PECTIN CONTENT OF SMALL FRUITS AND THEIR SUITABILITY FOR JELLY MAKING

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PECTIN CONTENT OF SMALL FRUITS AND THEIR SUITABILITY FOR JELLY MAKING

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INTRODUCTION

Jelly manufacturers depend upon the proper proportion of three main ingredients; namely, acid, pectin and sugar. Of these, pectin is the most important because it is needed to form the "net-like" structure for the holding of the sugar and water.

Most fruits used in jelly making are low in pectin and acid at the stage of maturity most desired for making jellies. Therefore, pectin usually has to be added to obtain good jellies.

The purpose of this investigation is to determine the pectin content of the small fruits at the immature and mature stages of their development and to make jellies from these fruits (a) by enriching the fruit juice with the amount of pectin determined necessary, and (b) by adding pectin according to the pectin grade, neglecting that naturally present in the fruit juice.

The fruits used for this investigation included Taylor red raspberries, Bristol black raspberries, Montmorency

cherries, Red Lake red currants, Rubel blueberries, and El Dorado blackberries.

REVIEW OF LITERATURE

According to Lathrop (19) the preserve, jam or jelly industry requires the proper selection of the right varieties of fruits at their most desirable stages of development and the subsequent prevention or retardation of the alteration of their chemical constituents influenced by the environmental conditions.

Chenoweth (4) stated that blackberries, blueberries and raspberries for jelly making should be selected before they become soft ripe. They should be well colored but firm. Blueberries normally make a very tender jelly of delicate flavor and fragrance. Red varieties of currants are most generally used for jelly making. The fruits should be ripe and fresh. Fruits that are picked and stored prior to jelly making are likely to be deficient in pectin.

Yeatman and Steinbarger (36) stated, "The color substances in fruits are mostly carotinoids (the yellow to orange color range) and anthocyanins (the red and blues). The yellow to orange colors are fairly stable, but the reds and blues tend to change to dull browns when the fruits are overcooked. Tannin

present in fruits in varying amounts tend to break down during cooking and discolor products made of light-colored fruits."

Cruess (7) reported that the jelly formation is a colloidal phenomenon influenced by pectin concentration, constitution of pectin, size of molecule, hydrogen ion concentration, distilled water in proper proportion and sugar concentration. Fruit juices normally deficient in pectin or acid or both will make good jelly if these constituents are added.

According to Lal Singh (17), the amounts of pectin and acid in fruits are the determining factors in jelly making. The relative amount of sugar in fruit juices is of less importance since addition of sugar is necessary in all fruit juices for jelly making. A juice containing no pectin or acid will not make jelly while a juice containing these in small amounts will make jelly only when it is highly concentrated.

Cruess and McNair (8) stated that fruits like apples, loganberries and blackberries contain sufficient acid and pectin to give satisfactory jellies. Some of the varieties of strawberries, cherries and apricots are rich in acid and deficient in pectin, and that ripe blackberries have moderate concentration of both acid and pectin.

Hinton and Macara (14) reported that pectin containing tissues tend to give up their pectin in varying degrees according to the nature and pH of the extracting liquid; concentration of salt also has a marked influence.

Tarr (30) found that increasing the pectin content increased the strength of jelly within certain limits. Boiling the pectin with acid, prior to the addition of sugar, reduced the strength of jelly. However, in presence of sugar, boiling for a long time failed to affect appreciably the strength of jelly. Increasing the quantity of acid increased the strength of jelly until the optimum jelly was obtained; further additions of acid decreased the jelly strength.

The strength of jelly was decreased with the increase of temperature and increased with the time of standing.

According to Myer and Baker (24), the jelly grade of a pectin reaches an optimum value when the pectin is extracted at a hydrogen ion concentration of approximately pH 2.40 and decreases as the time of boiling during extraction increases.

Morris (22) using fresh red currants, found crude pectin content of 1.045 per cent and pH 3.23. Four hundred ninety cc of this extraction was boiled with 500 grams of sugar to

yield a jelly having 67 per cent soluble solids. The addition of citric acid increased the speed of setting, but did not appear to affect the jelly strength. Sodium citrate increased the jelly strength. Sodium carbonate seemed to have an affect similar to sodium citrate.

Lal Singh (18) reported that the higher the amount of pectin in fruit juice the lower the Balling degree at which it begins to jell, resulting in a saving of sugar.

Leinbach and his co-workers (20) stated that the Cuthbert red raspberries had higher sugar content and higher sugar-acid ratio than the other varieties tested and it had lower methoxyl and uronic anhydride content for its pectin. Pectinase was found in significant amounts in all the varieties of raspberries tested.

According to Krishnamurthi and Giri (16), the mere presence of pectin in any plant material does not confer upon it the property of forming jellies in the presence of sugar and acid. The uronic anhydride or methoxyl value of the pectins and their jellying power may be involved in jelly formation.

Myers and Baker (23) pointed out that the jelly strength is the function of the viscosity of the pectin solution from which the jelly is made. The sugar necessary to add to a

pectin solution to produce a jelly of a given strength and the viscosity of the total solution determines the yield of jelly.

Hinton (13) stated that pectin has a reducing action on alkaline solutions indicating a chain structure for the molecule; this property of pectin can be correlated with the jellying power. The jellying power varies with the type of fruit, the heat to which it has been subjected, pH conditions and pectase action.

Macara (21) reported that the pectin is rendered insoluble by an enzyme in the fruit that escapes when it is bruised. In raspberries the enzyme is so active that sometimes no soluble pectin is left in the fruit after 12 hours. This change can be prevented by heating the fruit to 150° F. which destroys the enzyme.

Tikka and Porvari (33) studied cranberries and red currants and found that the setting capacity of pectin did not suffer reduction during storage if the acidity was kept below pH 2.0. The pectins were most easily decomposed by the enzymes at a pH of 4.5 to 5.0.

Baker (1) found that a definite pectin-sugar ratio must be maintained for a certain pH in order to obtain a jelly of

optimum strength; he also stated that decreasing the temperature of jelly increases the jelly strength.

Tarr and Baker (32) stated that the texture, flavor and yield of jelly are mainly determined by the quantity of sugar that should be added; there is no fixed amount of sugar that should be added to insure successful jelly formation. Other conditions being equal, a weak jelly results from the addition of too much sugar and the tough jelly results from the addition of too little sugar. The quantity of sugar that may be added varies with the pH of the fruit juice. The function of sugar may be that of a dehydrating agent. The acid is understood to control the precipitation of the pectin in the jelly form.

Tolman et al. (34) reported that during the jelly making, cane sugar is inverted. The extent of inversion varies with the time of heating and nature and kind of acid present.

Goldthwaite (10, 11) supported the work of Tolman and his co-workers and added that a certain degree of inversion is desirable to prevent the crystallization of sucrose in the finished jellies.

According to Fiedler (9), satisfactory pectin jellies cannot be made with invert sugar. Inversion of sucrose causes the pectin to lose its jellying power.

Cole et al. (5) pointed out that inversion of sucrose in jelly after its formation does not alter appreciably the properties of jelly and the sucrose inversion which takes place cannot be accounted for jelly failure as described by Fiedler. They also suggested that jelly failure often results from "preventive gelation."

Griebel and Weiss (12) found an approximate direct proportionality between the methoxy content and jellying power of a pectin product.

Crocker (6) stated, "The hydrogen ion concentration has a unique influence on the color and flavor of many articles that are cooked as a step in their preparation."

Tarr (29) reported that there is a direct correlation between jelly formation and hydrogen ion concentration. The minimum hydrogen ion concentration at which jelly formation occurs is pH 3.46 for the purest source of pectin. Jelly formation occurs irrespective of the quantity of pectin present. Once the minimum pH is attained the quantity of pectin, however, must

equal the minimum amount that is essential for the production of jelly. With pectin, sugar and water constant, the character of jelly is determined as there is a stoichiometric relationship between pectin and combining power of acid.

According to Stuewer, et al. (28), the optimum pH of the pectin jellies varies with the age of sample, method of preparation and concentration of pectin.

Pederson and Beattie (26) stated that the juice and the products should be prepared from the fruits of the type which have particular nutritive qualities and would appeal to the consumers.

The best juice could be obtained if extracted from chilled sliced fruits to which about 12 per cent of sucrose was added, but the largest yield was obtained when extracted at 49^{o} C.

Baker and Goodwin (3) found that even small amounts of metals present in pectin solutions cause abnormal changes in viscosity in certain pH ranges. Perplexing shifts from high to low viscosity jelly grade ratios are influenced by the presence of salts and lack of pH control.

Tarr (31) reported that the anion of the salt functions mainly as a buffering agent and may also function as a peptizing agent if present in sufficient quantities, thereby increasing the strength of jellies and preventing synersis. The character of the jelly depends on the ionic concentration of the juice from which jelly is made.

Baker and Gilligan (2) pointed out that the addition of one per cent polyphosphate prior to heating and pressing the blackberries gave 82 per cent increase of pectin at pH 3.35.

EXPERIMENTAL PROCEDURE

The method used for the pectin determination was that described by Storto (27). A one per cent pectin solution was made from Speas 170 grade pure pectin and from this solution dilutions were made to contain 0.02, 0.04, 0.05, 0.06, 0.075 and 0.0875 per cent pectin. Duplicate 5 ml samples of these solutions were pipetted into 15 ml centrifuge tubes graduated in 0.1 ml. One-half gm of talc powder was added and they were vigorously shaken for 15 seconds. Then 10 mls of 95 per cent ethyl alcohol were added and the tubes again shaken vigorously and uniformly for one minute. The tubes were allowed to stand for 10 minutes and the height of the sediment determined. Readings were made every 5 minutes until two successive readings varied less than 0.05 ml. A blank determination was made, to determine the amount of sedimentation due to the talc powder, by substitution of distilled water for the pectin solution. The sedimentation due to pectin was determined by difference. The results obtained are shown in Table I and Figures 1 and 2.

The fruits used in this study were Taylor red raspberries, Bristol black raspberries, Montmorency cherries, Red Lake red currants, Rubel blueberries and El Dorado blackberries. With the exception of the raspberries, two stages of maturity, namely immature and mature, of the fruits were used.

