

Properties of Pectin Isolated from Lawulu (*Crysophyllum roxbergi* G Don) and Development of Jam and Fruit Leather using Lawulu and Pineapple

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ABSTRACT. Lawulu fruit (*Crysophyllum roxbergi* G Don) possess nutritional, medicinal and functional properties. However, it is less consumed due to its characteristic off flavour. The present study was carried out to investigate the potential of utilizing lawulu fruit for isolation of pectin and to develop jam and fruit leather. Products were evaluated based on physico-chemical and sensory properties.

Pectin isolated from firm ripe lawulu fruit using 0.1 M hydrochloric acid followed by 96% ethanol precipitation yielded 7.3% pectin on wet weight basis and 26.1% on dry weight basis. The isolated pectin contained 0.74% ash, 0.02% acetyl content and 7.85% methoxyl content with equivalent weight of 993.5. These values were comparable with commercial high methoxyl pectin. In addition, lawulu pectin at 1.5% concentration formed a gel within 12-14 min in the presence of 68% sucrose and 0.5% citric acid.

Jam was prepared by using lawulu-pineapple ratio as 1:2, 1:1 and 2:1 respectively. The gel strength of jam (65°Brix and pH 3.1) at 0.35% commercial high methoxyl pectin was comparable with commercial mixed fruit jam. Sensory evaluation indicated a significant preference ($p < 0.05$) for jam containing lawulu-pineapple ratio of 1:2 and 1:1 respectively over the ratio of 2:1. With increased lawulu percentage both yellowness and lightness of jam increased significantly ($p < 0.05$).

Fruit leather was prepared by changing lawulu-pineapple ratio as 1:2, 1:1 and 2:1 respectively with 20% sucrose, 0.3% citric acid, 0.05% pectin and 100 ppm potassium metabisulphite followed by drying at $65 \pm 1^\circ\text{C}$ for 12-14 h. Sensory evaluation data revealed that changes in lawulu-pineapple ratio had no significant effect on taste, texture and overall quality of fruit leather. However, significant preference ($p < 0.05$) for colour was observed with increasing lawulu percentage. Both yellowness (b' value) and lightness (L' value) of fruit leather were significantly increased ($p < 0.05$) with increasing lawulu percentage.

INTRODUCTION

Lawulu (*Crysophyllum roxbergi* G Don) belongs to family Sapotaceae is also known as *Marmalade* or *Gross sapota* in English and *Kat-illupai* in Tamil. It is native to Sri Lanka, South Asia and Indochina. It grows well under temperature of 22-29°C and well distributed rain falls of 2000-2300 mm. In Sri Lanka it occurs in primary wet evergreen

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forests up to 900 m and commonly cultivated in home gardens throughout the country. Some varieties of lawulu in Sri Lanka bear fruits throughout the year while some are seasonal (March-April and September-October) (Thilakarathna, 1981; Karunanayaka, 1986). However, no scientific investigation has been received yet for lawulu and it remains underutilised on commercial basis.

Lawulu fruit contains 0.6 g of protein, 0.4 g of fat, 1200 mcg of carotene, 14 mg of calcium, 1.3 mg of iron, 0.08 mg of thiamin, 0.03 mg of riboflavin and 0.6 mg of niacin in 100 g of edible portion (Wickramanayaka, 1987). Among them β -carotene is important because of its possible involvement in wound healing and prevention of anemia, cancer and cardiovascular diseases (Berg *et al.*, 2000). Special sterols present in the fruit are used in ayurvedic medicine as it imparts laxative and vermifugal effects (DOA, 1997). Generally, lawulu fruit has been recommended for those suffering from heart problems, hepatitis, jaundice, cirrhosis, hemorrhoids, rheumatic and bile problems (Thilakarathne, 1981).

Apart from the nutritional and medicinal properties, natural dark yellow colour of the fruit is an added advantage in food processing. Presence of starch and gum in lawulu improve the texture of the product during processing. High starch content in the fruit (DOA, 1997) could reduce the processing time and hence preserve the organoleptic qualities while minimizing nutritional losses. Anti oxidant capacity of β -carotene would help to improve the keeping quality of processed product.

In Sri Lanka products formulated with lawulu are not available in the market. Lawulu is used in preparations of rotti, pittu and jaggery at household level. Most of the people do not like to enjoy this fruit due to its characteristic off flavour. However, this could be overcome by blending with several other fruits (Scholey, 1973). Pineapple with a distinctive taste due to the presence of large number of volatile compounds could be mixed with lawulu to mask the off flavour. In addition, pineapple which contains high amount of acids (0.6%) would help to minimize the amount of citric acid in formulation of fruit products (Sen, 1990).

