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Physico-chemical properties of pectin extracted from mango peel

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Abstract
Pectins are complex carbohydrate mainly used as gelling agents, thickener and stabilizer in the food industry. In the present study pectin was extracted from mango peel with different combinations of precipitation time and sample to solution ratio to optimize highest yield and its physicochemical properties were studied. Maximum yield (14.23%) was obtained for C-9 combination. Mango Peel pectin (MPP) extracted from all the combinations had significantly low moisture content compared to commercial pectin (CP). The ash content of MPP (0.12 to 0.33%) was significantly lower compared to CP (1.18±0.15). The pH of mango peel pectin was ranged between 2.24 (C-7) and 3.24 (C-1), whereas for CP it was 3.77±0.07. For colour, lightness *(L*)* value of CP was significantly higher (69.53). MPP at C-6 had least (3.80±0.05) redness (*a**) value, the yellowness (b*) value of MPP was on par with CP. Findings revealed that pectin extracted from mango peel possess high chances to be exploited and commercialized.

Keywords: Ash content mango peel pectin, moisture, pH and yield

1. Introduction
India is the third major producer of fruits and vegetables and ranks next to Brazil and China respectively, in the world. In recent years, the effect of fruit waste is one of major concern contributing to global environmental burden. The rise in production of fruit-based products in the processing industry, especially using off-season fruits like mango, makes fruit availability throughout the year and which results in generating massive fruit by-products. In the mango processing industries approximately 40-50 per cent of the overall fruit waste is produced of which 12-15 per cent is peel, 5-10 per cent is pulp and 15-20 per cent is kernel (Gerg, 2016) [5]. Mango peel is sometimes referred to as total waste although a small portion of the peel is used to make concentrate, the majority of which is considered waste and is a pollutant for the environment. The mango peel contains beneficial nutrients and nutraceutical compounds which can create economic gains in the food sector, minimizing environmental concerns and resolving them. Themajor components as determined experimentally on an Indian variety of mango peels were as follows: cellulose, 15−18; hemicellulose, 5−11; lignin, 9−12; pectin, 20−35; proteins, 6−10; ash, 2; per cent respectively. The majority of the carbohydrates were found to be soluble dietary fibre such as pectin (Maran *et al*. 2015).
Pectin is a high-value functional ingredient widely used in food as a gelling agent in jams and jellies, as a thickening agent in sauce and ketchup and also as an emulsifier in an acidic milk drink. Pectin is a complex mixture of polysaccharides that consist of repeating units of D-galacturonic acid which are joined by α-1-4-linkage. It is located in the cell wall and the middle lamellae of plants. Pectin appears in a different amount in fruit cell walls and has gel forming capabilities, especially for jams, marmalade, and concentrate. The gelling abilities of pectin depend on the degree of methyl esterification that can be divided into low methoxyl (LM) pectin and high methoxyl (HM) pectin based on the degree of esterification (DE). The DE value of commercial HM pectin is more than 50 per cent, while for LM pectin is less than 50 per cent. The major sources for commercial pectin are apple pomace (10−15%), citrus peel (25−35%), sugar beet (10−20%) and sunflower (15−25%) respectively (Maran *et al*. 2015) [10].
The physicochemical properties and structural entities of pectin depend on their source and extraction method. The steps followed for commercial pectin production are extraction with hot dilute acid while controlling pH and temperature to obtain pectin with the desired levels of esterification, centrifugation of extract, filtration, precipitation with alcohol, washing with dilute alcohol, pressing to remove excess water, and finally drying (Herbstreith *et al*., 2005) [6].

As mango peel is not currently being utilized for any commercial purpose, it is discarded and becoming a source of pollution. Number of investigators has been conducted studies on the composition and possible utilization of mango seed kernel. Mango peels were reported to contain appreciable amount of pectin (Maran *et al*., 2015) [10]. Hence, this study was undertaken to extract pectin from mango peel and to analyze its Physico-chemical properties.

2. Materials and Methods

2.1 Materials

The mango peel was procured from a local mango processing Safal industry, Bengaluru, Karnataka, India. The mango peel samples were cleaned, blanched and dried in hot air oven at 70° C for 15 hours. The dried sample was ground to fine powder and passed through a 60 mesh sieve and stored in air tight zip lock covers in room temperature conditions for further use.