The fruits were frozen and held at -5° F. until used. When removed from frozen storage, they were sorted to remove floral parts, blossom ends and all spoiled fruit. The jelly stock of each fruit was prepared by simmering one pound of fruit with 3/4 pint of water in a kettle for five minutes and then allowing them to stand for ten minutes for better extraction of pectin and color of the fruit. About six facial tissues, that had been previously macerated, thoroughly washed in hot water and squeezed out, were added during the cooking process to aid in filtration. The cooked fruit was placed in a jelly cloth and the juice pressed out. The pulp was returned to the kettle and a second extraction was made repeating the above procedure. The juice from the two extractions was mixed, refiltered with the aid of more tissues and used as the stock solution for the pectin determinations and the making of jelly.

Two jellies were made from each fruit jelly stock. The first by adding, if necessary, the calculated amount of pectin required to obtain good jellification, and the second by adding pectin according to the pectin grade, assuming that the jelly stock had no pectin present.

The data on the jelly formulas are given in Table III.

The jelly stock was placed in a steam-jacketed kettle and concentrated to about one-half of its original volume by rapid boiling. The amount of pectin required, mixed with the dry sugar was then dissolved in the boiling concentrated jelly stock and boiling continued until the solution reached 65 per cent soluble solids as determined by an Abbé refractometer. The jelly was then filled hot in 5-ounce glass jars containing 0.75 ml of 50 per cent citric acid solution (except for Montmorency cherries where it was found necessary to use 1.25 ml of a 50 per cent tartaric acid solution to get gellation), sealed and allowed to cool.

The soluble solids content and pH of the jelly stock before and after concentrating were determined using an Abbé refractometer and Beckman pH meter, respectively.

The jellies, after two weeks' storage, were evaluated by a consumer preference panel which graded them on the basis of color, flavor, consistency and acceptability, using a score sheet (Plate 1).

TABLE I

RELATION OF PECTIN CONCENTRATION TO VOLUME OF SEDIMENT

No. of Experiment	Solution			Amount of Deposit		Time	Observations
	Talc	Pectin		Total	Corrected		
	gm	mg	%	ml	ml	min.	
4	0.5	0	0	0.55	0.55	35	Liquid very turbid
8	0.5	1	0.02	0.70	0.15	45	Liquid turbid
8	0.5	2.0	0.04	0.85	0.30	45	Liquid clear
8	0.5	2.5	0.05	0.92	0.37	55	Liquid clear
8	0.5	3.0	0.06	0.99	0.44	50	Liquid clear
8	0.5	3.75	0.075	1.10	0.55	50	Sed. slow
8	0.5	4.375	0.0875	1.19	0.64	55	Sed. slow, liquid turbid

FIGURE 1

SEDIMENTATION RATE OF TALC AND PECTIN SOLUTIONS*

A - Sedimentation rate of talc

B - Sedimentation rate of 0.02% pectin solution

C - Sedimentation rate of 0.04% pectin solution

D - Sedimentation rate of 0.05% pectin solution

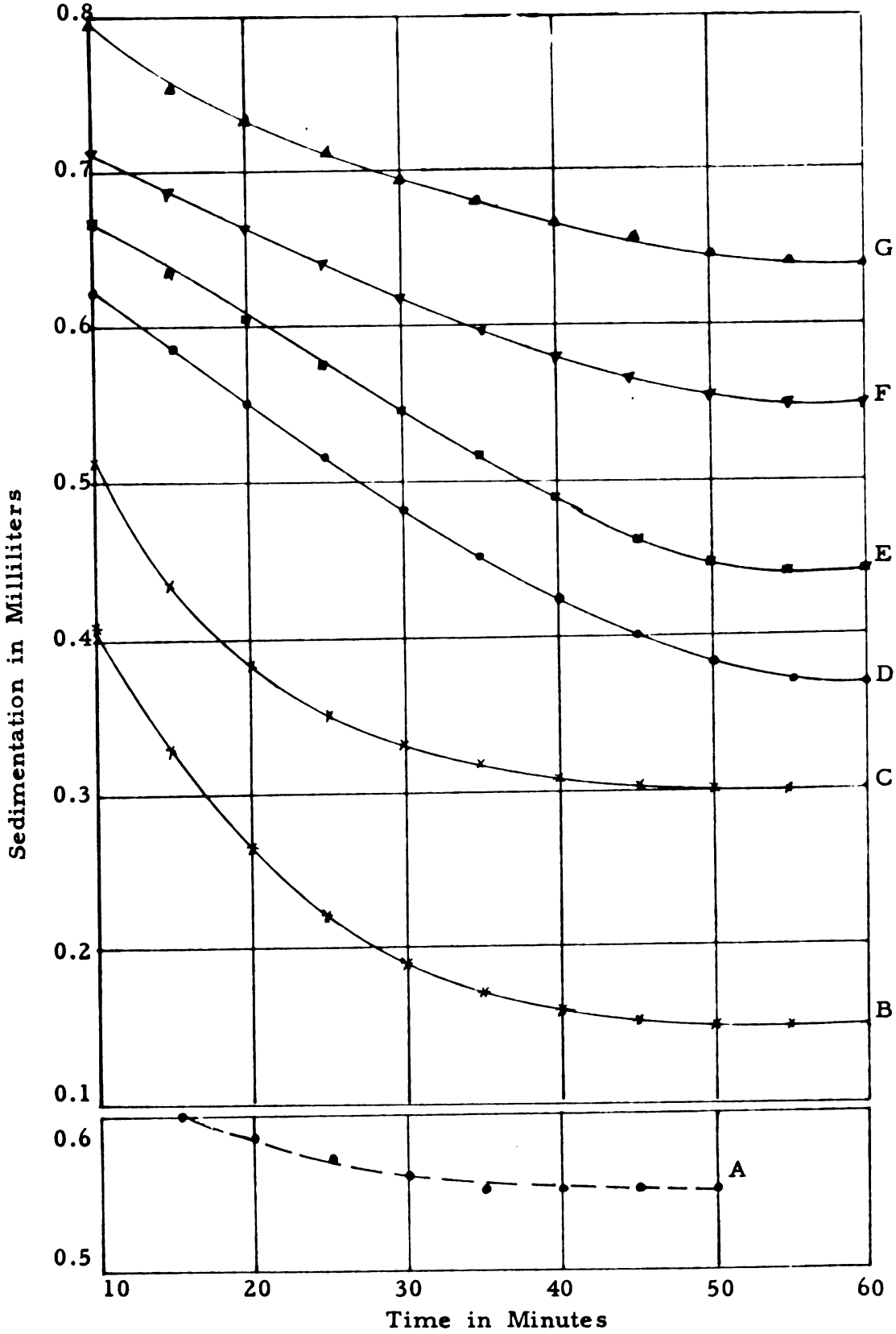
E - Sedimentation rate of 0.06% pectin solution

F - Sedimentation rate of 0.075% pectin solution

G - Sedimentation rate of 0.0875% pectin solution

* 170 grade pure pectin.

Figure 1. Sedimentation rate of talc and pectin solutions*



* 170 grade pure pectin.

FIGURE 2

STANDARD PECTIN CURVE

Sedimentation in milliliters against concentrations of pectin solutions in percentages.

Figure 2. Standard pectin curve.

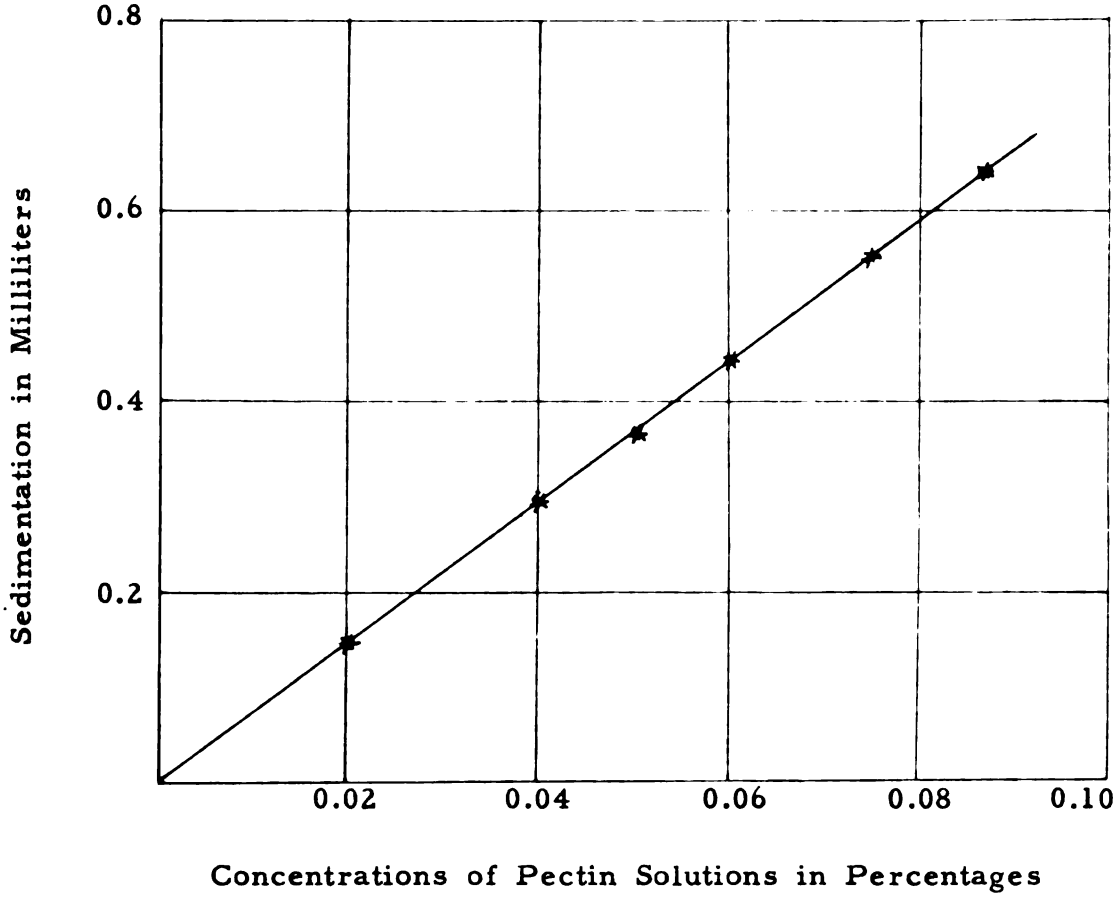


TABLE II

FRUIT JELLY STOCK ANALYSIS

No.	No. of Exp.	Fruit	Jelly Stock	Soluble Solids	pH	Dilution	Amount of Deposit	
							Actual	Corrected
			ml./lb. fruit	%			ml	ml
1	3	Red Raspberries	Original 745	6.8	3.48	1-20	1.49	0.94
	3		Concentrated 372.5	13.6	3.48	1-20	1.70	1.15
2	3	Black Raspberries	Original 695	7.4	3.91	1-8	1.43	0.88
	3		Concentrated 347.5	14.8	3.90	1-10	1.52	0.97
3	3	Cherries Immature	Original 720	6.0	3.68	1-10	0.65	0.10
	3		Concentrated 360	12.0	3.68	1-10	0.75	0.20
4	3	Cherries Mature	Original 860	7.0	3.68	0	1.02	0.47
	3		Concentrated 430	14.0	3.68	1-2	1.02	0.47