Development of products from the lawulu fruit could help to produce nutritionally valuable, organoleptically desirable and economically viable food products. In addition to product development isolation and characterization of lawulu pectin is important for food technologists to better use of it in food processing. This study was directed towards the isolation and characterization of pectin, development of jam and fruit leather from lawulu fruit.

MATERIALS AND METHODS

Mature lawulu fruits were obtained from a home garden in Kandy district. Pineapple and food grade additives; citric acid, commercial high methoxyl pectin, potassium metabisulphite were procured from a food ingredient shop. All chemical reagents used were in the analytical grade.

Isolation and characterization of pectin

Pectin was extracted from lawulu pulp of firm ripe fruits by acid hydrolysis (0.1 M hydrochloric acid) followed by ethanol (96%) precipitation (Ptitchkina *et al.*, 1994). The ash content of the extract and the commercial pectin were measured by incinerating the samples overnight in a muffle furnace at 550°C (AOAC, 1984). Equivalent weight, methoxyl content and acetyl value were determined according to the method described by Ranganna (1986). Gelling capacity of extracted pectin and commercial high methoxyl pectin were determined at pectin concentration of 0.5, 1.0 and 1.5%.

Preparation of jam

The fruits were washed and peeled. They were cut into pieces and pureed for 3-5 min using a blender (HL 3294/C). Lawulu and pineapple fruits were analysed for total soluble solids, titratable acidity and pH (IM-40S ToA Electronics) (Ranganna, 1986). Jam samples (lawulu : pineapple ratio, 1:1) were prepared by changing the pectin concentration as 0, 0.35 and 0.70%. Suitable pectin concentration was determined by comparing the texture with a commercial jam sample using a penetrometer. Selected pectin concentration was used for preparing jams with changing the lawulu-pineapple ratio as 1:2 (T1), 1:1 (T2) and 2:1 (T3) respectively.

Jam was prepared according to the recipe described by Lesschaeve *et al.* (1991). Recipes were used to make 500 g of jam. Total amount of sucrose added was calculated to obtain a final Brix of 65°. Calculated amount of citric acid was added to reach the final pH of 3.1. Prepared jams were poured into medium sized glass bottles and subjected for colour measurements and sensory evaluation.

Preparation of fruit leather

Fruit leather was prepared according to the method of Gowda *et al.* (1995). Various combinations of lawulu and pineapple fruit pulp *viz.*; 1:2 (M1), 1:1 (M2) and 2:1 (M3) were made. The prepared pulp was mixed with 20% sugar and 0.3% citric acid and heated at 65°C to a total soluble solid content of 40°Brix. 100 ppm potassium metabisulphite was added to the mixture after cooling (Aruna *et al.*, 1999). This mixture was spread in the form of thin layer in stainless steel trays to 5 mm thickness smeared with fat (margarine) and dried in an oven at 65±1°C for 12-14 h. It was cut into pieces and subjected for measurement of colour and sensory evaluation.

Measurement of colour

Absolute L' (lightness), a' (redness) and b' (yellowness) values of jam and fruit leather were measured (Ranganna, 1986) from the colour difference metre (ZE 2000). Hue can be expressed as $\tan^{-1} b/a$ while chroma is expressed as $(a^2 + b^2)^{1/2}$. The data were statistically analysed in a CRD model with four replicates. Treatment means were compared at $p < 0.05$ according to Duncan (New) Multiple Range Test.

Sensory evaluation

Sensory evaluation was conducted using an untrained consumer panel consisting of 50 undergraduate students. Hedonic scale of 5-points was used to evaluate the jams and fruit leathers containing different fruit ratios. Data were analysed using non-parametric Friedman test and treatments were compared according to the Multiple Comparison technique (Sheskin, 1997).

RESULTS AND DISCUSSION

Extraction yield of pectin

Lawulu fruit contains considerable amount of pectin (7.3% on wet weight basis and 26.1% on dry weight basis) compared to other fruit sources such as passion fruit rind (16.1%), guava (6.5%) and mango (20.8%) on dry basis (Sudhakar and Maini, 1995). However, the amount of pectin could vary with degree of ripening and method of extraction.

Physico-chemical properties of lawulu pectin

Comparison of physico-chemical properties of lawulu pectin and commercial high methoxyl pectin are given in Table 1.