2.2 Extraction of pectin from mango peel powder

Mango peel pectin was extracted as per the procedure given by kratchanova *et al*., (2010) [8]. For pectin extraction100g of stabilized mango peel powder and 1000ml of 0.05N HCL were taken in a 2000ml beaker and placed over boiling water bath for 2hrs. After extraction, the slurry was filtered through a thin cloth and the filtrate was cooled to room temperature. The ethanol was added to the filtrate in the ratio of 1:2 of the filtrate volume and left for 8 hrs for precipitation of pectin to occur. The slurry was filtered for separation of pectin from the solution. Then the pectin (precipitate) was washed with ethanol for three to four times and dried at 45°C to a constant weight. Further, nine experimental runs (variations) with different combinations of precipitation time and sample to solution ratio i.e. 2, 4 and 6 hours at 1:10, 1:15 and 1:20 was tried to obtain maximum yield and physico-chemical properties such as colour, moisture, pH and ash content were analyzed.

2.3 Physico-chemical properties of extracted pectin from mango peel

Colour of the pectin was measured by using spectrophotometer (CM-5) Konica Minolta. Colour was expressed in *L**(lightness/darkness), *a**(redness/greenness) and *b** (yellowness/blueness) values (Nazaruddin *et al*., 2011) [12]. Moisture content of pectin was determined by using moisture analyser and results were expressed in grams (Rasti *et al*., 2020) [15]. The pH of the sample was determined by taking about 1 g of sample and diluting in 20 ml of distilled water. The pH of the sample was recorded using a digital pH meter (Elico, India) which was standardized to pH 7.0 and 4.0 with buffer solution according to AOAC (2005) [2].

Ash content of pectin was determined by Ranganna's method (1995) [14]. 1.2g of pectic substance (sample) was ignited slowly, then, heated for 3-4 hr. at 600 ºC. Then cooled the crucible to room temperature in a desiccator and weighted properly. The process was repeated till constant weight come and final weight was recorded.

$$\text{Total ash}(\%) = \frac{W3 - W1}{W2 - W1} \times 100$$

Where, W1 - Weight of empty crucible
W2 - Weight of pectin sample with crucible
W3 - Final weight of crucible and ash

3. Results and Discussion

3.1 Pectin yield

Extraction of pectin from mango peel powder by different experimental combinations of precipitation time and sample to solution ratio i.e. 2, 4 and 6 hours at 1:10, 1:15 1:20 were assessed and presented in table 1. The pectin yield ranged from 6.16 to 14.23 per cent on dry weight basis. The highest yield 14.23±0.25 per cent is obtained for the combination C-9. Statistically significant difference ($p< 0.01$) for pectin yield was observed among different combinations except for C-7, C-8 and C-9. The pectin yield was found to be increased with increase in sample to solution ratio and precipitation time. As the sample to solution ratio and precipitation time was increased the pectin yield was also increased. This could be due to increased rate of conversion of insoluble pectic substances in the cell wall of peel into soluble pectic substance.

study by sangheetha *et al.* (2018) [17] on pectin extraction from mango peel collected from mango processing industry reported pectin yield ranging from 6.12 to 16.3 per cent with different combinations of pH (1.3, 2.5 and 3.7), temperature (60, 75 and 90ºC) and time (45, 90 and 135 minutes).The findings of the present study commemorate with that reported by Aida and Zailan. (2019) [1] who reported pectin yield of 15.4 per cent from mango peel powder extracted by using 0.1 N HCL at 70ºC for 75 minutes and precipitated by 95 per cent ethanol. Similarly Ismail *et al.* (2012) [7] reported pectin yield of 14.96 per cent from dragon fruit peel by extracted with different pH, acid and temperature. However lower pectin yield 10.45 per cent was reported by Sommano *et al.* (2018) [18] for extraction of pectin from mango peel by conventional and phase commercial pectin microwave assisted extraction method. Similarly Masmoudi *et al*. (2008) [11] reported lower pectin yield of 11.21 per cent extracted from lemon by-product with different combinations of temperature, pH and extraction time.

The difference in pectin yield between the present study and reported values might be due to fruit variety and method adopted for extraction. The present finding reveals that, these combinations of sample to solution ratio and precipitation time can be commercially applied to extract pectin from mango peel.