TABLE II (Continued)

Time	Pectin Content	Pectin per lb. of Fruit	Pectin Destruction	Pectin per qt. of Jelly Stock	Observations
min.	%	gms	%	gms	
40	0.1275	19.0		24.12	
45	0.1555	11.583	39.04	29.41	Solution clear
45	0.12	6.655		9.88	
45	0.1315	4.57	31.33	12.44	Solution slightly turbid
45	0.014	1.008		1.323	
55	0.027	0.972	3.57	2.552	Solution turbid initially, slightly turbid after sedimentation
40	0.064	0.5505		0.606	
40	0.064	0.2978	45.91	0.655	Solution clear

TABLE II (Continued)

No.	No. of Exp.	Fruit	Jelly Stock	Soluble Solids	pH	Dilution	Amount of Deposit	
							Actual	Corrected
			ml/lb. fruit	%			ml	ml
5	3	Red Currants Immature	Original 835	6.5	3.20	1-20	1.16	0.61
	3		Concentrated 417.5	13.0	3.20	1-50	1.02	0.47
6	3	Red Currants Mature	Original 910	6.5	3.20	1-25	1.21	0.66
	3		Concentrated 455	13.0	3.15	1-50	1.21	0.66
7	3	Blueberries Immature	Original 560	5.5	3.20	1-20	1.34	0.79
	3		Concentrated 280	11.0	-	1-50	1.28	0.73
8	3	Blueberries Mature	Original 775	6.8	3.28	1-4	1.67	1.12
	3		Concentrated 387.5	13.6	-	1-8	1.74	1.19

TABLE II (Continued)

Time	Pectin Content	Pectin per lb. of Fruit	Pectin Destruction	Pectin per qt. of Jelly Stock	Observations
min.	%	gms	%	gms	
45	0.083	13.85		15.69	
45	0.064	13.34	3.68	30.28	Solution clear
45	0.088	20.0		20.79	
45	0.088	20.0	0.0	49.55	Solution clear
40	0.107	11.98		20.22	
40	0.099	13.85	-	46.8	Sedimentation fast and solution slightly turbid
40	0.152	4.705		5.745	
40	0.161	4.99	-	12.20	Sedimentation fast and solution slightly turbid

TABLE II (Continued)

No.	No. of Exp.	Fruit	Jelly Stock	Soluble Solids	pH	Dilution	Amount of Deposit	
							Actual	Corrected
			ml/lb. fruit	%			ml	ml
9	3	Blackberries Immature	Original 700	4.3	3.50	1-20	1.05	0.50
	3		Concentrated 350	6.8	3.50	1-40	0.97	0.42
10	3	Blackberries Mature	Original 700	-	-	1-20	0.79	0.24
	3		Concentrated 350	-	-	1-50	0.86	0.31

TABLE II (Continued)

Time	Pectin Content	Pectin per lb. of Fruit	Pectin Destruction	Pectin per qt. of Jelly Stock	Observations
min.	%	gms	%	gms	
55	0.068	9.525		12.875	
55	0.057	7.98	16.24	21.58	Solution slightly turbid
55	0.033	4.616		6.225	
50	0.042	7.345	-	19.85	Solution slightly turbid

FIGURE 3

SEDIMENTATION RATE OF RED AND BLACK RASPBERRY JELLY STOCK

A - Red raspberry original jelly stock, dilution 1-20

B - Red raspberry concentrated jelly stock, dilution 1-20

C - Black raspberry original jelly stock, dilution 1-8

D - Black raspberry concentrated jelly stock, dilution 1-10

Figure 3. Sedimentation rate of red and black raspberry jelly stock.

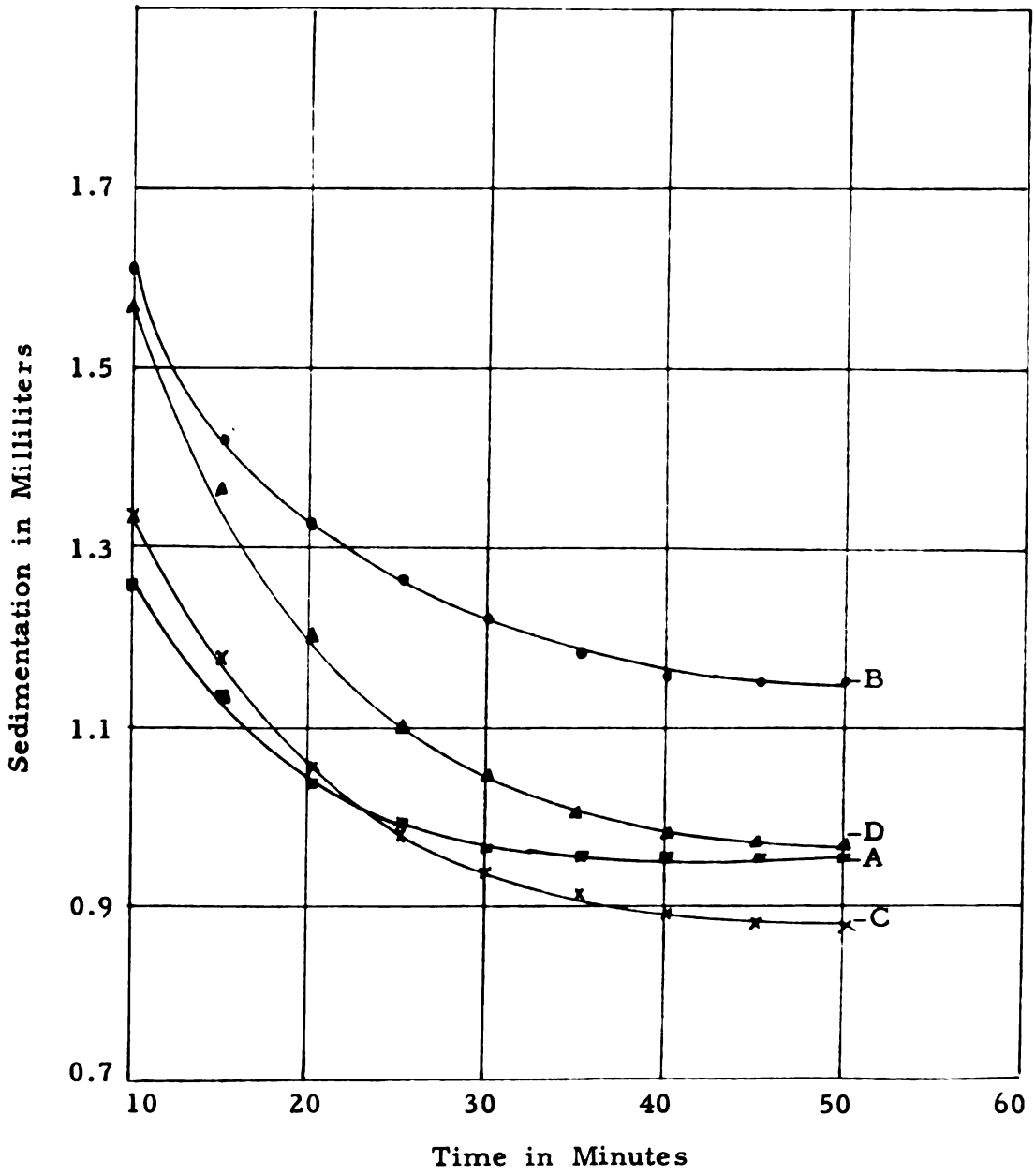


FIGURE 4

SEDIMENTATION RATE OF CHERRY AND RED CURRANT JELLY STOCK

A - Immature red currant original jelly stock, dilution 1-20

B - Immature red currant concentrated jelly stock, dilution 1-50

C - Mature red currant original jelly stock, dilution 1-25

D - Mature red currant concentrated jelly stock, dilution 1-50

E - Immature cherry original jelly stock, dilution 1-10

F - Immature cherry concentrated jelly stock, dilution 1-10

G - Mature cherry original jelly stock, dilution 0

H - Mature cherry concentrated jelly stock, dilution 1-2

Figure 4. Sedimentation rate of cherry and red currant jelly stock.

