

Chapter VI

APPLICATION OF LOW METHOXYL PECTINS IN FOOD PRODUCTS

Fruit jellies and jams based on pectin, have been known for over 500 years. Along with sugar, acid and water, pectin plays an important role in gel formation. The customary high methoxyl pectin (HMP) produced commercially is the chief gelling agent used in the manufacture of jams, jellies and marmalades. LMP on the other hand, is a modified pectin marketed exclusively for some specific purposes. LMP is used in the preparation of products, containing little or no added sugar, for use by consumers who are calorie-conscious or for manufacture of sugar-free products required by diabetics.

Towle and Christensen¹ have extensively reviewed the various uses of LMP in food products and pharmaceuticals. The most important usage for LMP is in the manufacture of low solids gels. It is also used in products such as frozen berries to improve the quality of fruit under freeze-thaw conditions, and in coating compositions for fruits used in ice cream to improve the fruit texture and quality.^{2,3}

LMP, as opposed to HMP, do not require the rigid conditions, such as pH and total soluble solids for gelling. One of the most successful application of LMP is in the preparation of "artificial cherries"⁴. LMP, in combination with gelatin, has been suggested for use in a sour cream mix to prevent "wheying-off" and provide body.⁵

Foods, coated with a transparent edible coating of LMP, may be dehydrated osmotically without direct impregnation of the tissue with the dehydrating media.⁶ Amidated LMP has been suggested for use in the preparation of canned, storage-stable, ready-to-eat, gelled food products.^{7,8}

In pharmaceutical applications, LMP is used in combination with aluminium and magnesium hydroxides for treatment of gastric and duodenal ulcers.⁹

A. Stabilization Of Cloud In Citrus Beverages

Fruit beverages are refreshing non-alcoholic drinks. The different types of beverages manufactured in India and the minimum compositional requirements are given in Table VI-1.

In bottled fruit juice beverages, like squash, crush, etc., the separation of pulp within a few hours of preparation has been a serious concern to the manufacturers. The separated pulp may coalesce and rise to the top or settle down at the bottom of the bottle leaving a clear or slightly hazy serum, thus imparting an unattractive appearance to the product.

Cloud in citrus juices is made up of finely divided particles of pulp, natural pigments and flavouring oil. The cloud components insoluble in alcohol, acetone and hexane have been shown to be rich in pectins (80%), nitrogen and phosphorus, but are very low in cellulose components (2.5%), indicating that the cloud originates in the juice cells rather than from mechanical disintegration of structural tissue.¹⁰

Most of the published work relating to the loss of cloud in

Table VI-1. Fruit products order specifications for the manufacture of fruit juice beverages in India

Beverage	Fruit juice content	Minimum TSS	Mode of preservation
	%	%	
Ready-to-serve beverage ^a	10	10	70 ppm of SO ₂ or 120 ppm benzoic acid and pasteurization
Unsweetened juice	100	Natural	Pasteurization
Sweetened juice	85	10	Pasteurization
Squash	25	40	350 ppm SO ₂ or 600 ppm benzoic acid
Barley water ^b	25	30	350 ppm SO ₂ or 600 ppm benzoic acid
Crush	25	55	350 ppm SO ₂ or 600 ppm benzoic acid
Cordial	25	30	350 ppm SO ₂ or 600 ppm benzoic acid
Fruit syrup	25	65	350 ppm SO ₂ or 600 ppm benzoic acid
Fruit Nectar	20	50	Pasteurization

a. With or without carbonation

b. Contains not less than 0.25 % barley starch

citrus juices and concentrates has been mainly attributed to the action of pectic enzymes and, more so, to the action of enzyme, pectin methyl esterase (PME).¹¹⁻¹⁴ At least, part of the methyl ester linkages are split forming pectinic acids or, possibly, pectic acids, with which the calcium naturally present in the juice forms a precipitate. Cloud loss in fruit juices and concentrates may be prevented by pasteurization to inactivate the enzymes. Joslyn and Pilnik¹⁵ have reviewed the subject in detail.

According to Verbeek-Inckel,¹⁶ the principle governing the rising or the sinking of particles in a soft drink is related to Stoke's Law. Stoke's law is strictly applicable to free settling of the spherical particles of a nonporous incompressible nature suspended in an incompressible liquid.^{17,18} The pulp particles in a beverage are, however, of widely varying shapes and sizes and are porous and compressible. Ranganra and Raghuramiah¹⁹ found that the size of the particles in orange squash varied from 150μ to 1000μ , and irrespective of the size, the pulp tended to settle. The authors concluded that under the conditions prevailing in fruit juice squashes, etc., a theoretical treatment of Stoke's law, even if applicable, is difficult.

