texture; the heating had a tendency to drive out the air, causing the material to shrink.

The tendency for the material to turn dark in cooking seemed to be due to the presence of tanninlike substances associated with low acidity. Iron and salts also reacted with the tannins to form compounds that darkened in the air, hence it is obvious that care should be exercised not to bring the material into contact with iron.

In the canning process there was a tendency for the product to turn dark, become soft, and lose its form. The tin can was rather severely corroded by the material. The presence of oxygen and nitrates suggests that these may have been responsible for the action on the can.

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