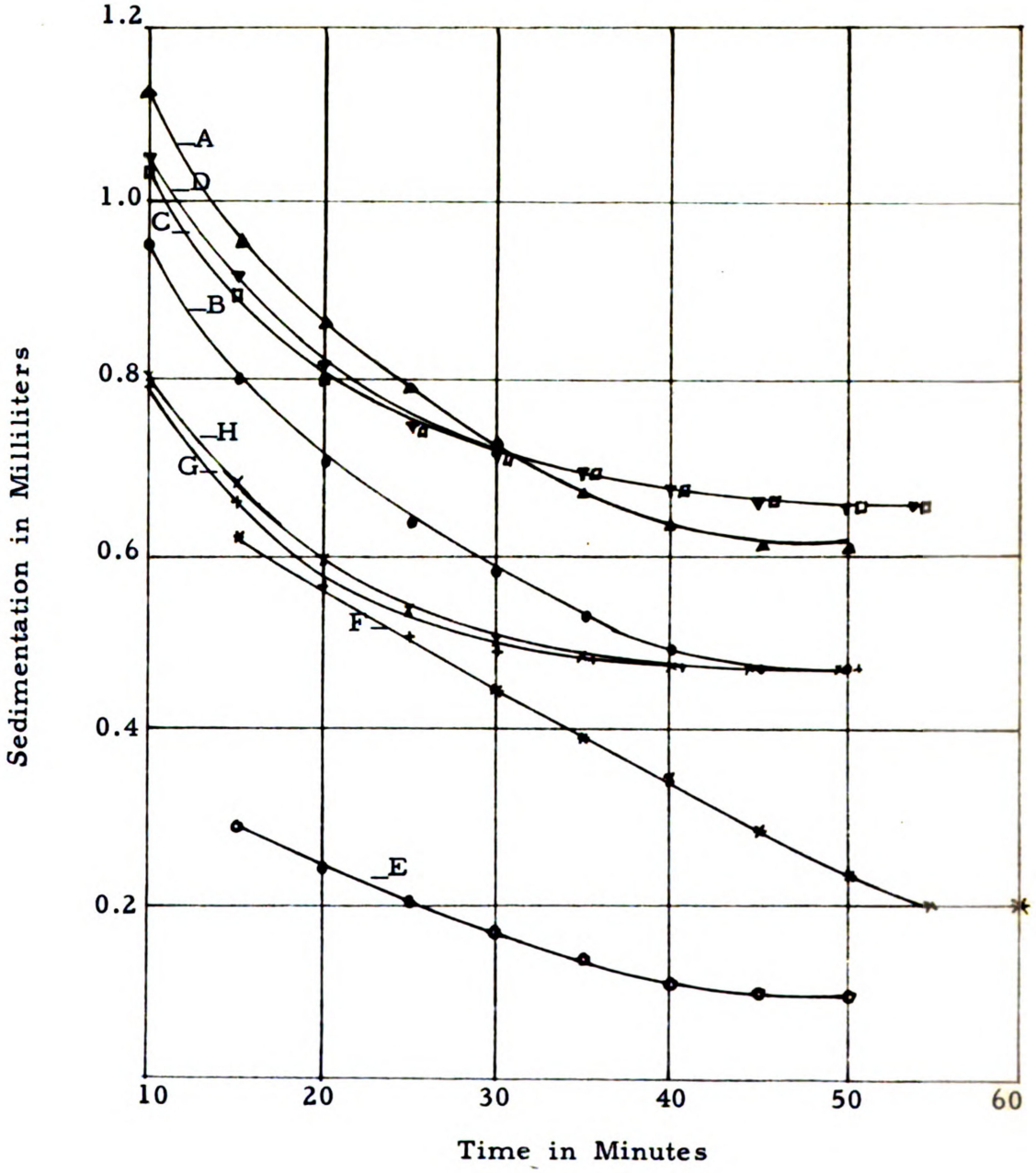


FIGURE 5

SEDIMENTATION RATE OF BLUEBERRY AND BLACKBERRY JELLY STOCK

A - Immature blueberry original jelly stock, dilution 1-20

B - Immature blueberry concentrated jelly stock, dilution 1-50

C - Mature blueberry original jelly stock, dilution 1-4

D - Mature blueberry concentrated jelly stock, dilution 1-8

E - Immature blackberry original jelly stock, dilution 1-20

F - Immature blackberry concentrated jelly stock, dilution 1-40

G - Mature blackberry original jelly stock, dilution 1-20

H - Mature blackberry concentrated jelly stock, dilution 1-50

Figure 5. Sedimentation rate of blueberry and blackberry jelly stock.

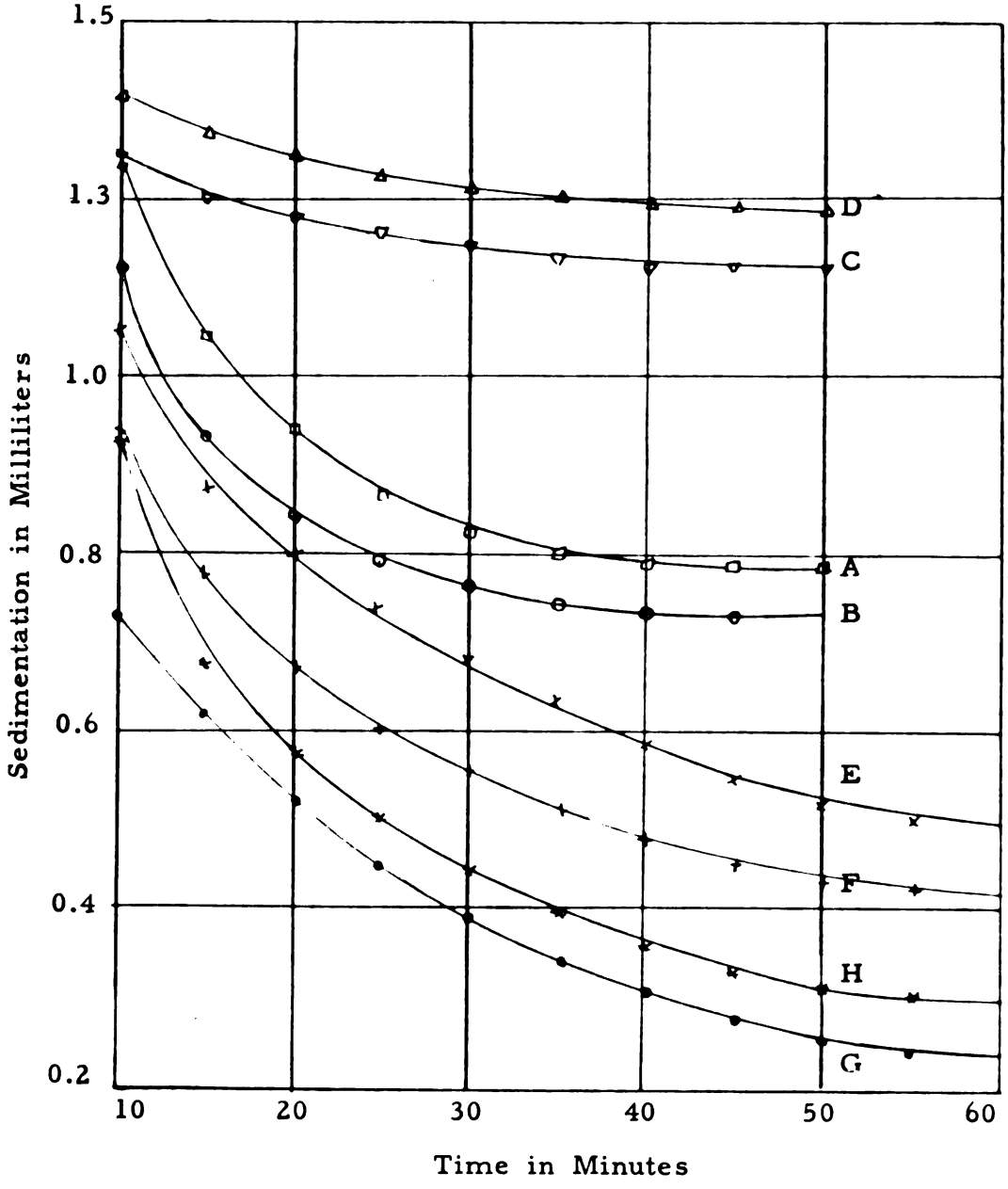


TABLE III

JELLY FORMULAS

No.	Fruit	Jelly Stock	Sugar	Pectin* Required	Pectin Present in Jelly Stock		Pectin* Added
					Original	Concentrated	
		fl. oz.	oz.	gms.	gms./qt.	gms./qt.	gms.
1	Red Raspberries	32	16	4.54	24.12	29.41	-
2	Black Raspberries	32	16	4.54	9.88	12.42	-
3	Cherries Immature	32	16	6.81	1.323	2.552	5.487
4	Cherries Mature	32	16	6.81	0.606	0.655	6.204
5	Red Currants Immature	32	16	4.54	15.69	30.28	-
6	Red Currants Mature	32	16	4.54	20.79	41.55	-
7	Blueberries Immature	32	16	4.54	20.22	46.8	-
8	Blueberries Mature	32	16	4.54	5.745	12.20	-
9	Blackberries Immature	32	16	4.54	12.875	21.58	-

* 100 grade pectin.

PLATE 1

JELLY SCORE SHEET (15)

Name Date

Color: The color of the jelly should be clear, transparent, and typical of the fruit used.

Flavor: The jelly should retain as closely as possible the original flavor of the fruit used.

Consistency: The jelly should be tender when cut, yet still sufficiently firm that a sharp edge and smooth surface remain. It should be gelatinous and not sirupy, gummy or sticky.

Suggested method for testing:

Taste each jelly separately.

Remove the taste of the jelly with the use of cracker or water or both before proceeding to the next jelly.

Key: 1. Very Poor; 2. Poor; 3. Fair; 4. Medium; 5. Good; 6. Very Good; 7. Excellent.

Factors	Code
Color	
Flavor	
Consistency	
Acceptability (yes or no)	
Added Comments	

If scored below Fair (3), please give reason:

Color: Off Color, Too Light, Too Dark.

Flavor: Off Flavor, Too Light, Too Strong.

Consistency: Too Soft, Too Firm, Gummy.