Table 1. Physico-chemical properties* of lawulu pectin and commercial pectin.

	Ash %	Methoxyl content	Acetyl value	Equivalent weight
Lawulu Pectin	0.74 ± 0.01	7.85 ± 0.01	0.02 ± 0.00	993.50 ± 0.42
Commercial Pectin	0.82 ± 0.01	9.77 ± 0.02	0.02 ± 0.00	846.15 ± 0.50

*Means of four determinations ± standard deviation.

Lawulu pectin contained low amount of ash (0.74%) compared to commercial pectin (0.82%). It is favourable for gel formation. The low amount of ash in lawulu pectin may be attributed to the use of acid in extraction and washing of pectin extract with pure ethanol (Miyamoto and Chang, 1992). Sugar beet pectin extracted using acid also contained low amount of ash compared to EDTA extraction method (Phatak *et al.*, 1988).

Methoxyl content or degree of esterification defines the extent of galacturonic acid residues esterified with methanol. It determines the solubility, setting time and gelation requirement of pectin. Methoxyl content of lawulu pectin was 7.85%. Therefore it could be considered as high methoxyl pectin which generally requires high amount of sugar and acid to initiate gel formation. However, degree of esterification is sensitive to the

conditions during extraction (Phatak *et al.*, 1988) and can be subjected to acid-, base- or enzymatic- deesterification to obtain low methoxyl pectin (Cruess, 1958) which is used in the preparation of dietetic and acid sensitive food in the presence of calcium ions.

Acetyl content in pectin may adversely affect the functional properties such as pectin solubility, pregelation, and brittleness (Miyamoto and Chang, 1992). Several studies have shown that high amount of acetyl content in sugar beet pectin was responsible to inhibit the gel formation (Sudhakar and Maini, 1995). According to Michel *et al.* (1985), sugar beet pectin contained 21-25 acetyl groups per 100 molecules of anhydrouronic acid. In contrast, lawulu pectin contained low amount of acetyl groups (0.02%). The degree of acetylation also varies depending on isolation procedure. It is reported that acid extracted pectin contained lower amount of acetyl groups compared to ammonium oxalate or EDTA extraction procedures (Phatak *et al.*, 1988).

Equivalent weight of lawulu pectin (993.5) is comparable with commercial pectin (846.7) as that of mango peel (971.0) and guava fruit (949.0) (Sudhakar and Maini, 1995).

Effect of pectin concentration on gel formation

In the presence of 68% sucrose and 0.5% citric acid perfect setting of jelly (pH, 3.0) was observed at 1.5% for lawulu pectin and 1% for commercial pectin (Table 2). Time taken for them to form jelly at 90°C was 12-14 min and 10-12 min respectively. Rapid setting pectin usually takes less than 25 min to set (Ranganna, 1986). Rapid set pectin is suitable in the preparation of jam and marmalade to avoid floatation of fruit particles. The setting time can be extended by mixing with buffer salts such as sodium citrate, sodium acetate and calcium carbonate *etc.* Extended setting time is preferable in preparation of jellies to avoid formation of air bubbles inside the jelly matrix (Cruess, 1958).

Table 2. Effect of pectin concentration on gel formation.

Pectin concentration	Lawulu pectin	Commercial pectin
0.5%	No setting	Poor setting
1.0%	Poor setting	Perfect setting
1.5%	Perfect setting	Perfect setting

Preparation of jam

Lawulu and pineapple pulps contained 28.0% and 14.3% total soluble solids, 0.1% and 0.4% titratable acidity and 5.2 and 3.8 pH respectively. Brix value of lawulu fruit was much higher than pineapple fruit. However, both fruits do not contain adequate acidity,

which is required for jam making. Citric acid was added externally depending on lawulu : pineapple ratio to achieve the desired gel consistency.

A successful gel consisting of 65°Brix and 3.1 pH with comparable texture to commercial mixed fruit jam resulted at 0.35% pectin concentration. According to Dull (1971) and Lal *et al.* (1986), 0.50-0.75% pectin was required for pineapple jam as it contains 0.06-0.16% pectin on wet weight basis. Setting of lawulu-pineapple jam at low concentration of commercial pectin might be due to the presence of high amount of pectin in lawulu fruit.

Effect of fruit ratios on colour of jam

Colour of jams (measured as L', a', b') containing different proportions of lawulu and pineapple (Table 3) were significantly different at 5% level. Jam containing 2:1 ratio of lawulu to pineapple had the highest L value and most intense yellow colour (highest b' value). Increased in yellowness may be due to higher amount of β -carotene present in the lawulu. With increased pineapple percentage lightness and yellowness decreased and the redness increased. Similar changes were observed with hue (h) and chroma (c) values. The significant increase of hue (83.0-89.5) with increasing lawulu percentage was accompanied by a colour change from orange to yellow which could be attributed to the higher amounts of β -carotene present in lawulu. The chroma character closely followed the b' values since a' values were quite minor. One or more browning reaction processes were suspected as the product become less light while increasing chroma.

Table 3. Colour of jams prepared using different proportions of lawulu and pineapple.

Lawulu : Pineapple ratio	Colour				
	L	+a'	+b'	h	c
1:2	23.4 ^a	2.0 ^a	16.3 ^a	83.0 ^a	16.4 ^a
1:1	29.8 ^b	1.6 ^b	19.5 ^b	85.3 ^b	19.6 ^b
2:1	34.3 ^c	0.2 ^c	22.7 ^c	89.5 ^c	22.7 ^c
Duncan Critical Value _{0.05}	2.5	0.3	1.5	1.8	2.1

Each value is an average of four measurements.

Means bearing different letters within same column are significantly different ($p < 0.05$).

Sensory evaluation of jam

There was significant difference ($p < 0.05$) among three treatments for sensory scores of colour, texture, flavour and overall acceptability. The median scores obtained for sensory attributes are shown in Fig. 1. Jam containing the lowest amount of lawulu (T1) received the highest score of 5 (like extremely) for appearance and was significantly

different ($P < 0.05$) from T2 (1:1) and T3 (2:1). However, T2 and T3 were not significantly different and both obtained the score of 4 (like slightly). Panelists indicated that both T2 and T3 were slightly light in colour compared to T1. The instrumental colour values are also comparable with the data on sensory evaluation (Table 3).

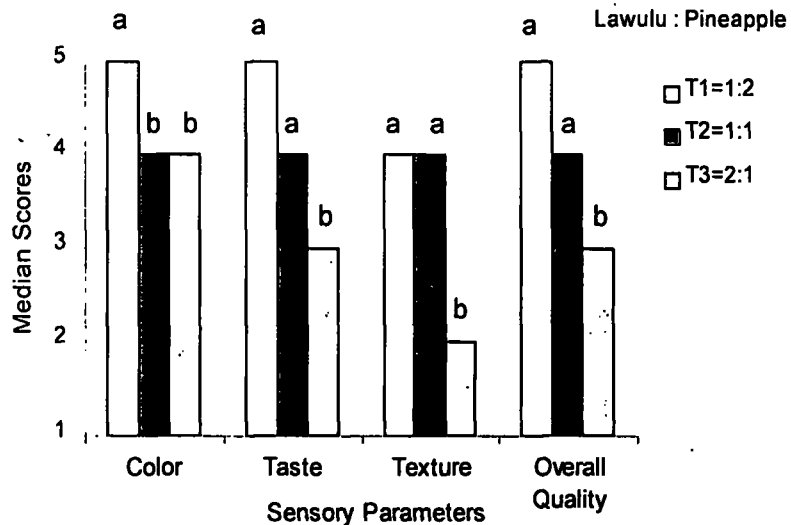


Fig. 1. Sensory responses for jam by variation of ratio of fruit.

[Note: Medians with the same letter within the parameter are not significantly different at $p=0.05$ level].

The results indicated that the median values for taste of all these three types were significantly different ($P < 0.05$) from each other. However, jam containing high amount of pineapple (T1 and T2) were within acceptable range with median score values of 5 (like extremely) and 4 (like slightly) respectively. Jam with the highest amount of lawulu (T3) received the median score of 3 (neither like nor dislike). Panelists had recorded in the comments that T3 had an odd flavour compared to T1 and T2. It may be due to presence of high amount of lawulu in T3. Comparatively lower scores for flavour may be due to the loss of volatile compounds from open vessel during preparation of jam. Lesschaeve *et al.* (1991) observed that loss of volatiles in strawberry jam were closely related to the design of cooker and the pressure used and they have concluded that incorporation of condensed volatiles into pectin solution would result a more flavourful product.