In India, fruit juice beverages, like squashes, crushes, etc., are manufactured from unpasteurized fresh or chemically preserved juices. The finished product is preserved using sodium benzoate and/or sulphur dioxide. In the U.K., to overcome the pulp separation, juice is flash-pasteurized and the finished product is homogenized. In spite of this, the pulp tends to settle down or float at the top after a few days of storage

leaving a clear or hazy serum. Higby²⁰ attributed the cloud loss in carbonated orange beverages to soluble solids concentration gradient. Stevens et al.²¹ patented a procedure for retaining natural cloud in citrus beverages by incorporating sodium hexametaphosphate (200-400 ppm) and locust bean gum.

Ranganna and Raghuramaiah¹⁹ showed that mere pasteurization of the juice to inactivate the enzymes and addition of high methoxyl pectin or sodium alginate did not help in stabilizing the cloud in orange juice beverages containing 40% to 60% TSS. The authors developed a procedure for effective stabilization of cloud in such beverages by pasteurizing the juice, and increasing the viscosity of the finished product using low-density propylene glycol ester of alginic acid.

In the U.K., beverages containing 20% TSS with added saccharin are commercially prepared. There is a growing awareness for the manufacture of low-calorie or diabetic beverages with low sugar content, which has scope in years to come.

B. Jams

In preparing jams and jellies with LMP, the presence of calcium or other polyvalent cations is necessary for stable gel formation. Calcium is added in the form of a soluble salt, either at the end or after cooking. Often, the calcium present in fruits is sufficient to cause gelation.

In Chapter IV, it was shown that the calcium added to the LMP solution in concentrations, lower than those required for gelling, increased the viscosity of the LMP solution considerably

(see Table IV-6 in page 88). Making use of this principle, a procedure developed to ensure the stability of cloud in orange and lime juice beverages containing 25% juice and 20% to 65% TSS is presented below. Similarly, studies on the preparation of low solids jams using LMP prepared in this laboratory are given below.

EXPERIMENTAL

Loose-jacketed mandarin oranges (Citrus reticulata) were washed, cut into halves in a halving machine, and the juice extracted in a power-driven rosin machine. The extracted juice was passed through a screw type juice extractor having a screen of 1 mm perforations to remove the seeds and coarse pulp. Wherever required, the juice was heated for 2 min at 92°C to inactivate the enzyme and cooled to room temperature immediately. Both heated and unheated juices were preserved using 1000 ppm of sodium benzoate or 700 ppm of sulphur dioxide (as potassium metabisulphite) until required for preparation of the beverages.

In a similar manner, juice was extracted from limes (Citrus aurantifolia) by hand-pressing or by the rosin machine and preserved.

The prepared beverage, hereafter called "Squash", irrespective of the TSS, contained 25% juice, 1.5% acidity (as anhydrous citric acid) and 1000 ppm of sodium benzoate or 700 ppm of sulphur dioxide. The TSS content was varied from 20% to 65%. The calculated quantity of sugar was added as 70° Brix syrup and citric acid as a 50% stock solution.

Exploratory Studies on the Stabilisation of Cloud: Orange squash

was prepared from the heated and unheated juices. The pulp particles started separating within a few hours of preparation, and the serum was clear after 2 months of storage. In squashes containing 20% to 50% TSS, the pulp settled at the bottom, whereas at 55% to 65% TSS, the pulp rose to the top. On adding 0.05% to 0.3% ammonia deesterified LMP having 4.5% methoxyl groups but not calcium, the pulp separation occurred as usual in squashes containing 20% to 50% TSS but in those containing 55% to 65% TSS, it remained in uniform suspension at a concentration of 0.1% and 0.05% respectively.

Effect of LMP and Calcium Concentration on Sugar Syrup, Whole Juice and Serum Squashes: In the next set of experiments, the effect of increasing concentrations of added LMP and calcium on the viscosity of the beverages was investigated. Orange juice was centrifuged in a MSE centrifuge at 2500 rpm for 20 min. The clear serum was decanted and the sediment was discarded. Squashes were prepared with varying TSS from 20% to 65% using either serum (hereafter called serum squash) or whole juice (hereafter called whole juice squash). Sugar syrups, having the same TSS as in the squashes, were used as control. Whole juice or serum, aliquots of sugar syrup, citric acid, LMP-solution, orange oil and preservative were mixed together in required proportions and made to known weight with water. The calcium concentration in the syrup and serum as well as whole juice squashes was increased from 0 to 20 mg at the rate of 2 mg after every 24 hr to study the changes in viscosity. With added calcium a slight increase in the viscosity was noted after overnight storage as compared to the value noted immediately. Hence, calcium concentration was increased after 24 hr. The

calcium solution used was made by dissolving 36.75 g of calcium chloride ($\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$) in 1000 ml distilled water (1 ml of this solution was equivalent to 10 mg of calcium).