TABLE IV

JELLY-COLOR RATING

	Red Raspberries		Black Raspberries		Immature Cherries		Mature Cherries	
	A*	B**	A*	B**	A*	B**	A*	B**
	5	5	5	5	6	6	5	5
	4	4	6	6	4	4	6	6
	4	4	5	5	5	5	6	6
	5	5	5	6	5	7	4	5
	6	5	7	6	6	5	5	6
	6	6	6	6	5	5	7	7
	4	4	6	6	5	3	6	5
	5	5	6	6	5	3	5	5
	2	2	6	7	5	6	3	4
	5	5	4	5	5	5	6	6
	5	4	5	6	5	4	5	6
	6	6	6	6	6	6	6	6
	4	2	6	6	6	6	4	4
	3	2	6	6	4	5	6	5
	5	5	7	7	5	5	6	5
	5	5	5	5	5	7	5	5
	1	2	4	5	4	5	3	2
	2	1	7	6	5	6	5	6
	4	4	5	5	4	4	4	5
	6	6	6	6	6	6	7	7
	5	5	5	5	6	6	6	6
	5	6	6	6	6	6	6	6
	4	5	5	5	5	6	5	6
Average	4.4	4.3	5.6	5.74	5.1	5.25	5.35	5.35

* Pectin added.

**Calculated Amount of Pectin added.

TABLE IV (Continued)

Immature Red Currants		Mature Red Currants		Immature Blueberries		Mature Blueberries		Immature Black-berries	
A*	B**	A*	B**	A*	B**	A*	B**	A*	B**
5	5	5	5	5	5	5	5	4	4
6	6	5	6	6	6	6	6	6	6
6	6	6	7	4	4	5	6	5	5
6	6	6	6	5	5	5	5	5	7
6	6	6	6	6	5	5	6	7	7
6	6	6	5	5	5	5	5	7	7
7	7	7	7	6	7	7	6	7	7
7	7	7	7	7	7	7	7	7	7
5	5	5	5	3	3	5	5	5	5
6	6	6	7	7	7	7	7	5	7
5	5	5	5	5	5	5	5	5	5
5	4	5	6	6	4	4	5	6	5
6	5	6	4	5	4	5	6	6	5
3	3	2	3	4	3	3	6	4	5
5	6	6	5	5	5	3	6	7	6
5	5	4	4	2	3	3	5	5	6
7	7	7	7	4	5	5	5	7	7
6	6	5	5	5	5	5	5	6	6
7	7	7	7	5	7	7	6	6	6
5.74	5.68	5.58	5.63	5.0	5.0	5.1	5.63	5.9	5.95

Key: 1. Very Poor; 2. Poor; 3. Fair; 4. Medium; 5. Good; 6. Very Good; 7. Excellent.

TABLE V

JELLY-FLAVOR RATING

Red Raspberries		Black Raspberries		Immature Cherries		Mature Cherries	
A*	B**	A*	B**	A*	B**	A*	B**
1	1	6	6	4	4	3	3
1	1	6	6	5	4	6	6
1	1	4	5	4	4	5	5
4	6	6	5	5	7	4	5
6	5	7	6	6	5	5	6
7	5	7	7	4	4	5	6
5	4	6	5	4	3	6	4
2	2	6	7	5	6	3	4
3	4	6	6	6	2	6	5
6	3	6	4	5	4	5	6
3	4	6	7	5	5	5	6
2	1	7	7	5	3	5	6
1	1	7	6	3	4	6	4
1	1	7	7	2	4	3	6
1	1	6	6	5	5	5	5
1	2	4	4	2	2	4	4
2	1	6	5	4	5	6	7
4	4	7	5	5	5	5	6
3	2	6	5	4	3	4	4
6	7	6	6	6	6	7	7
6	4	7	7	6	7	6	7
4	3	4	5	5	4	6	4
4	5	5	4	5	6	4	6
Average 3.21	2.95	6.00	5.61	4.57	4.49	5.13	5.3

* Pectin added.

**Calculated Amount of Pectin added.

TABLE V (Continued)

Immature Red Currants		Mature Red Currants		Immature Blueberries		Mature Blueberries		Immature Black-berries	
A*	B**	A*	B**	A*	B**	A*	B**	A*	B**
5	5	5	5	4	4	5	5	3	3
5	5	4	5	3	4	5	6	5	6
4	5	5	4	3	4	6	6	5	6
5	6	2	2	2	2	5	2	3	5
6	6	4	5	6	5	4	6	6	7
6	6	6	4	5	4	4	5	6	7
6	6	6	6	6	6	5	5	7	7
6	6	5	5	6	6	5	5	4	4
4	4	4	5	3	3	4	4	3	2
4	2	7	5	2	2	5	7	2	2
4	4	4	4	2	2	5	5	4	4
6	5	6	6	6	7	5	7	5	5
4	4	5	4	3	3	5	4	4	6
3	3	2	3	4	3	4	6	5	5
6	6	6	5	4	4	5	6	7	7
5	6	4	5	3	3	5	6	4	5
7	7	6	7	6	5	5	4	7	6
5	6	5	6	4	4	5	4	2	2
5	6	7	7	3	5	7	6	6	7
5.05	5.16	4.84	4.89	3.95	4.00	4.95	5.2	4.63	5.05

Key: 1. Very Poor; 2. Poor; 3. Fair; 4. Medium; 5. Good; 6. Very Good; 7. Excellent.

TABLE VI

JELLY-CONSISTENCY RATING

	Red Raspberries		Black Raspberries		Immature Cherries		Mature Cherries	
	A*	B**	A*	B**	A*	B**	A*	B**
	5	3	4	4	5	3	4	4
	5	2	3	2	5	1	6	6
	6	3	4	3	6	2	6	5
	7	3	4	4	6	1	5	6
	3	3	4	4	6	3	5	5
	6	4	5	4	6	2	6	6
	4	2	5	4	4	2	5	6
	3	2	5	5	4	2	5	5
	4	3	4	4	7	3	5	5
	3	3	5	5	6	2	6	5
	6	3	6	4	5	1	7	7
	4	2	3	2	5	2	5	5
	2	1	2	1	4	1	6	5
	2	2	5	4	2	1	7	5
	2	4	7	5	2	1	6	2
	5	3	5	6	7	2	7	7
	1	3	4	4	2	1	3	2
	5	1	3	2	6	1	7	5
	5	4	5	3	6	2	6	5
	4	4	6	4	5	1	4	5
	4	3	6	6	5	2	6	5
	5	3	6	6	6	3	6	6
	4	3	4	3	5	2	5	2
Average	4.13	2.8	4.55	3.87	5.0	1.78	5.57	5.0

* Pectin added.

**Calculated Amount of Pectin added.

TABLE VI (Continued)

Immature Red Currants		Mature Red Currants		Immature Blueberries		Mature Blueberries		Immature Black-berries	
A*	B**	A*	B**	A*	B**	A*	B**	A*	B**
4	4	4	5	3	3	5	3	4	5
4	4	2	6	3	3	1	5	2	5
5	4	4	7	4	4	3	5	4	5
3	6	1	6	3	2	2	4	2	6
6	7	7	5	4	5	6	6	7	7
7	7	7	6	2	4	5	3	7	7
6	6	6	6	5	6	5	5	6	6
5	5	5	5	3	3	3	4	4	4
5	5	5	5	3	3	4	4	5	5
3	3	3	3	4	4	5	6	5	5
6	6	6	6	4	4	7	4	6	6
5	3	4	6	4	4	2	6	2	4
5	5	5	4	2	2	3	2	5	4
3	3	1	4	3	3	3	6	3	5
7	7	6	6	3	5	4	6	6	7
5	6	4	5	3	3	5	6	5	6
7	6	6	7	3	3	3	4	6	7
5	6	5	7	3	3	4	3	5	6
6	7	7	6	2	3	7	5	7	7
5.1	5.26	4.63	5.53	3.21	3.52	4.05	4.58	4.79	5.63

Key: 1. Very Poor; 2. Poor; 3. Fair; 4. Medium; 5. Good; 6. Very Good; 7. Excellent.

RESULTS AND DISCUSSION

The results obtained with pure pectin, using the method described by Storto (27) are summarized in Table I and Figures 1 and 2. The sedimentation rate of the talc was fairly rapid and a constant amount of precipitate was obtained after 35 minutes. The sedimentation rate of the pectin solutions was rapid during the initial 5 to 15 minutes, and then decreased to a slower constant rate until the amount of precipitate became constant. The time of the initial rapid rate depended to some extent upon the concentration of the pectin being longer at the lower concentrations (Figure 1). At concentrations above 0.0875 per cent, the volume of precipitate obtained varied between samples, and regardless of the time allowed for sedimentation, consistent results could not be obtained.

The line obtained by plotting concentration of pectin against volume of sediment, when concentrations of pectin 0.02 per cent to 0.0875 per cent were used, was a straight line (Figure 2). The time required to obtain a constant and reproducible precipitate was from 45 to 55 minutes. This method, therefore,

is fairly rapid and precise when the pectin concentration is maintained within the above range.

The data obtained on jelly stocks are summarized in Table II and the rates of sedimentation shown in Figures 3, 4 and 5. The pectin determinations were made on both the original and concentrated jelly stocks diluted so that the amount of sediment obtained would fall within the range of the curve established with pure pectin.

The results show that the pectin content of the red currants increased with the maturing of the fruit, while that of the cherries, blueberries and blackberries decreased. Concentrating the jelly stock to half its original volume resulted in the destruction of some pectin. This was most marked in cherries and red and black raspberries, and least in mature blackberries. This cannot be explained on the basis of acidity because the pH of the red currants and blueberries was the lowest of the fruits used.

Concentrating of the jelly stock had no effect on the pH. The soluble solids content were doubled (Table II).

The data on the jelly stocks (Table III) showed that only the red cherry jelly stock was low in pectin and required additional

pectin. In the other fruit jelly stocks the pectin content, as determined, was sufficient for good jelly making. The use of 1.25 ml of 50 per cent tartaric acid in place of 0.75 ml of citric acid in the making of red cherry jelly was found necessary to obtain a jelly of about pH 3.2. The pH of the red cherry jelly stock when concentrated with pectin and sugar shifted from pH 3.68 to pH 4.0 and the addition of citric acid, even at a concentration of 1.25 ml did not reduce the pH below 3.6.

The results on the grading of the jellies after two weeks' storage are given in Tables IV, V and VI. No significant differences were found between the color and flavor of the jellies made with total pectin added and with the calculated required amount of pectin added. The results on the consistencies of the jellies were variable. The jellies made from red and black raspberries where no pectin was added were given lower scores than those with the standard amount of pectin added while the immature and mature blueberry, immature and mature currant and immature blackberry jellies with no pectin added were given higher scores than those with pectin added. The immature and mature cherry jellies with the calculated amount of pectin added were also scored lower than those with the standard amount of

pectin added. It is to be noted, however, that only the differences between the scores of the immature cherry and red raspberry jellies were highly significant.

At the present time, no definite explanation can be given for the differences obtained. It is known, however, that the pectic substances naturally present in various fruits differ in their jellying power and this, in part, may account for some of the differences obtained. These differences were not taken into consideration in the method used for the pectin determination. Therefore, it seems that this procedure, although it gave consistent results with respect to the amount of the precipitate, cannot be relied upon to determine whether or not pectin should be added to make a satisfactory jelly and further investigations need to be made to determine the relationship between the amount of precipitate and the jellying power of the pectin it contains. The procedure developed by Storto (27) was only used on apple and citrus jelly stocks, both known to contain pectin of good jellying properties, and he obtained good correlations between the pectin determined and its calcium pectate content.

SUMMARY

The pectin contents of red and black raspberries, immature and mature cherries, currants, blueberries and blackberries were determined. Jellies were made from these fruits by adding (a) the calculated required amount of pectin, and (b) a standard amount neglecting that present in the jelly stock and were graded after two weeks' storage for color, flavor and consistency.

A straight line curve was obtained for the pectin determination when the pectin concentration was between 0.02 and 0.0875 per cent.

With the exception of red cherries, the fruits contained sufficient pectin, as determined, for good jellification. There was a destruction of pectin during concentration of the jelly stock. This destruction showed no correlation with the pH of the jelly stock.

There were no significant differences between the color and flavor of the jellies made with and without added pectin.

The consistency of red and black raspberry jellies without added pectin was poorer than that of the jellies with

added pectin while the consistency of the immature and mature blueberry, red currant and immature blackberry jellies without added pectin was better than that of the jellies with added pectin. The cherry jellies required more added pectin and acid than the other fruit jellies to obtain good consistency.

The poor correlation obtained between the consistency of the jellies and the pectin content, as determined, indicated that further studies need to be made to determine the relationship between the amount of pectin present and its jellying power.

LITERATURE CITED

1. Baker, G. L. Jelly Strength of Pectin Jells. Ind. Eng. Chem., 18, 89 (1926).

2. Baker, G. L., and Gilligan. Commercial Jelly Making. Food Packer, 27, 56 (1946).

3. Baker. G. L., and Goodwin, M. V. Fruit Jellies X - The Role of Pectin. 6. Viscosity of Dilute Pectin Solutions as Affected by Metallic Salts and pH. Del. Agr. Exp. Sta., Bull., 216, Tech. No. 23 (1939).

4. Chenoweth, W. W. Food Preservation. 1930, John Wiley and Sons, New York, N. Y.

5. Cole, G. M., Cox, R. E., and Joseph, G. H. Does Sugar Inversion Affect Pectin Jelly Formation? Food Industries, 21, 219 (1930).

6. Crocker, E. C. Flavor 1945, McGraw-Hill Publishing Co., New York, N. Y.

7. Cruess, W. V. Commercial Fruit and Vegetable Products. 1948, McGraw-Hill Publishing Co., New York, N. Y.

8. Cruess, W. V., and McNair, J. B. Jelly Investigations. Jour. Ind. Eng. Chem., 8, 417 (1916).

9. Fiedler, K. The Influence of the Sugar Inversion on the Gel Formation. Konserven-Ind. 15, 405, 427 (1928).

10. Goldthwaite, N. E. Contribution on the Chemistry and Physics of Jelly-Making. Ind. Eng. Chem., 1, 333 (1909).

11. _____. Contribution on Jelly-Making. Ind. Eng. Chem., 2, 457 (1910).

12. Griebel, C., and Weiss, F. The Pectin Question. Z. Untersuch Lebensm, 58, 189 (1929).

13. Hinton, C. L. Fruit Pectins - Their Chemical Behavior and Jellying Properties. Dept. Sci. Ind. Research (Brit.), Food Invest., Special Rept. No. 48, 96 (1939).

14. Hinton, C. L., and Macara, T. The Composition of Some Jam Fruits and the Determination of the Fruit Contents of Jams. Analyst, 65, 540 (1940).

15. Klomparens, K. Combination Jellies - A Study of Some Combinations, Storage Times, and Temperature. Thesis for the Degree of M.S., Michigan State College. 1950.

16. Krishnamurthi, C. R., and Giri, K. V. Preparation, Purification and Composition of Pectins from Indian Fruits and Vegetables. Proc. Indian Acad. Sci., 29B, 155 (1949).

17. Lal Singh. Factors in Manufacturing Fruit Products. Canning Age, 3, 17, June (1922).

18. _____. Important Discoveries in Jelly Making. Canning Age, 3, 5, July (1922).

19. Lathrop, C. R. Chemistry and the Preserve or Jam Industry. Ind. Eng. Chem., 20, 1298 (1928).

20. Leinbach, C. P., Seegmiller, C. S., and Wilbur, J. S. Composition of Red Raspberries, Including Pectin Characterization. Food Technology, 5, 51 (1951).

21. Macara, T. Science and the Conservation of Food: Some Special Problems. Proc. Roy. Invest. Gt. Brit., Advance Copy, Apr. 16, 1937. Pp. 34.

22. Morris, T. N. The Effect of Modifying the Acidity of Extract of Red Currants on the Speed of Setting and the Strength of the Jelly. Dept. Sci. Ind. Research, (Brit.) Rept. Food Invest. Board, 1935, 186 (1936).

23. Myers, P. B., and Baker, G. L. Fruit Jellies V - The Role of Pectin. 1. The Viscosity and Jellying Properties of Pectin Solutions. Del. Agr. Exp. Sta., Bull., 149, Tech. No. 8 (1927).

24. _____. Fruit Jellies VI - The Role of Pectin. 2. The Extraction of Pectin from Pectic Materials. Del. Agr. Exp. Sta., Bull, 160, Tech. No. 10 (1929).

25. Neukomm, H. Pectin Gels. Mitt. Gebiete Lebensm. Gyg., 39, 21 (1948).

26. Pederson, C. S., and Beattie, H. G. Preparation and Preservation of Juices from Certain Small Fruits. Fruits Products Jour., 22, No. 9, 260 (1943).

27. Storto, T. A New Method of Determination of Pectin. Ind. ital. Conserve, 26, 7 (1951).

28. Stuewer, R., Beach, N. M., and Olsen, A. G. Sugar-Acid-Pectin Relationships and Their Bearings Upon Routine Evaluation of Apple Pectin. Ind. Eng. Chem., Anal. Ed., 6, 143 (1934).

29. Tarr, L. B. Fruit Jellies I - The Role of Acids. Del. Agr. Exp. Sta., Bull., 134, Tech. No. 2 (1923).

30. Tarr, L. B. Fruit Jellies III - Jelly Strength Measurements. Del. Agr. Exp. Sta., Bull., 142, Tech. No. 5 (1926).

31. Tarr, L. B. Fruit Jellies IV - The Role of Salts. Del. Agr. Exp. Sta., Bull., 144, Tech. No. 7 (1926).

32. Tarr. L. B., and Baker, G. L. Fruit Jellies II - The Role of Sugar. Del. Agr. Exp. Sta., Bull., 136, Tech. No. 3 (1924).

33. Tikka, J., and Porvari, R. Pectin Investigations, Valt. tekn Tulkimuslaitos Tiedoitus, No. 50 (1947).

34. Tolman, L. M., Munson, L. J., and Bigelow, W. D. The Composition of Jellies and Jams. J. Amer. Chem. Soc., 23, 347 (1901).

35. United States Standards for Grades of Fruit Jelly. Jan., 1948, U. S. Dept. Agr. Production and Marketing Admin., Washington, D. C.

36. Yeatman, F. W., and Steinbarge, M. C. Home Made Jams and Preserves. Farmers' Bull., No. 1800, 1938, U. S. Dept. Agr., Washington, D. C.

APPENDIX

TABLE 1

SEDIMENTATION RATE OF TALC

Tube	No.	Time in Minutes								
		10	15	20	25	30	35	40	45	50
		ml	ml	ml	ml	ml	ml	ml	ml	ml
1	A	-	0.60	0.59	0.58	0.56	0.55	0.55	0.55	0.55
	B	0.58	0.57	0.57	0.56	0.55	0.55	0.55	0.54	0.54
2	A	0.64	0.63	0.63	0.60	0.59	0.58	0.58	0.58	0.58
	B	-	0.62	0.61	0.60	0.59	0.57	0.57	0.57	0.57
3	A	0.61	0.61	0.60	0.58	0.56	0.55	0.55	0.55	0.55
	B	0.57	0.57	0.56	0.55	0.54	0.53	0.53	0.53	0.53
4	A	-	0.59	0.57	0.56	0.56	0.55	0.55	0.55	0.55
	B	-	0.58	0.57	0.55	0.54	0.54	0.54	0.54	0.54
Average		-	0.60	0.59	0.57	0.56	0.55	0.55	0.55	0.55

TABLE 2

SEDIMENTATION RATE OF 0.02 PER CENT PECTIN SOLUTION*

Tube	No.	Time in Minutes								
		10	15	20	25	30	35	40	45	50
		ml	ml	ml	ml	ml	ml	ml	ml	ml
1	A	0.96	0.88	0.80	0.77	0.72	0.71	0.70	0.70	0.70
	B	0.95	0.87	0.79	0.78	0.73	0.71	0.70	0.68	0.68
2	A	0.95	0.87	0.81	0.77	0.71	0.70	0.68	0.67	0.67
	B	0.96	0.88	0.80	0.77	0.72	0.71	0.68	0.68	0.68
3	A	0.96	0.90	0.83	0.79	0.73	0.71	0.69	0.69	0.69
	B	1.00	0.91	0.83	0.80	0.74	0.73	0.72	0.72	0.72
4	A	0.96	0.87	0.80	0.76	0.73	0.72	0.70	0.70	0.70
	B	0.95	0.88	0.81	0.77	0.72	0.72	0.71	0.70	0.70
5	A	0.95	0.88	0.80	0.78	0.73	0.72	0.70	0.70	0.70
	B	1.00	0.89	0.81	0.78	0.75	0.74	0.73	0.73	0.73
6	A	0.95	0.87	0.81	0.77	0.72	0.72	0.71	0.70	0.70
	B	0.96	0.88	0.80	0.78	0.73	0.72	0.71	0.70	0.70
7	A	0.98	0.89	0.82	0.78	0.75	0.74	0.73	0.73	0.73
	B	0.95	0.90	0.82	0.78	0.73	0.73	0.71	0.71	0.71
8	A	0.94	0.90	0.80	0.76	0.71	0.71	0.69	0.69	0.69
	B	0.95	0.88	0.81	0.76	0.73	0.72	0.71	0.70	0.70
Average		0.96	0.885	0.81	0.775	0.73	0.72	0.705	0.70	0.70
Corrected		0.41	0.335	0.26	0.225	0.18	0.17	0.155	0.15	0.15

* 170 grade pure pectin.