Sensory scores obtained for texture was lower compared to the other attributes. T1 (1 lawulu : 2 pineapple) and T2 (1 lawulu : 1 pineapple) received the median score of 4 (like slightly) while T3 (2 lawulu : 1 pineapple) obtained the median score of 2 (dislike slightly). Besides T3 was significantly different ($P < 0.05$) from T1 and T2. Panelists had indicated that starchy texture was more prominent in T3 resulting in lower preference. According to Lal *et al.* (1986), fruits containing high amount of starch (*eg.* immature fruits) are not suitable for jam making as it does not dissolve in juice giving cloudy appearance to

the product. However, T1 and T2 were within the acceptable range with obtaining the median score of 4.

Sensory scores obtained for overall quality were similar to the values obtained for taste. Jam containing the lowest amount of lawulu received the highest value for overall quality.

Effect of fruit ratios on colour of fruit leather

Colour of fruit leather as evaluated from L', a' and b' values were significantly different ($p < 0.05$) among three treatments. With increasing lawulu percentage L', b', hue and chroma values increased while decreasing the redness (Table 5). The results were comparable with the values obtained for jam.

Table 5. Color of fruit leather by variation of lawulu-pineapple ratio.

Lawulu : Pineapple ratio	Colour				
	L'	+a'	+b'	h	c
1:2	21.2 ^a	1.7 ^a	18.1 ^a	84.6 ^a	18.2 ^a
1:1	23.7 ^b	1.4 ^b	20.0 ^b	86.0 ^b	20.0 ^b
2:1	26.6 ^c	0.3 ^c	21.8 ^c	89.2 ^c	21.8 ^c
Duncan critical value _{0.05}	2.1	0.3	1.2	0.9	1.5

Each value is an average of four measurements.

Means bearing different letters within same column are significantly different ($P < 0.05$).

Sensory evaluation of fruit leather

Median scores obtained for sensory attributes for fruit leather are presented in Fig. 2. The product containing the proportion of 2 lawulu : 1 pineapple (M3) received the highest score of 5 for appearance and was significantly different ($p < 0.05$) from M1 (1 lawulu : 2 pineapple) and M2 (1 lawulu : 1 pineapple). This may be due to the bright yellowness attributed from high amount of lawulu.

For taste, the highest score of 4 (like slightly) was obtained for M1 and, with increasing lawulu percentage the taste was reported to be less acceptable. However, the treatments were not significantly different at $p < 0.05$.

Similarly, there was no significant difference between treatments for texture. In contrast with the jam, the highest score for texture was obtained for the sample containing the highest amount of lawulu. High amount of starch and gummy nature of the lawulu fruit might contribute to this property. Nanjundaswamy *et al.* (1976) reported that pulpy

varieties of fruits are more suitable for development of fruit leather as it imparts better texture to the product.

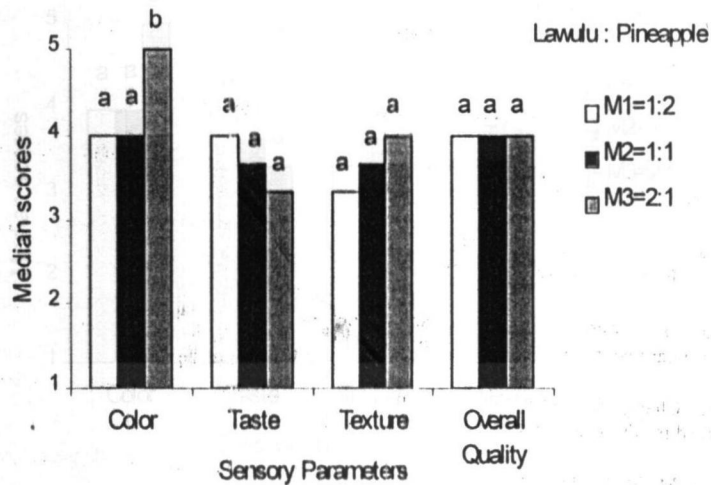


Fig. 2. Sensory responses for fruit leather by variation of fruit ratio.

[Note: Medians with the same letter within the parameter are not significantly different at $p=0.05$ level].

There was no significant difference ($p>0.05$) for overall quality between treatments and each treatment had the median score of 4.

CONCLUSIONS

Lawulu fruit contained a remarkable amount of pectin (7.3% on wet weight basis and 26.1% on dry weight basis) having properties comparable with commercial high methoxyl pectin. Lawulu fruit could be successfully combined with pineapple in the development of jam and fruit leather with the fruit ratio of 1:1 and 2:1 respectively.

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