Based on the results obtained in the above study, squashes were prepared using heated and unheated orange juices with optimum LMP and calcium concentrations to ensure the cloud stability, filled into bottles, stoppered and stored for one year at room temperature (25-30°C).

For studies on jams, apple, pineapple, sour plum (Alu Bukhara), mango and musk melon pulps were made use of. Low solids jams containing 1% LMP were prepared using 50% fruit pulp without or with sugar (35% TSS in the finished product). In some cases, saccharin was added as a sweetening agent. In the preparation of plum jam, since the fruit used was of a tart variety (acidity: 3.25% as anhydrous citric acid), about half acidity was neutralized with Na_2CO_3 (10% w/v). LMP samples, prepared by acid, NaOH and ammonia deesterification procedures and containing 4.5% \pm 0.2% methoxyl were used in these studies. In most of the experiments, however, ammonia deesterified LMP were used as they gave jams of a better texture. The method of preparation of jams was as follows:

Fruit pulp (390 g) was mixed with 5 g of LMP dissolved in 250 ml of distilled water, and the pH adjusted to 3.0 using 10% (w/v) solution of citric acid. The mixture was brought to a boil, and sufficient quantity of sucrose (270 g - TSS from pulp) was added with continuous stirring followed by required amounts of calcium. The jam was cooked to a final weight of 775 g, poured into jelly glasses and allowed to set overnight.

Sugar-free jams were prepared in a similar manner using 250 g of fruit pulp, 5 g of LMP, required amount of calcium, and sufficient water to make the final weight of jam to (775 - weight of sugar added to jams containing 35% TSS =) 505 g. Wherever saccharin was used, it was added to the jam before the finished product was poured into the jelly glasses.

Analytical Methods: Pectin methyl esterase (PME) activity in orange and lime juices was determined essentially according to the method described by Owens *et al.*²² To a known weight of the juice (5 to 10 g), 2 ml of 1.5 M NaCl solution, 10 ml of 1% HMP solution and calculated quantities of 3 N NaOH were added to adjust the pH to 6.8, followed by 0.1 N NaOH to adjust the pH to exactly 7.0. Sufficient quantity of distilled water was added to make up the volume of the mixture to 25 ml and incubated at 30°C in a constant temperature water bath. At the end of 20 or 30 min, the exact time was recorded, and the volume of 0.02 N NaOH required to adjust the pH to 7.0 was noted. The PME activity was calculated using the expression:

$$\text{PME activity} \quad \left(U \times 10^4 / g \right) = \frac{\text{ml of 0.02 N NaOH} \times 0.02 \times 10,000}{\text{Time in minutes} \times \text{weight of juice}}$$

The viscosities of the syrups and squashes were measured at room temperature (25°C ± 1°C) in a Brookfield synchro-lectric viscometer using spindles 1 and 2 at 30 rpm.

Measurement of cloud stability: In some squashes prepared with LMP and calcium, the pulp tended to settle down or rise to the top gradually during storage, leaving a clear serum. Therefore, the total height (H) of squash, and the height (h) to which

the pulp was held in suspension were measured. The extent of cloud stability (per cent) was calculated using the expression:

$$\text{Cloud stability (\%)} = \frac{h \times 100}{H}$$

The gelstrength of the jams was determined using a BFMIRA jelly tester according to the method described in Chapter II (see page 25).

RESULTS

A. Stability of Cloud in Citrus Beverages

Changes in PME Activity During Storage: The initial PME activity in the juice was dependent upon the mode of extraction. The activity in lime juice, extracted by pressing in a hand-operated lime squeezer, was considerably less as compared to the activity in juice extracted using a rosin machine (Fig. VI-1). During frozen storage, the enzyme activity decreased, but some residual activity was present even after three months. The activity in orange juice was considerably lesser than that in the lime juice (Fig. VI-1) but residual activity was seen even after three months of frozen storage as in the case of frozen lime juice (Fig. VI-1).

In sulphited lime and orange juices, residual enzyme activity was not present when examined at the end of six months. The benzoated lime and orange juices extracted in a rosin machine had 11.5% and 25.0% of the initial PME activity at the end of six months of storage. However, in lime juice obtained by a lime squeezer, no residual activity was found at the end of six months (Fig. VI-1).

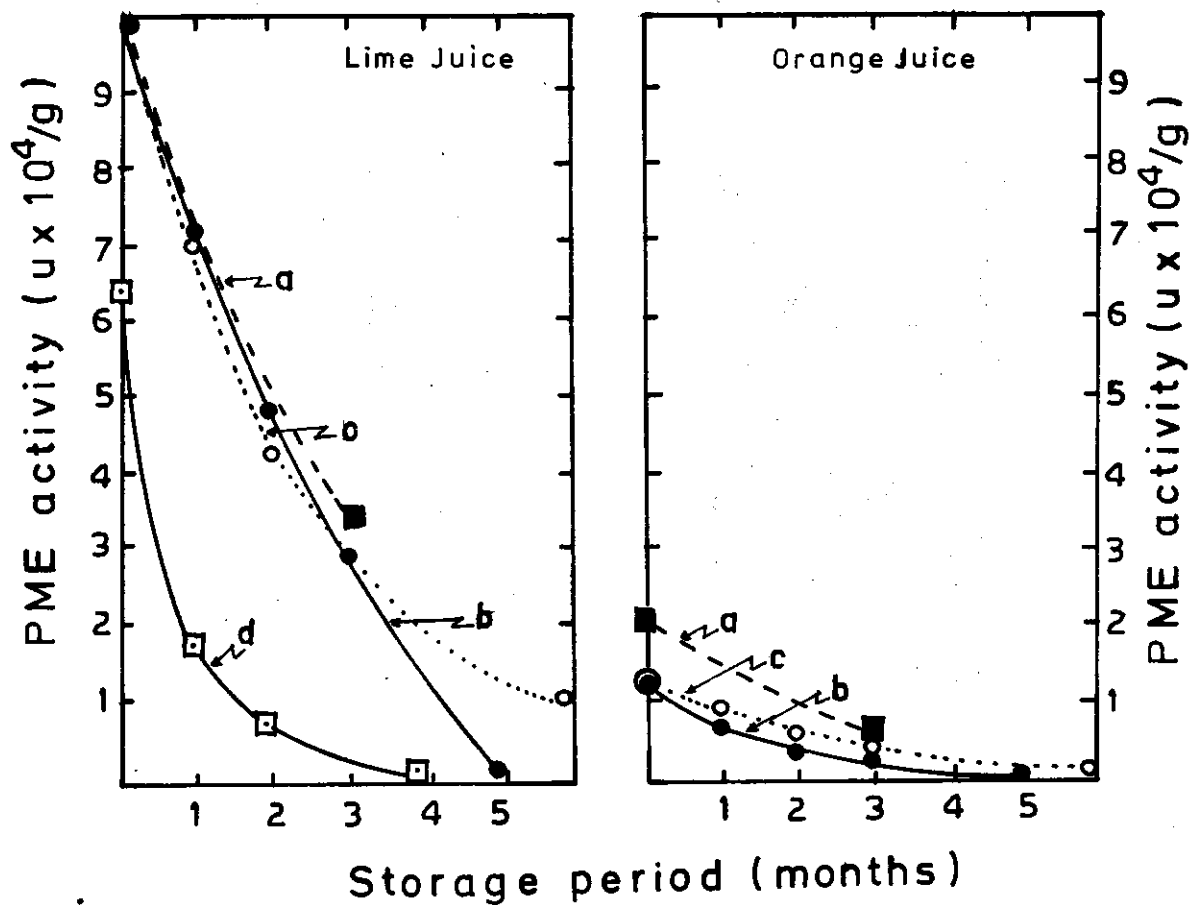


Fig. VI-1. Changes in pectin methyl esterase (PME) activity in lime juice and orange juice during storage.

(a) Frozen, (b) Sulphited and (c) benzoated lime juice and orange juice extracted in rosin machine; (d) sulphited lime juice extracted using hand operated lime squeezer.

Effect of Inactivation of Enzymes on the Stability of Cloud in Orange Juice: Heating freshly extracted orange juice for 2 min at 92°C, completely inactivated the PME. On storage of such a juice preserved with either sulphur dioxide or sodium benzoate, the pulp gradually separated from the serum.

Changes in Viscosity of Sugar Syrup, Orange Serum Squash and Whole Juice Orange Squash: The viscosity of sugar syrup, whole juice and serum squashes without any additives are given in Table VI-2. The viscosities increased with increase in the TSS between 20% and 65%. The extent of viscosity increase was extremely high beyond 55% TSS. When the TSS was maintained constant, the viscosity of the whole juice squash was greater than serum squash, sugar syrup coming last.

Addition of LMP at 0.1% level increased the viscosity still further. The TSS remaining constant, the extent of increase in viscosity followed the same pattern. The slightly higher increase in viscosity in serum squash as compared to that of the syrup, might be attributed to the pectin naturally present in the serum. Apart from pectin, the whole juice, in addition, contains suspended pulp solids and, hence, the viscosity was still higher.

The effect of increasing concentration of added calcium is shown in Fig. VI-2. At lower concentrations (20% and 30% TSS), the increase in viscosity in the presence of 0.1% LMP was negligible; hence, higher concentrations were used (0.25% to 0.3%). When the TSS and concentration of LMP were maintained constant, the viscosity increased with added calcium upto a certain level and decreased

Table VI-2. Effect of added LMP on the viscosity of sucrose syrup, orange serum squash and whole juice squash

TSS of squash	Viscosity without LMP			Viscosity with LMP			
	Sugar syrup	Serum squash	Whole juice squash	Concn of LMP	Sugar syrup	Serum squash	Whole juice squash
%	cp	cp	cp	%	cp	cp	cp
20	4.5	5.0	5.5	0.10	5.0	7.0	8.0
				0.20	7.0	7.0	7.5
				0.30	8.0	8.0	9.0
30	6.0	6.5	7.5	0.10	8.0	9.0	10.0
				0.20	9.0	9.0	9.5
				0.25	10.0	10.0	11.0
40	8.0	9.0	12.0	0.10	13.0	15.0	23.0
45	12.0	13.0	15.0	0.10	21.0	29.0	65.0
50	17.0	20.0	23.5	0.10	26.5	60.0	120.0
55	27.0	29.0	32.0	0.10	36.0	120.0	190.0
60	51.0	52.0	55.0	0.05	120.0	130.0	200.0
				0.10	190.0	200.0	360.0
65	110.0	120.0	130.0	0.05	200.0	270.0	290.0
				0.10	350.0	390.0	530.0

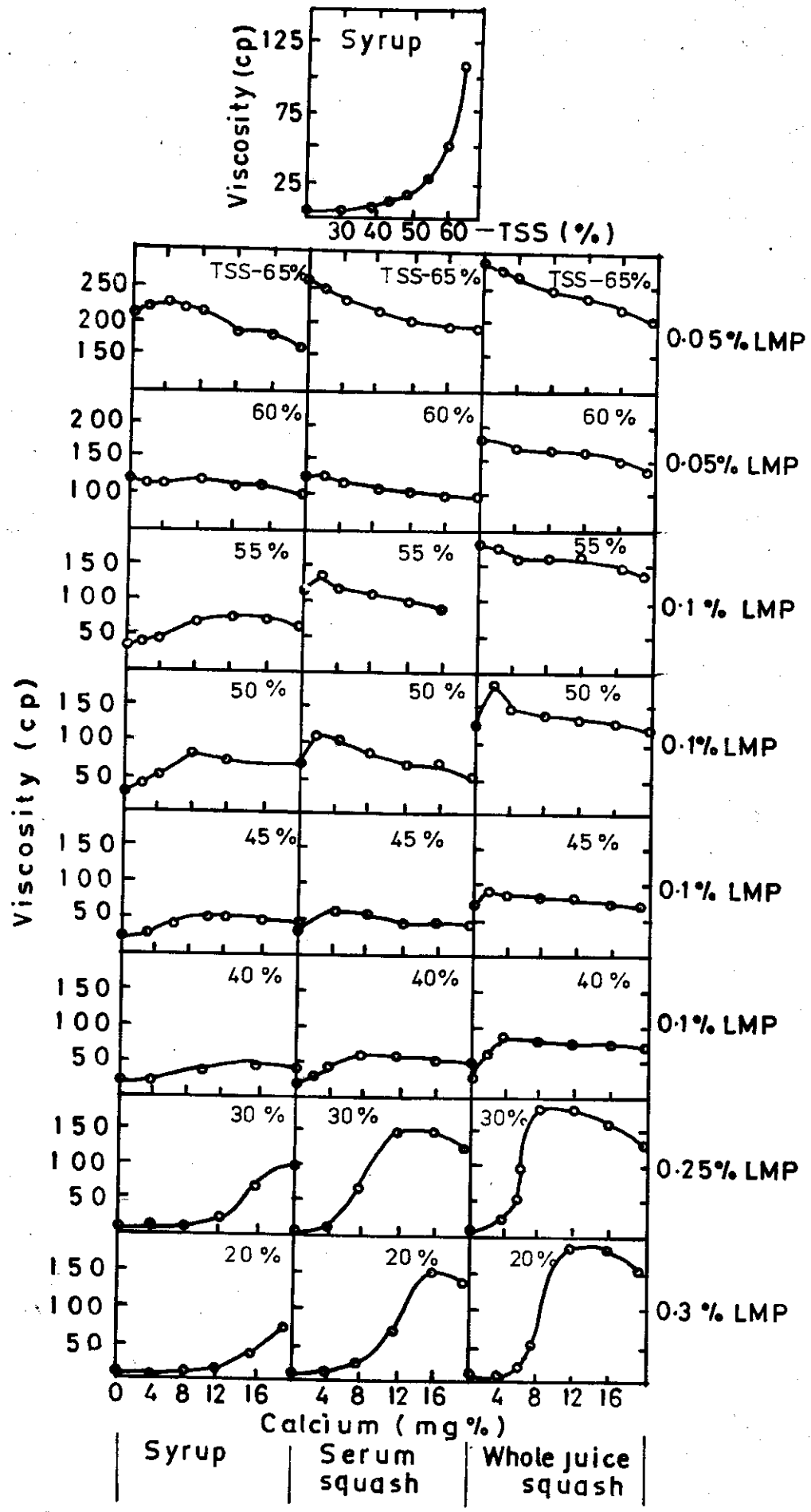


Fig. VI-2. Effect of LMP and calcium on the viscosity of sugar syrups, orange serum squashes and orange whole juice squashes having 20-65% TSS.

thereafter (Fig. VI-2). The concentrations at which these changes take place are given in Table VI-3. The calcium requirements for maximum increase in viscosity followed the reverse pattern of viscosity increase - whole juice squash < serum squash < sugar syrup.

LMP and Calcium Requirements for Stabilization of Cloud in Orange and Lime Juice Beverages: In orange squash prepared from fresh or heated juice, the pulp separated within a few hours or after overnight's storage. At 20% and 30% TSS, even when 0.1% to 0.2% LMP and upto 20 mg % of calcium were added, the suspension of pulp was not uniform and hence, a higher concentration (0.25-0.3%) of LMP was required. Between 40% and 55% TSS, 0.1% LMP was sufficient; at 60% and 65% TSS, the increase in viscosity was very high at 0.1% concentration of LMP and hence, 0.05% was sufficient. The calcium concentration required for uniform stability of cloud in orange squash was found to be lower than that required for maximum increase in viscosity at the particular concentration of TSS (Table VI-3). The squashes prepared using varying concentrations of LMP and calcium were stored for one year at room temperature (25-30°C) and the results are shown in Table VI-4. During this period of storage, a slight separation of the serum occurred but the extent of cloud loss was extremely low (0.1-5%). The viscosity of the squashes increased considerably during storage with 20% to 45% TSS, remained more or less the same at 50%, 55% and 60% TSS, but decreased at 65% TSS (Table VI-5).

Lime juice is known to develop bitterness on heating and hence, the squashes were prepared only with the unheated juice. Observations on the concentrations of LMP and calcium required for

Table VI-3. LMP and calcium requirement for maximum viscosity and for stabilization of cloud in orange squash

TSS	Optimum concentration of LMP	Calcium concentration required for maximum viscosity			Calcium concentration required for cloud stability in squash
		Sugar syrup	Serum squash	Juice squash	
%	%	mg %	mg %	mg %	mg per 100 g of squash
20	0.30	20 ^a	16	12	4-6
30	0.25	20 ^a	12	12	4-6
40	0.10	12	8	4	4-6
45	0.10	10	4	4	2-4
50	0.10	8	2	2	2-4
55	0.10	8	2	0	2-4
60	0.05	0	0	0	2-4
65	0.05	0	0	0	2-4

a. Maximum concentration of calcium studied in this investigation

Table VI-4. Effect of added LMP and calcium on the cloud stability of orange and lime juice beverages stored for one year at room temperature

TSS	Particulars of squash		Extent of cloud stability	
	Concentration of LMP	Concentration of calcium	Orange squash	Lime squash
%	%	mg %	%	%
20	0.10	20	67.4	
20	0.30	6	99.7	98.0
20	0.30	10	95.6	
20	0.50	6	20.0	
30	0.20	8	81.0	
30	0.25	6	99.7	98.2
40	0.10	4	100.0	
40	0.10	6	97.7	99.4
40	0.10	10	90.0	
45	0.10	2	100.0	
45	0.10	4	95.0	98.9
45	0.10	6	90.0	
50	0.10	0	100.0	
50	0.10	2	99.8	95.7
50	0.10	4	96.5	
55	0.10	0	100.00	96.0
55	0.05	4	90.0	
60	0.10	0	100.0	
60	0.05	0-2	100.0	100.0
65	0.10	0	100.0	
65	0.05	0-2	100.0	100.0

Table VI-5. Changes in the viscosity of the orange squash during storage for 1 year at room temperature

<u>Particulars of squash</u>			<u>Viscosity</u>	
<u>TSS</u>	<u>Concentration of LMP</u>	<u>Calcium</u>	<u>Prior to storage</u>	<u>After storage</u>
<u>%</u>	<u>%</u>	<u>mg %</u>	<u>cp</u>	<u>cp</u>
20	0.30	6	30	400 ^a
30	0.25	4	53	650 ^a
40	0.10	4	74	100
45	0.10	2	94	135
50	0.10	2	138	140
55	0.10	0	180	180
60	0.05	0	200	200
65	0.05	0	290	225

a. These squashes resembled a loose gel after three months of storage and remained unchanged after one year

uniform cloud stability in lime squashes (20% to 65% TSS) were similar to those found for orange squashes (Table VI-4).

B. Jams

The characteristics of the different types of fruit jams prepared using acid, NaOH and ammonia deesterified LMP samples, are given in Table VI-6. The jams prepared using ammonia deesterified LMP had better texture and higher gel strength than those prepared using NaOH and acid deesterified LMP samples. The calcium optimum for jams varied with the fruit used. Thus, for example, pineapple jams had a good set even at very low calcium concentrations (10 mg) whereas the plum or mango jams required higher calcium (40 mg).

Unlike gels prepared using only LMP and water, which had a good set even at a calcium concentration slightly higher than the optimum, fruit jams had a critical optimum calcium concentration. Great care is, therefore, necessary in the addition of calcium to prepare jams of good texture and gel strength. Thus, for example, pineapple formed a mushy jam (coagulated gels) at 15-20 mg calcium, but gave a good set at 10 mg. Irrespective of the presence or the absence of sugar added (35% TSS), the fruit jams had good set and high gel strength at the optimum calcium concentration (Table VI-6).

DISCUSSION

In the preparation of squash, although juice screened through 1 mm mesh is used, the particles are irregular in shape and of varying size. Ranganna and Raghuramaiah¹⁹ found that the size distribution of the particles widely varied from 150 μ to

Table VI-6. Characteristics of jams prepared with or without added sugar using acid, sodium hydroxide and ammonia deesterified LMP

Particulars of Jam				Jam characteristics		
Type of LMP	Fruit pulp	TSS of pulp	Sugar ^d	Optimum calcium	Gel strength	Appearance ^e
		%		mg/g LMP	ml H ₂ O	
Acid deesterified LMP ^a (MeO=4.23 %)	Musk melon	8.0	+	20	36	+++
	Musk melon	8.0	-	30	38	+++
	Mango	13.0	+	20	34	+++
	Mango	13.0	-	30	35	+++
NaOH deesterified LMP ^b (MeO = 4.35 %)	Musk melon	8.0	+	20	40	+++
	Musk melon	8.0	-	30	45	+++
	Mango	13.0	+	20	38	+++
	Mango	13.0	-	30	39	+++
Ammonia deesterified LMP ^c (MeO = 4.25 %)	Musk melon	8.0	+	20	50	++++
	Musk melon	8.0	-	30	52	++++
	Mango	13.0	+	20	43	++++
	Mango	13.0	-	40	52	++++
	Apple	14.0	+	20	48	++++
	Apple	14.0	-	20	48	++++
	Pineapple	18.0	+	10	43	++++
	Pineapple	18.0	-	10	43	++++
	Plum	8.0	+	40	35	+++
	Plum	8.0	-	40	38	+++

a. LMP prepared by deesterifying the extract for 9 hr at 60°C and pH 0.5, and precipitated at pH 0.5.

b. LMP prepared by deesterifying the extract for 15 min at 5°C and pH 11.7, and precipitated at pH 0.5.

c. LMP prepared by deesterifying the extract for 1 hr at 25°C and pH 11.7, and precipitated at pH 0.5.

d. '+' with added sugar (35 % TSS) or '-' without added sugar.

e. ++++ Very good set; +++ good set; ++ soft set; + coagulated set.

1000 μ , and that, irrespective of the size, the pulp tended to settle down. The authors also found that mere heating (pasteurization)^{of} the juice to inactivate the pectic enzymes, as in the case of fruit juices and concentrates, was insufficient to render the cloud stable in bottled beverages like squashes, crushes and syrups, wherein the TSS varied from 40% to 65%.

The enzyme PME is known to be responsible for the loss of cloud in fruit juices. Most of the published work relates to this aspect.¹¹⁻¹⁴ Krop and Pilnik²³ reported the usefulness of the enzyme polygalacturonase (PG) in the presence of PME in preventing the cloud loss in citrus juices. Stabilization of cloud in reconstituted orange juice was considered to be due to the destruction of polygalacturonide formed by PME action to low molecular uronides by PG.

In India, during the season, fruit juices are chemically preserved in bulk without any pasteurization. The beverages are prepared subsequently during the off-season. In the present study, it was found that the PME activity is dependent upon the mode of extraction of the juice. In juices stored with sulphur dioxide or sodium benzoate, and in frozen juices, the PME activity gradually decreased during storage.

Unlike the ready-to-serve fruit juices, the TSS of 40% to 65% in fruit squashes, crushes and syrups render the specific gravity of the serum heavier than that of the suspended particles resulting in the latter rising to the top. Hence, in such beverages, the cloud could be stabilized by increasing the viscosity of the serum which would retard the floating of the pulp. Rangama and

Raghuramaiah¹⁹ made use of a low-density propylene glycol ester of alginic acid for increasing the viscosity of the orange squash containing 40% to 60% TSS. This additive has to be imported and, moreover, it is not permitted for use in many countries. Instead, LMP could safely be used for increasing the viscosity of squashes to ensure cloud stability. Since pectin is a natural ingredient of fruit juices, the use of LMP should meet with no objections. The concentration of LMP, and calcium required for increasing the viscosity sufficient enough to maintain uniform suspension, decreases with increasing TSS (Table VI-3). In beverages containing 20% to 50% TSS, addition of 6 to 2 mg of calcium along with 0.3% to 0.1% LMP is necessary to render the cloud stable, but at 55%, 60%, 65% TSS, addition of calcium is not necessary as LMP (0.1% to 0.05%) alone, increases the viscosity sufficiently to stabilize the cloud (Tables VI-3 and 5). During prolonged storage, there is, however, a tendency for the pulp to coalesce and rise to the top leaving a small portion of serum at the base. Hence, addition of 2-4 mg% of calcium is, perhaps, advisable.

In bottled beverages, containing either low-density propylene glycol ester of alginic acid¹⁹ or LMP as the cloud stabilizing agent, the slight separation of serum during storage is obvious to the naked eye. Turbidity determinations have been made use of as a measure of cloud stability.²³ The procedure of Ranganna and Raghuramaiah¹⁹ for measuring the cloud stability, viz., the ratio of the total height of the beverage to the height to which the pulp is held in suspension, is an objective measure of cloud stability as observed by the naked eye, and hence, this method was made use of

for measuring the extent of cloud stability. In the present study, no mechanical agitation or homogenization was used. The cloud loss of 1-5% observed in orange and lime juice beverages containing 20-65% TSS, during one year of storage at RT (25-30°C), could possibly be overcome by mechanical agitation or by homogenization.

During storage of the chemically preserved unheated juice, the PME activity decreased (Fig. VI-1). The residual activity might, at the most, further lower the methoxyl of the LMP added to the beverages, which would only increase its calcium sensitivity, thereby increasing the viscosity (Table VI-5), and aid in uniform suspension of pulp in the beverages. Furthermore, no difference was observed in cloud stability in squashes prepared from fresh, heated or unheated stored (3 months) juices. Hence, when LMP and calcium are used to render the cloud stable, heating of the fruit juice to inactivate the pectic enzymes is not necessary, as reported by Banganna and Raghuramaiah¹⁹. This would obviate the need for addition processes (heating and cooling) to the present manufacturing practice.

Of the three types of LMP prepared in this laboratory, the ammonia deesterified LMP was the most suitable in the preparation of jams with or without sugar, followed by NaOH and acid deesterified samples.

SUMMARY

In bottled fruit juice beverages like squashes, crushes, syrups, etc., the pulp tends to coalesce and rise to the top or settle down, leaving a clear or hazy serum, which results in the unattractive appearance of the product. Mere pasteurization of the juice to inactivate the pectic enzymes was not effective in preventing this cloud loss.

Calcium added in concentration lower than that required for gelling increased the viscosity of the LMP solution considerably. Making use of this principle, addition of 0.05% to 0.3% LMP and 2 to 6 mg of calcium per 100 g of beverages containing 65% to 20% TSS has been found to stabilize the cloud. The concentration of LMP and calcium required for adequately increasing the viscosity to maintain uniform suspension decreased with increasing TSS.

During storage of chemically preserved unpasteurized fruit juices, pectin methyl esterase (PME) activity gradually decreased. The residual activity did not alter the cloud stability achieved by added LMP and calcium. Heating the fruit juice to inactivate the pectic enzymes was not necessary.

Of the three types of LMP prepared in this laboratory, the ammonia deesterified LMP was the most suitable in the preparation of jams with or without sugar, followed by NaOH and acid deesterified samples.

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