TABLE 3

SEDIMENTATION RATE OF 0.04 PER CENT PECTIN SOLUTION*

Tube	No.	Time in Minutes								
		10	15	20	25	30	35	40	45	50
		ml	ml	ml	ml	ml	ml	ml	ml	ml
1	A	1.10	0.99	0.94	0.90	0.88	0.86	0.85	0.85	0.85
	B	1.09	0.99	0.93	0.89	0.88	0.87	0.85	0.85	0.85
2	A	1.08	1.02	0.92	0.91	0.90	0.87	0.88	0.87	0.87
	B	1.06	0.98	0.92	0.91	0.89	0.87	0.85	0.85	0.85
3	A	1.07	1.00	0.94	0.93	0.92	0.88	0.86	0.86	0.86
	B	1.07	0.98	0.89	0.90	0.86	0.86	0.86	0.84	0.84
4	A	1.06	0.97	0.91	0.90	0.86	0.85	0.84	0.84	0.84
	B	1.07	1.00	0.93	0.91	0.90	0.87	0.85	0.85	0.85
5	A	1.05	0.96	0.89	0.86	0.85	0.84	0.83	0.82	0.82
	B	1.08	1.00	0.92	0.89	0.86	0.86	0.85	0.86	0.85
6	A	1.10	1.01	0.93	0.91	0.90	0.90	0.90	0.88	0.88
	B	1.08	1.03	0.95	0.94	0.93	0.92	0.90	0.89	0.89
7	A	1.05	0.99	0.91	0.90	0.89	0.86	0.84	0.84	0.84
	B	1.04	0.95	0.88	0.87	0.85	0.85	0.83	0.82	0.82
8	A	1.06	0.98	0.92	0.89	0.86	0.85	0.84	0.84	0.84
	B	1.07	0.99	0.92	0.90	0.88	0.87	0.86	0.85	0.85
Average		1.07	0.99	0.92	0.90	0.88	0.87	0.855	0.85	0.85
Corrected		0.52	0.44	0.37	0.35	0.33	0.32	0.305	0.30	0.30

* 170 grade pure pectin.

TABLE 4

SEDIMENTATION RATE OF 0.05 PER CENT PECTIN SOLUTION*

Tube	No.	Time in Minutes										
		10	15	20	25	30	35	40	45	50	55	60
		ml	ml	ml	ml	ml	ml	ml	ml	ml	ml	ml
1	A	1.15	1.14	1.08	1.07	1.0	0.98	0.93	0.91	0.90	0.88	0.88
	B	1.16	1.15	1.10	1.08	1.1	1.0	0.94	0.92	0.90	0.89	0.89
2	A	1.13	1.12	1.05	1.02	0.99	0.97	0.95	0.93	0.91	0.91	0.91
	B	1.17	1.15	1.11	1.07	1.02	1.0	0.98	0.94	0.93	0.93	0.93
3	A	1.24	1.20	1.17	1.15	1.13	1.12	1.10	1.10	1.08	1.06	1.06
	B	1.18	1.15	1.13	1.12	1.09	1.09	1.08	1.07	1.05	1.02	1.02
4	A	1.17	1.12	1.10	1.07	1.04	1.02	0.98	0.95	0.94	0.92	0.92
	B	1.17	1.12	1.08	1.08	1.05	1.02	0.97	0.94	0.92	0.92	0.92
5	A	1.18	1.14	1.12	1.10	1.07	1.03	1.01	0.97	0.96	0.96	0.96
	B	1.16	1.13	1.11	1.08	1.06	1.04	0.99	0.97	0.93	0.93	0.93
6	A	1.15	1.11	1.06	1.02	0.99	0.98	0.96	0.92	0.92	0.91	0.91
	B	1.17	1.14	1.12	1.09	1.04	1.01	0.98	0.96	0.95	0.94	0.94
7	A	1.18	1.14	1.12	1.08	1.03	1.02	0.98	0.94	0.93	0.93	0.93
	B	1.19	1.16	1.13	1.10	1.05	1.02	0.98	0.94	0.93	0.92	0.92
8	A	1.20	1.16	1.14	1.10	1.04	1.03	0.98	0.94	0.92	0.92	0.92
	B	1.18	1.14	1.12	1.08	1.05	1.02	0.97	0.94	0.93	0.93	0.93
Average		1.17	1.14	1.10	1.08	1.04	1.02	0.97	0.94	0.925	0.92	0.92
Corrected		0.62	0.59	0.55	0.53	0.49	0.46	0.42	0.39	0.375	0.37	0.37

* 170 grade pure Pectin.

TABLE 5

SEDIMENTATION RATE OF 0.06 PER CENT PECTIN SOLUTION*

Tube	No.	Time in Minutes										
		10	15	20	25	30	35	40	45	50	55	60
		ml	ml	ml	ml	ml	ml	ml	ml	ml	ml	ml
1	A	1.21	1.17	1.15	1.11	1.10	1.07	1.03	1.01	0.98	0.98	0.98
	B	1.22	1.18	1.17	1.13	1.12	1.09	1.05	1.02	0.99	0.99	0.99
2	A	1.10	1.09	1.08	1.04	1.03	1.00	0.95	0.92	0.90	0.90	0.90
	B	1.20	1.16	1.14	1.10	1.08	1.05	1.02	0.99	0.96	0.96	0.96
3	A	1.25	1.22	1.20	1.17	1.16	1.13	1.10	1.06	1.04	1.04	1.04
	B	1.28	1.19	1.17	1.13	1.13	1.10	1.06	1.02	1.00	1.00	1.00
4	A	1.20	1.18	1.16	1.12	1.11	1.09	1.05	1.01	0.99	0.99	0.98
	B	1.25	1.20	1.18	1.14	1.12	1.08	1.04	1.01	1.00	0.99	0.99
5	A	1.23	1.19	1.19	1.13	1.12	1.10	1.07	1.04	1.02	1.02	1.02
	B	1.52	1.44	1.47	1.45	1.40	1.40	1.37	1.35	1.30	1.28	1.25
6	A	1.20	1.18	1.17	1.13	1.13	1.10	1.05	1.01	0.99	0.99	0.99
	B	1.18	1.15	1.13	1.10	1.08	1.04	1.00	0.97	0.95	0.95	0.95
7	A	1.25	1.20	1.18	1.13	1.12	1.08	1.04	1.00	0.99	0.99	0.99
	B	1.23	1.18	1.16	1.12	1.10	1.06	1.04	1.02	1.01	1.00	1.00
8	A	1.20	1.17	1.14	1.11	1.10	1.07	1.04	1.01	0.99	0.99	0.99
	B	1.22	1.17	1.15	1.10	1.10	1.08	1.03	1.00	0.99	0.99	0.99
Average		1.22	1.18	1.16	1.12	1.11	1.08	1.04	1.01	0.99	0.99	0.99
Corrected		0.67	0.63	0.61	0.57	0.56	0.53	0.49	0.46	0.44	0.44	0.44

* 170 grade pure pectin.

TABLE 6

SEDIMENTATION RATE OF 0.075 PER CENT PECTIN SOLUTION*

Tube No.		Time in Minutes										
		10	15	20	25	30	35	40	45	50	55	60
		ml	ml	ml	ml	ml	ml	ml	ml	ml	ml	ml
1	A	1.28	1.23	1.20	1.17	1.14	1.11	1.08	1.07	1.07	1.06	1.06
	B	1.29	1.24	1.20	1.18	1.15	1.10	1.10	1.09	1.08	1.08	1.08
2	A	1.30	1.26	1.23	1.21	1.17	1.13	1.11	1.10	1.09	1.09	1.09
	B	1.29	1.26	1.24	1.21	1.18	1.15	1.13	1.12	1.11	1.11	1.11
3	A	1.30	1.27	1.24	1.20	1.19	1.16	1.15	1.15	1.14	1.14	1.14
	B	1.42	1.37	1.32	1.30	1.30	1.28	1.27	1.26	1.25	1.24	1.24
4	A	1.28	1.27	1.23	1.20	1.17	1.14	1.13	1.12	1.12	1.12	1.12
	B	1.30	1.26	1.21	1.20	1.16	1.15	1.14	1.13	1.12	1.12	1.12
5	A	1.21	1.17	1.15	1.13	1.12	1.12	1.11	1.10	1.10	1.10	1.10
	B	1.20	1.16	1.16	1.15	1.13	1.12	1.11	1.10	1.10	1.09	1.09
6	A	1.24	1.20	1.18	1.16	1.93	1.12	1.10	1.09	1.08	1.07	1.07
	B	1.20	1.16	1.16	1.15	1.13	1.12	1.11	1.10	1.10	1.09	1.09
7	A	1.25	1.21	1.20	1.19	1.15	1.14	1.13	1.12	1.11	1.11	1.11
	B	1.26	1.21	1.20	1.17	1.16	1.14	1.13	1.11	1.10	1.10	1.10
8	A	1.21	1.17	1.16	1.14	1.13	1.13	1.11	1.10	1.09	1.09	1.09
	B	1.24	1.19	1.17	1.15	1.14	1.13	1.12	1.11	1.10	1.10	1.10
Average		1.26	1.22	1.20	1.175	1.15	1.13	1.12	1.108	1.10	1.10	1.10
Corrected		0.71	0.67	0.65	0.625	0.60	0.58	0.57	0.558	0.55	0.55	0.55

* 170 grade pure pectin.

TABLE 7

SEDIMENTATION RATE OF 0.0875 PER CENT PECTIN SOLUTION*

Tube	No.	Time in Minutes										
		10	15	20	25	30	35	40	45	50	55	60
		ml	ml	ml	ml	ml	ml	ml	ml	ml	ml	ml
1	A	1.31	1.25	1.24	1.22	1.21	1.20	1.19	1.18	1.17	1.16	1.16
	B	1.34	1.26	1.25	1.24	1.23	1.22	1.22	1.21	1.19	1.19	1.19
2	A	1.33	1.29	1.27	1.26	1.24	1.22	1.21	1.20	1.18	1.18	1.18
	B	1.36	1.31	1.30	1.29	1.27	1.25	1.23	1.23	1.21	1.21	1.20
3	A	1.33	1.28	1.26	1.26	1.23	1.23	1.21	1.20	1.20	1.19	1.19
	B	1.35	1.31	1.28	1.27	1.25	1.23	1.23	1.21	1.19	1.19	1.19
4	A	1.39	1.34	1.32	1.29	1.28	1.25	1.24	1.23	1.23	1.21	1.21
	B	1.37	1.37	1.31	1.30	1.28	1.25	1.24	1.22	1.20	1.20	1.20
5	A	1.35	1.30	1.29	1.28	1.26	1.23	1.21	1.20	1.19	1.19	1.19
	B	1.35	1.29	1.27	1.26	1.23	1.22	1.22	1.20	1.19	1.19	1.19
6	A	1.38	1.33	1.31	1.29	1.28	1.24	1.23	1.21	1.20	1.20	1.20
	B	1.34	1.29	1.26	1.25	1.23	1.22	1.21	1.19	1.19	1.18	1.18
7	A	1.48	1.42	1.41	1.39	1.38	1.36	1.36	1.35	1.33	1.30	1.30
	B	1.53	1.45	1.43	1.40	1.35	1.33	1.31	1.29	1.28	1.28	1.27
8	A	1.36	1.31	1.29	1.28	1.26	1.24	1.23	1.22	1.20	1.19	1.19
	B	1.35	1.31	1.28	1.27	1.24	1.23	1.22	1.21	1.19	1.19	1.19
Average		1.35	1.30	1.28	1.27	1.25	1.23	1.22	1.21	1.195	1.19	1.19
Corrected		0.80	0.75	0.73	0.72	0.70	0.68	0.67	0.66	0.645	0.64	0.64

* 170 grade pure pectin.

TABLE 8

SEDIMENTATION RATE OF RED AND BLACK RASPBERRY, IMMATURE AND MATURE RED CHERRY, AND RED CURRANT JELLY STOCKS

No. of Experiments	Jelly Stock	Dilution		Time in Minutes										
				10	15	20	25	30	35	40	45	50	55	60
				ml	ml	ml	ml	ml	ml	ml	ml	ml	ml	ml
6	Red Raspberry Original	1-20	Avg.*	1.79	1.68	1.57	1.54	1.51	1.505	1.50	1.50	1.50		
			Cor.**	1.24	1.13	1.02	0.99	0.96	0.955	0.95	0.95	0.95		
6	Red Raspberry Concentrated	1-20	Avg.	2.16	1.96	1.86	1.81	1.78	1.73	1.70	1.70	1.70		
			Cor.	1.61	1.41	1.31	1.26	1.23	1.18	1.15	1.15	1.15		
6	Black Raspberry Original	1-8	Avg.	1.88	1.73	1.59	1.52	1.47	1.46	1.44	1.43	1.43		
			Cor.	1.33	1.18	0.94	0.97	0.92	0.91	0.89	0.88	0.88		
6	Black Raspberry Concentrated	1-10	Avg.	2.12	1.91	1.74	1.65	1.60	1.55	1.53	1.52	1.52		
			Cor.	1.57	1.36	1.19	1.10	1.05	1.00	0.98	0.97	0.97		

TABLE 8 (Continued)

No. of Experiments	Jelly Stock	Dilution		Time in Minutes										
				10	15	20	25	30	35	40	45	50	55	60
				ml	ml	ml	ml	ml	ml	ml	ml	ml	ml	ml
6	Immature Cherry Original	1-10	Avg.	-	0.84	0.80	0.76	0.73	0.68	0.66	0.65	0.65		
			Cor.	-	0.29	0.25	0.21	0.18	0.13	0.11	0.10	0.10		
6	Immature Cherry Concentrated	1-10	Avg.	-	1.17	1.10	1.07	1.01	0.96	0.91	0.84	0.78	0.75	0.75
			Cor.	-	0.62	0.55	0.52	0.46	0.41	0.36	0.29	0.23	0.20	0.20
6	Mature Cherry Original	-	Avg.	1.34	1.21	1.11	1.07	1.05	1.03	1.02	1.02	1.02		
			Cor.	0.79	0.66	0.56	0.52	0.50	0.48	0.47	0.47	0.47		
6	Mature Cherry Concentrated	1-2	Avg.	1.35	1.24	1.15	1.09	1.05	1.04	1.02	1.02	1.02		
			Cor.	0.80	0.69	0.60	0.54	0.50	0.49	0.47	0.47	0.47		
6	Immature Red Currant Original	1-20	Avg.	1.69	1.51	1.40	1.34	1.27	1.22	1.18	1.16	1.16		
			Cor.	1.14	0.96	0.85	0.79	0.72	0.67	0.63	0.61	0.61		

TABLE 8 (Continued)

No. of Experiments	Jelly Stock	Dilution		Time in Minutes										
				10	15	20	25	30	35	40	45	50	55	60
				ml	ml	ml	ml	ml	ml	ml	ml	ml	ml	ml
6	Immature Red Currant Concentrated	1-50	Avg.	1.52	1.34	1.25	1.18	1.13	1.08	1.04	1.02	1.20		
			Cor.	0.97	0.79	0.70	0.63	0.58	0.53	0.49	0.47	0.47		
6	Mature Red Currant Original	1-25	Avg.	1.60	1.45	1.34	1.29	1.27	1.25	1.22	1.21	1.21	1.21	
			Cor.	1.05	0.90	0.79	0.74	0.72	0.70	0.67	0.66	0.66	0.66	
6	Mature Red Currant Concentrated	1-50	Avg.	1.60	1.48	1.36	1.30	1.27	1.24	1.23	1.21	1.21	1.21	
			Cor.	1.05	0.93	0.81	0.75	0.72	0.69	0.68	0.66	0.66	0.66	

* Average

**Corrected

TABLE 9

SEDIMENTATION RATE OF IMMATURE AND MATURE BLUEBERRY AND BLACKBERRY JELLY STOCKS

No. of Experiments	Jelly Stock	Dilution		Time in Minutes										
				10	15	20	25	30	35	40	45	50	55	60
				ml	ml	ml	ml	ml	ml	ml	ml	ml	ml	ml
6	Immature Blueberry Original	1-20	Avg.*	1.29	1.59	1.50	1.41	1.37	1.36	1.34	1.34	1.34		
			Cor.**	1.24	1.04	0.95	0.86	0.82	0.81	0.79	0.79	0.79		
6	Immature Blueberry Concentrated	1-50	Avg.	1.68	1.47	1.37	1.31	1.30	1.29	1.28	1.28	1.28		
			Cor.	1.13	1.92	0.82	0.76	0.75	0.74	0.73	0.73	0.73		
6	Mature Blueberry Original	1-4	Avg.	1.78	1.74	1.72	1.71	1.71	1.68	1.67	1.67	1.67		
			Cor.	1.23	1.19	1.17	1.16	1.16	1.13	1.12	1.12	1.12		
6	Mature Blueberry Concentrated	1-8	Avg.	1.86	1.82	1.79	1.79	1.77	1.76	1.74	1.74	1.74		
			Cor.	1.31	1.27	1.24	1.24	1.22	1.21	1.19	1.19	1.19		

TABLE 9 (Continued)

No. of Experiments	Jelly Stock	Dilution		Time in Minutes										
				10	15	20	25	30	35	40	45	50	55	60
				ml	ml	ml	ml	ml	ml	ml	ml	ml	ml	ml
6	Immature Blackberry Original	1-20	Avg.	1.61	1.40	1.35	1.29	1.24	1.19	1.12	1.09	1.07	1.05	1.05
			Cor.	1.06	0.85	0.80	0.74	0.69	0.64	0.59	0.54	0.52	0.50	0.50
6	Immature Blackberry Concentrated	1-40	Avg.	1.49	1.32	1.20	1.14	1.10	1.06	1.04	1.00	0.97	0.97	0.97
			Cor.	0.94	0.77	0.65	0.59	0.55	0.51	0.49	0.45	0.42	0.42	0.42
6	Mature Blackberry Original	1-20	Avg.	1.28	1.19	1.05	0.99	0.93	0.89	0.84	0.82	0.80	0.79	0.79
			Cor.	0.73	0.64	0.50	0.44	0.38	0.34	0.29	0.27	0.25	0.24	0.24
6	Mature Blackberry Concentrated	1-40	Avg.	1.33	1.19	1.10	1.07	0.99	0.94	0.90	0.88	0.86	0.86	0.86
			Cor.	0.78	0.64	0.55	0.52	0.44	0.39	0.35	0.31	0.31	0.31	0.31

* Average

**Corrected