Table 1: The yield of pectin from different combinations

Combinations (C)	Extraction conditions		Yield (%) (Mean±SD)
	Sample to solution ratio	Precipitation time(hours)	
C-1	1:10	2	6.56±0.11
C-2	1:10	4	6.23±0.25
C-3	1:10	6	6.16±0.28
C-4	1:15	2	11.3±0.26
C-5	1:15	4	11.66±0.76
C-6	1:15	6	11.5±0.5
C-7	1:20	2	13.6±0.28
C-8	1:20	4	13.83±0.76
C-9	1:20	6	14.23±0.25
	F-value		**
	SE(m)		0.23
	CD@1%		1.98

**Significant at 1 per cent level ($p< 0.01$)

3.2 Physico-chemical properties of mango peel pectin.

3.2.1 Color measurement

Color analysis will influence the likeness of extracted pectin as it might affect the appearance of the final products. The

least or transparent color of pectin solution is more preferable because it shows pectin will have the least effect in color of final products such as in jams and jellies (Leong *et al*., 2016) [9]. Fig 1, 2 and 3 show the color parameters of pectin produced using mango peel powder by using acid (HCL0.05N) extraction method.

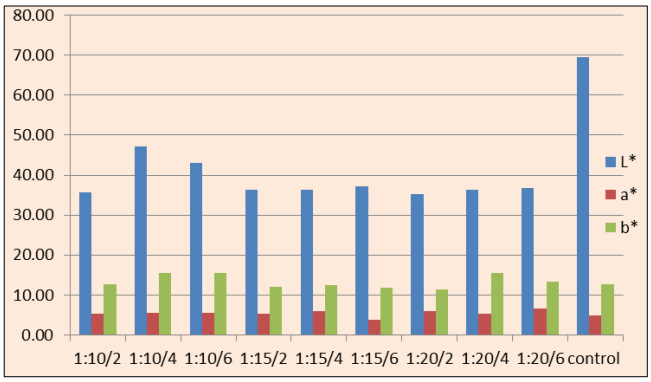

Fig 1: Colour values of mango peel pectin

Fig 1 showed the Color parameter L (lightness) of pectin from different combinations and commercial pectin. The commercial pectin had significantly higher lightness (*L**) (more to white) value of 69.53 compared to mango peel pectin. The lightness value for mango peel pectin ranged between 35.24 and 47.20 and the highest lightness and lowest lightness values were observed for C-2 (47.20±0.09) and C-7 (35.24±0.03) respectively. The redness (*a**) value of mango peel pectin ranged from 3.80 to 6.57. MPP at the ratio of 1:15 at 6 hours of time (C-6) had least (3.80±0.05) redness (*a**) value, followed by commercial pectin (4.84±0.03). Whereas, C-7 (6.57±0.11) & C-5 (5.97±0.21) had significantly higher value for redness. The yellowness (b*) value of mango peel pectin ranged from 11.36 to 15.53. Pectin obtained from C-1 (12.68±0.18), C-4 (12.7±0.17) and C-5(12.57±0.04) had yellowness (b*) value are on par with commercial pectin (12.57).However C-6 (11.8±0.05) and C-7 (11.36±0.05) had significantly lower yellowness (b*) value compared to commercial pectin (Fig 1).

Similar values were obtained by Aida and Zailan (2019) [1] for lightness *L**, redness a* and yellowness b* of the mango peel pectin were 51.13±0.06, 5.08±0.32 and 10.45±0.41 respectively. In present study, most of the colour values decreased with increase in yield. Different combinations of sample to solution ratio and precipitation time are influencing on colour of the extracted pectin. Sample to solution ratio of 1:10 imparted lightness to MPP, whereas low redness values obtained at 1:15. Least yellowness was observed in 1:20 ratio at 2 hours of precipitation time. However, with the precipitation time lightness value decreased and yellowness increased for MPP. In future, intermittent methods may be employed to stabilize the colour of the pectin and to enhance its applicability in the food industry.

3.2.2 Moisture and ash content of mango peel pectin

The moisture and ash content of mango peel pectin is presented in table 2. The moisture content of MPP ranged from 8.42 to 13.93 per cent whereas it was 13.28±0.01 for commercial pectin. All the extracted MPP had significantly low moisture content compared to commercial pectin (13.28±0.01) except C-9, as this combination was highest in sample to solution ratio and precipitation time. The variation in moisture content is due to different combinations of sample to solution ratios. As the sample to solution ratio increased, moisture content also increased. Since drying temperature was constant and different MPP were dried at different time intervals leading to variation in moisture content of the pectin. Present findings for moisture content of extracted pectin are in tune that reported by Faruque *et al*. 2016 [4] (8.8 to 12.3 per cent) for pectin extracted from mango peel wastes. Similarly Ismail *et al*. (2012) [7] reported 11.3 per cent for dragon fruit peel pectin and for other fruits pectin like Kinnow, