

PREPARATION, PURIFICATION AND COMPOSITION OF PECTINS FROM INDIAN FRUITS AND VEGETABLES

BY C. R. KRISHNAMURTI AND K. V. GIRI, F.A.SC.

(From the Department of Biochemistry, Indian Institute of Science, Bangalore)

Received August 25, 1948

CONSIDERABLE attention has been devoted in recent years to the isolation of pectins from plant materials indigenous to India and the elucidation of their chemical composition. Singh and Dutt (1941) studied the distribution of pectin in a variety of fruits like wood apple, *bel*, guava, etc., and the physico-chemical conditions affecting the formation of sugar-pectin-acid jellies from these fruit juices. Damodaran and Rangachari (1945) have estimated the pectin content of nearly twenty fruits and vegetables and have attempted to prepare pectins from these sources in a pure condition. Savur and Srinivasan (1946) examined various fruits and vegetables for their pectin content and found several of them to be good sources of high grade pectin. Trehan and Ahmed (1947) have given the pectin content of several fruits, vegetables and nuts and have drawn attention to the fact that the ash content of crude pectins obtained from these sources can be reduced to a considerable extent by repeated precipitation with alcohol.

Although the materials investigated by the above authors cover a wide range of fruits and vegetables abundantly available in India, no attempt has, however, been made so far to correlate the pectin contents, chemical composition and jelly forming power of various preparations. The present paper is an attempt in this direction and describes the results obtained in the course of an investigation on the distribution, preparation and purification of pectins from a variety of plant materials and their possible application in jelly making.

EXPERIMENTAL

Preliminary treatment of materials handled

Papaya.—Fruits which had just begun to ripen were chosen. They were cut into small pieces and minced in a meat mincer recovering as much of the juice as possible. The minced pulp was pressed in cloth bags and the juice obtained was mixed with the juice from the mincer. The pressed pulp was washed with some water and the wash water added to the

juice. The collected juice was received in a clean flask, thoroughly mixed, weighed and used for a separate estimation of the pectin content. The sugars, the colouring matter and other soluble impurities were removed by repeated washing and decanting with water. The pulp was soaked in 95% alcohol and left overnight, then pressed free from alcohol, rewashed with water, pressed free of as much water as possible, spread on trays and dried in a current of hot air (50 to 55° C.). The dried material though it retained a part of the moisture was found to preserve well for quite a long period. The dry material was powdered to 100 mesh and kept in air-tight bottles. The material was found to keep well for over one to two years. The treatment for unripe papaya was just the same. The juice, however, was not taken for estimation. Melon fruit, cucumber, guava and plantains were treated in a similar manner.

Jack fruit.—The fruit was separated into the seeds, edible kernel and pericarp. They were separately cut into small bits and dried in a current of warm air. The seeds on drying and powdering yielded a starch-like powder; the kernels gave a flour with a pleasant odour and the pericarp a loose buff coloured powder.

Tamarind and Indian gooseberry.—The materials were dried and ground into powdery consistency without removing the organic acids. Before estimation the organic acids were removed by repeated percolation with cold water. Pectins removed in the percolate were estimated separately. The percolated material was treated as for papaya.

Locust bean and tamarind seed.—These had hard outer coats which required the following processing for complete removal. The seeds were soaked in water and kept for forty-eight hours. A layer of toluene on the water surface acted as a preservative. The coats could be easily peeled off after this soaking. The kernels were then cut into pieces and dried as before.

Extraction of pectic substances

5 to 10 gm. of the dry powder were weighed and ground with 5 gm. of chemically treated sand after slightly moistening the mixture. Three such lots were taken in 500 c.c. conical flasks. 350 c.c. lots of distilled water, 0.5% oxalic acid solution and 0.5% ammonium oxalate solutions were added to the first, second and third flasks respectively. The flasks were plugged with cotton and put on a water-bath maintained at 80 to 90° C. Extraction was carried on for 18 hours continuously. The extract was first filtered through two layers of muslin cloth and subsequently through fluted filter-papers. The clear filtrate was made up to volume and preserved under

toluene. The same extract was used for all the four following methods of estimation:

1. *Alcohol precipitation method*.—Aliquot portions of the extracts were taken in beakers and concentrated to a small bulk on a water-bath. The oxalic acid extracts were neutralised with 0.1% alkali prior to concentration. Three and half times by volume of 95% alcohol which had been previously acidified with a few drops of hydrochloric acid to make the final concentration of the acid to 0.1 N were added to the concentrate in a thin stream with constant stirring. The voluminous precipitate that separated out was thoroughly mixed and left overnight for settling. The precipitate was carefully transferred to a tared filter-paper, washed successively with hot 60%, 75% and 95% alcohol till free from salts and finally with a few drops of absolute alcohol followed by ether. The filter-paper and contents were dried to constant weight at 105° C. and the weight taken after which the precipitate with the filter-paper was incinerated in a silica crucible and heated to dull redness in a muffle furnace at 600 to 750° C. for about four hours and the ash weighed. The weight of the ash was subtracted from the original weight of the precipitate and the pectin content expressed as percentage of ash-free alcohol precipitate.

2. *Estimation as calcium pectate* following the method devised by Carre and Haynes (1922, 1926) and modified by Nanji and Norman (1928). After noting down the weight of calcium pectate in each case, the calcium content of the precipitate was estimated by incinerating the precipitate and estimating the calcium in the ash.

3. *Estimation of pectin as pectic acid* (modified Wichmann's method) (Wichmann, 1922). The ash content of the pectic acid precipitates were subtracted from the original weights of the precipitates.

4. *Titration method* (Ahmann and Hooker, 1926). The temperature used for saponification was 55° C. and the time twelve hours.

A. PECTIN CONTENT OF SOME COMMON FRUITS AND VEGETABLES

In Table I are given the moisture content and calcium pectate yields by differential extraction of nearly a dozen plant materials.

The results show that papaya, jack fruit, sweet melon, ash pumpkin and Indian gooseberry are very rich sources of pectin. The locust bean imported from the Mediterranean countries is mainly used in the textile industry as a sizing material. It is evident that its application as a sizer is virtually dependent on its pectin content. Although it gave very high

TABLE I Moisture and pectin content of some common vegetables and fruits

Name of Material	Botanical Name	Moisture %	Method and the extractants used	Method of estimation				
				Alcohol ppte.	Calcium pectate	Calcium % in cal. pect.	Titration	Pectic acid
Ripe papaya fruit	<i>Carica papaya</i>	92	A—Water B—0.5% Oxalic acid C—0.5% Ammon. oxalate	2.13 28.67 42.92	1.40 20.58 34.67	7.44 7.48 7.56	1.49 21.19 35.53	1.32 15.21 21.62
Unripe papaya	<i>do</i>	85	A B C	13.10 42.64 48.75	10.02 30.78 33.57	7.39 7.47 7.38	10.21 31.70 34.19	8.93 27.52 28.35
Jack fruit	<i>Artocarpus integrifolia</i>	Kernel 70	A B C	15.76 23.04 23.51	2.02 2.74 6.19	7.47 7.53 7.53	2.08 2.93 6.31	1.56 2.04 4.97
		Seeds 59	A B C	12.22 13.34 15.47	2.01 2.85 3.95	7.43 7.59 7.49	2.03 2.99 5.10	1.25 1.97 3.85
		Pericarp 83	A B C	11.48 18.45 23.01	6.57 13.03 13.29	7.51 7.53 7.53	6.96 13.42 13.95	5.79 12.07 12.19
Sweet melon	<i>Citrullus vulgaris</i>	86.6	A B C	7.37 15.76 23.82	4.29 12.87 16.39	7.49 7.49 7.51	4.58 14.32 17.26	3.65 10.59 14.97
Tamarind fruit pulp without skin and seed after removal of tartaric acid by cold percolation	<i>Tamarindus indica</i>	72	A B C	2.56 6.48 7.87	0.46 0.82 1.03	7.53 7.51 7.47	0.48 0.89 1.12	0.32 0.67 0.92
Immature tamarind pulp after removal of organic acid by repeated cold percolation	<i>do</i>	67	A B C	3.14 6.27 6.93	0.27 1.01 1.13	7.48 7.43 7.51	0.27 1.12 1.27	0.23 0.97 1.07

Indian gooseberry whole fruit after removal of acid by cold percolation	<i>Phyllanthus emblica</i>	79	A B C	4.34	1.12	7.42	1.14	0.80
				7.52	6.37	7.46	6.56	4.51
				9.32	6.52	7.49	6.85	4.68
Plantains	<i>Musa paradisiaca</i>	88	A B C	2.85	1.25	7.51	1.37	1.01
				7.61	3.52	7.47	3.81	3.21
				12.89	4.21	7.42	4.71	3.92
Guava	<i>Psidium guajava</i>	71	A B C	6.79	4.21	7.43	4.32	4.03
				10.33	6.03	7.43	6.14	5.89
				13.47	6.74	7.48	6.97	6.13
Sweet pumpkin	<i>Cucurbita pepo</i>	87	A B C	12.35	2.17	7.43	2.21	1.69
				25.93	20.84	7.43	21.88	16.67
				26.55	21.43	7.46	22.07	16.73
Cucumber	<i>Cucumis sativus</i>	95	A B C	7.65	1.74	7.49	1.92	1.41
				18.37	15.65	7.48	15.81	15.12
				23.65	18.79	7.48	18.92	18.23
Ash pumpkin	<i>Lagenaria vulgaris</i>	93	A B C	9.17	7.75	7.51	7.91	6.40
				30.13	24.52	7.52	28.50	19.93
				32.51	28.02	7.51	28.86	23.54
Lemons after removal of acids by repeated cold percolation	<i>Citrus medica</i>	85	A B C	18.12	13.17	7.49	13.34	12.91
				24.32	18.21	7.48	18.72	17.93
				28.37	18.87	7.49	19.03	18.31
Oranges	<i>Citrus nobilis</i>	87	A B C	10.76	8.34	7.51	8.72	8.02
				14.48	11.73	7.51	11.94	11.27
				21.43	12.91	7.50	13.12	12.64
Tamarind seed	<i>Tamarindus indica</i>	13	A B C	10.76	0.00
				42.31	0.00
				58.14	0.00
Locust bean	..	11	A B C	40.76	32.93	7.53	33.12	31.21
				57.68	53.72	7.51	53.87	53.17
				69.73	61.05	7.51	61.21	60.84

yields of pectin the jellies prepared were not comparable to those made from papaya or gooseberry.

In Table II are presented the results of estimation of pectin in certain fruit juices. The juices were concentrated under vacuo to give a slurry of a syrupy consistency. Wherever the juice was rich in acid it was neutralised by adding alkali prior to concentration.

TABLE II
Pectin content of certain fruit juices

Material 100 c.c. of the fresh juice used	Alcohol precipitate	Calcium pectate	Titration	As pectic acid
Papaya juice ..	1.82	0.12	0.17	0.09
Water melon juice ...	2.17	0.29	0.31	0.23
Orange juice ..	1.93	0.09	0.11	0.07
Lemon juice ..	1.97	0.05	0.07	0.03
Cane juice ..	1.24	0.03	0.04	0.02
Tomato juice ..	1.76	0.13	0.13	0.07

B. PREPARATION OF PECTINS

Preparation of pectins from the fresh fruits or vegetables was found to be rather difficult since no clear extract could be obtained. The materials were hence subjected to a preliminary treatment similar to the one already described for the estimation of pectins.

Extraction.—The extractants used were (i) N/50 sulphuric acid and (ii) 0.5% ammonium oxalate. The materials were taken in flasks and soaked with the extractants and heated on a water-bath at 80 to 90° C. for six hours. The extraction was repeated twice or thrice. The extracts were pressed through cloth while hot.

Preliminary purification of the extracts.—When the materials were used for the extraction after the preliminary drying process clear filtrates could be obtained in all cases. Refiltration was carried out whenever necessary after treatment with supercel. Shaking up with one part of charcoal per 1,000 parts of the extract and filtration cleared the colour in almost all cases and gave a toning effect to the extracts. Clarification of the cloudy extracts obtained from fresh fruits and vegetables was effected by pressure filtration or centrifuging. In the case of fresh and immature tamarinds the extract was more or less a milky emulsion which did not lend itself either to centrifuging or filtration.

Concentration of extracts.—Concentration of the clear extract was effected by spreading it on shallow trays and exposing to a current of warm

air (55° C.) for a period of eight to twelve hours. After concentration to a syrupy consistency the extract was once again filtered.

Precipitation with alcohol.—The concentrated extract was kept in an open vessel of two to three litres capacity and alcohol added in a thin regulated stream keeping the solution constantly stirred. A few drops of hydrochloric acid were added to the alcohol prior to mixing with the pectin concentrate. The flocculent particles of pectin precipitated were allowed to settle overnight and first filtered through cloth and subsequently transferred to a Buchner and washed repeatedly with warm (60° C.) 65% alcohol and finally with warm (55° C.) absolute alcohol followed by ether. The dry crisp powder that remained on the Buchner was pressed between folds of filter-paper, spread on shallow basins and dried in a current of warm air. The drying was found to leave the pectin more or less crisp when it could be powdered to a uniform consistency.

The yield, moisture content, ash and calcium pectate numbers of pectins prepared from a number of fruits and vegetables are given in Table III.

TABLE III

Yield of pectins from certain fruits and vegetables

Name of material	Extractants used	Yield %	Moisture %	Ash %	Calcium pectate number
Ripe papaya ..	1. N/50 H ₂ SO ₄	25	13.9	2.16	59.55
	2. 0.5% ammon. oxalate	36	13.36	1.98	67.75
Unripe papaya ..	1. ..	28	7.50	3.61	50.65
	2. ..	39	15.63	2.83	56.45
Jack fruit seeds ..	1. ..	21	8.7	3.64	20.64
	2. ..	25	9.37	4.49	24.72
Jack fruit kernel ..	1. ..	23	6.9	2.31	21.85
	2. ..	28	10.0	2.97	25.39
Jack fruit pericarp ..	1. ..	25	12.10	2.61	26.12
	2. ..	30	12.54	2.92	37.03
Sweet melon ..	1. ..	20	2.41	2.01	73.14
	2. ..	27	2.65	2.12	76.87
Sweet pumpkin ..	1. ..	22	3.16	2.27	49.78
	2. ..	29	4.71	2.31	56.64
Ash pumpkin ..	1. ..	17	3.57	2.10	74.38
	2. ..	21	3.69	1.48	78.57
Cucumber ..	1. ..	14	2.73	1.87	32.16
	2. ..	17	3.12	2.12	36.72
Tamarind ..	1. ..	11	15.07	1.98	9.81
	2. ..	13	8.99	2.17	9.92
Indian gooseberry ..	1. ..	22	11.24	1.37	31.27
	2. ..	27	10.57	1.89	32.64
Guaya ..	1. ..	14	3.87	3.17	16.48
	2. ..	15	3.92	3.83	18.32

C. COMPOSITION OF THE PECTINS PREPARED

Furfural was estimated by the volumetric method of Powel and Whittaker (1924).

Uronic anhydride was determined by the method devised by Dickson, *et al.* (1930). From the yield of CO₂ obtained by decarboxylation, the anhydride was calculated according to Norris and Resch (1935). Methoxyl value was estimated by the micro method of Nanji and Norman (1926).

The above three analytical constants for the different pectin preparations are embodied in Table IV.

TABLE IV

Composition of the pectins prepared

Name of material	Extractant used	Uronic anhydride CO ₂ × 4	Furfural yield %	Methoxyl value %
Papaya ripe	1. Acid ext.	59.44	23.27	5.87
	2. Ammon. ox.	64.28	24.12	6.23
Papaya unripe	1. ..	46.04	15.69	4.36
	2. ..	51.84	18.40	4.82
Jack fruit seeds	1. ..	16.72	5.18	1.98
	2. ..	19.48	5.75	2.06
Jack fruit kernel	1. ..	18.03	6.39	2.87
	2. ..	21.68	6.75	2.92
Jack fruit pericarp	1. ..	22.05	8.42	3.16
	2. ..	28.73	10.64	3.89
Sweet melon	1. ..	57.16	20.21	5.12
	2. ..	60.88	19.83	5.87
Pumpkin	1. ..	38.92	13.23	3.13
	2. ..	45.32	14.11	3.97
Ash pumpkin	1. ..	55.56	19.71	5.12
	2. ..	58.48	20.72	5.39
Cucumber	1. ..	23.88	7.76	2.87
	2. ..	27.44	8.92	3.12
Tamarind	1. ..	9.00	3.05	2.06
	2. ..	8.08	2.74	2.12
Indian Gooseberry	1. ..	26.32	9.28	3.87
	2. ..	27.48	9.74	4.16
Guava	1. ..	9.48	3.87	0.97
	2. ..	9.78	4.12	1.27

D. PREPARATION OF SUGAR-ACID JELLIES

Method of jelly making.—The pectin was dispersed in water and extracted on a water-bath and filtered. Known amounts of sugar and acid were boiled with the pectin solution in weighed beakers and concentrated to the jelly forming point. The mixture darkened in colour and tended to boil over which was carefully avoided by regulating the flame.

Sheeting test on the jellies were carried out according to the method suggested by Tarr and Baker (1924). Jelly strength and syneresis temperature were determined according to the methods developed by Singh and Dutt (1941).

The jelly strength, syneresis temperature and composition of the various jellies are embodied in Table V.

TABLE V
Composition and characteristics of pectin jellies from various sources

Material used	Extractant used	Jelly* strength in seconds	Syneresis temp. °C.	Acid† in jelly %	Sugar in jelly %	Pectin in jelly %
Papaya ripe ..	1. N/50 H ₂ SO ₄	93	42	1.42	60.5	0.42
	2. 0.5% Ammon. ox.	97	47	1.38	59.3	0.47
Papaya unripe ..	1. ..	67	34	1.43	62.8	0.48
	2. ..	81	39	1.28	63.2	0.37
Jack fruit seeds ..	1. ..	22	27	1.12	60.8	0.23
	2. ..	23	27	1.14	60.2	0.27
Jack fruit kernel ..	1. ..	82	36	1.03	58.6	0.38
	2. ..	89	39	1.09	59.2	0.47
Jack fruit pericarp ..	1. ..	31	28	0.92	62.7	0.43
	2. ..	33	26	0.85	64.3	0.51
Sweet melon ..	1. ..	68	47	0.87	60.8	0.38
	2. ..	78	51	1.02	59.7	0.49
Sweet pumpkin ..	1. ..	42	38	0.91	61.7	0.31
	2. ..	51	41	0.98	60.8	0.52
Ash pumpkin ..	1. ..	93	49	1.32	63.8	0.28
	2. ..	97	56	1.17	60.2	0.41
Cucumber ..	1. ..	32	25	1.32	62.3	0.32
	2. ..	26	27	1.28	61.8	0.58
Tamarind ..	1. ..	53	42	1.02	60.8	0.48
	2. ..	64	46	1.13	59.8	0.52
Indian gooseberry ..	1. ..	88	48	1.21	58.4	0.43
	2. ..	102	51	1.08	59.6	0.58
Guava ..	1. ..	108	58	1.98	58.2	0.46
	2 ..	118	63	2.01	56.8	0.58

* The ideal jelly required 90 to 100 seconds to pass through a fixed length of the viscometer at room temperature.

† The acidity in each case is expressed as % lactic acid.

E. ATTEMPTS AT PURIFICATION OF THE PECTIN PREPARATIONS

The following methods were employed to effect partial purification of the crude pectin preparations.

(i) *Dialysis*.—5% suspensions of pectins were dialysed against 0.05 N hydrochloric acid in cellophane bags over three-day periods in the cold room using toluene as a preservative. The dialysed solution was concentrated to a small bulk and reprecipitated with alcohol,

(ii) *Treatment with bromine water.*—The method used was essentially similar to that developed by Nanji and Chinoy (1934).

(iii) *Repeated precipitation with alcohol.*—The crude pectins obtained were dispersed in water and precipitated with three and half volumes of alcohol. The precipitates were redissolved in water and reprecipitated with alcohol. The operation was repeated four times.

The calcium pectate number, ash content, uronic anhydride and methoxyl values of the crude and purified preparations obtained by the above methods are embodied in Tables VI, VII and VIII.

TABLE VI
Effect of dialysis of pectins

Material	Treatment	Ash %	Calcium pectate %	Uronic anhydride %
<i>Papaya ripe—</i>				
Acid extraction	Before dialysis	2.16	59.55	59.44
	After dialysis	0.98	63.87	62.72
Ammon. oxalate	Before dialysis	1.98	67.75	64.28
	After dialysis	0.72	68.32	66.17
<i>Jack fruit kernel—</i>				
Acid extraction	Before dialysis	2.31	21.85	18.08
	After dialysis	1.03	22.11	19.31
Ammon. oxalate	Before dialysis	2.97	25.39	21.68
	After dialysis	1.21	25.62	23.12
<i>Sweet melon—</i>				
Acid extraction	Before dialysis	2.01	73.14	57.16
	After dialysis	1.12	73.38	60.27
Ammon. oxalate	Before dialysis	2.12	76.87	60.88
	After dialysis	0.98	77.21	62.13
<i>Indian gooseberry—</i>				
Acid extraction	Before dialysis	1.37	31.27	26.32
	After dialysis	0.62	32.08	26.81
Ammon. oxalate	Before dialysis	1.89	32.64	27.48
	After dialysis	0.72	33.21	27.51
<i>Guava—</i>				
Acid extraction	Before dialysis	3.17	16.48	9.48
	After dialysis	1.21	17.32	9.76
Ammon. oxalate	Before dialysis	3.83	18.32	9.78
	After dialysis	1.41	19.17	9.97

TABLE VII
Purification of pectins with bromine water

Material	Papaya ripe		Jack fruit kernel		Sweet melon		Indian gooseberry		Guava	
	Acid extract	Ammon oxalate	Acid extract	Ammon oxalate	Acid extract	Ammon oxalate	Acid extract	Ammon oxalate	Acid extract	Ammon oxalate
<i>Uronic anhydride</i>										
Before treatment	59.44	64.28	18.08	21.68	57.16	60.88	26.32	27.48	9.48	9.78
After treatment	67.42	79.13	22.13	26.34	68.21	71.97	34.41	36.12	12.13	13.08
<i>Calcium pectate number</i>										
Before treatment	59.55	67.75	21.85	25.39	73.14	76.87	31.27	32.64	16.48	18.32
After treatment	68.32	78.32	27.32	34.43	81.37	84.13	38.14	39.34	17.14	19.47

TABLE VIII

Purification by repeated precipitation with alcohol

Material	Ash content	Calcium pectate	Uronic anhydride	Methoxyl value
<i>Papaya ripe</i>				
Ammon. oxalate extraction—				
Crude pectin ..	1.98	67.75	64.28	6.23
First precipitation ..	1.12	68.47	64.43	6.41
Second ,, ..	0.79	72.34	65.87	6.73
Third ,, ..	0.45	73.47	65.98	6.91
Fourth ,, ..	0.27	74.28	66.34	7.08
<i>Sweet melon</i>				
Ammon. oxalate extraction—				
Crude pectin ..	2.12	76.87	60.88	5.87
First precipitation ..	1.72	77.14	61.14	5.92
Second ,, ..	1.03	77.89	61.47	6.04
Third ,, ..	0.52	83.47	63.63	6.21
Fourth ,, ..	0.29	85.32	64.17	6.29
<i>Indian gooseberry</i>				
Ammon. oxalate extraction—				
Crude pectin ..	2.89	32.64	27.48	4.16
First precipitation ..	1.04	34.82	28.12	4.21
Second ,, ..	0.76	37.41	29.34	4.29
Third ,, ..	0.43	39.61	30.14	4.87
Fourth ,, ..	0.21	43.82	32.37	4.92

DISCUSSION

The complex nature of the pectic substances has been known since a long time. It is now fairly well established that the occurrence of the individual pectic substances varies from plant to plant. To standardise the conditions for the preparation of pectins it is of importance to study the distribution of the individual pectic substances. The chief difficulty encountered is in obtaining a completely uniform extraction on account of the inability of the extracting agent to penetrate properly into all the cells of the tissue and its failure to reach and dissolve out the insoluble pectic substances intimately connected with the cell wall either as an incrusting agent or in the form of the middle lamella (Nanji and Norman, 1928). In our studies we have developed methods for the preliminary treatment of materials depending on their individual characteristics. Thus, in the case of fruits containing the juices the latter were quantitatively pressed out and separately estimated for pectin. Most of the soluble materials had been washed away both with water and alcohol which ensured the yield of colourless products during extraction. After the removal of alcohol extractables the material was minced up and dried in a current of warm air and powdered to a fine state of division. Drying at 95° C. as suggested by Link and Tottingham (1923) was found to result in considerable caramelization.

Papaya, guava, pumpkin and jack fruit have been observed by us to contain more pectin than reported by Damodaran and Rangachari (*loc. cit.*). This is evidently due to the fact that the latter authors have used only N/75 hydrochloric acid for the extraction. A perusal of Table I will reveal the necessity of adopting the differential extraction method to get a correct estimate of the pectin content of any material.

A noteworthy feature of the method of preparation of pectins as developed by us is the method of concentration of the aqueous or acid extracts of the pectins. In usual practice the concentration is effected by vacuum evaporation. We have found, however, that mere exposure to a current of warm air is sufficient to bring down the volume of extract to a consistency when it can be precipitated with the minimum amount of alcohol.

We have used three methods of purification of the crude pectins to remove the ash and organic impurities. Dialysis of the preparation against dilute acid removed as much as 60 to 70% of the mineral impurities but resulted in a loss of about 25% of the pectin content during reprecipitation. Treatment with bromine water resulted in an overall increase of 20% of the pectin content. Evidently bromination must be resulting in an oxidation of the organic matter. In the alcohol precipitation method there was a 25% reduction in the mineral matter. A judicious combination of bromination and repeated precipitation with alcohol will in practice work out to be the ideal method of purification.

It would appear from our results that mere presence of pectin in any plant material does not confer upon it the important property of forming jellies in presence of sugar and acid. Although no direct correlation has been observed between either the uronic anhydride content or methoxyl values of the pectins and their jellying power when crude pectins are used, it is likely that these factors may be intrinsically involved in jelly formation.

The results obtained by us indicate the wide scope offered by our indigenous plant materials for the preparation of high grade pectins. Almost all the materials referred to are abundantly available in India and if only there is a proper organised effort to collect these materials in a central place they can be conveniently used for the preparation of pectin as such or jams, jellies and marmalades.

SUMMARY

1. The pectin content of a number of Indian fruits and vegetables has been estimated by four different analytical procedures using a differential extraction method.

2. The conditions for the preparation of pectins from these sources have been studied.

3. The structural constants like calcium pectate number, uronic anhydride, furfural and methoxyl values have been estimated.

4. Jellies have been made using the pectin preparations and their strengths have been estimated.

5. Attempts have been made to purify the crude pectin preparation by three different methods.

ACKNOWLEDGEMENT

Our thanks are due to Prof. V. Subrahmanyam, D.Sc., F.R.I.C., F.N.I., for his kind interest in the work and one of us (C. R. K.) wishes to thank the Director of Industries and Commerce, Madras, for the award of a Research Scholarship.

REFERENCES

- Ahmann, C. R., and Hooker, H. D. .. *Ind. Eng. Chem.*, 1926, **18**, 412.
- Carre, M. H., and Haynes, D. .. *Biochem. J.*, 1922, **16**, 60.
————— .. *Ibid.*, 1946, **20**, 6.
- Damodaran, M., and Rangachari, P. N. .. *J. Sci. and Ind. Res. (India)*, 1945, **4**, 298.
- Dickson, A. D., Otterson, H. and Link, K.P. .. *J. Am. Chem. Soc.*, 1930, **52**, 775.
- Link, K. P., and Tottingham, N. .. *U. S. Patent Literature*, 1924.
- Nanji, H. R., and Norman, A. .. *J. Soc. Chem. Ind.*, 1926, **45 T**, 337.
————— .. *Biochem. J.*, 1928, **22**, 596.
- Nanji, H. R., and Chinoy, J. J. .. *Ibid.*, 1934, **28**, 456.
- Norris, F. W., and Resch, C. E. .. *Biochem. J.*, 1935, **29**, 1590.
- Powell, A., and Whittaker, T. .. *J. Soc. Chem. Ind.*, 1924, **43 T**, 35.
- Savur, G. R., and Srinivasan, A. .. *J. Sci. and Ind. Res. (India)*, 1946, **5**, 41.
- Singh, B. N., and Dutt, S. .. *Ind. J. Agr. Sci.*, 1941, **11**, 1006.
- Tarr, A., and Baker, L. .. *Delaw. Univ. Agr. Bull.*, 1924, **134**.
- Trehan, Y. N., and Ahmed, B. .. *J. Sci. and Ind. Res. (India)*, 1947, **5**, 16.
- Wichmann, A. .. *J. Ass. Off. Agr. Chem.*, 1922, **6**, 34.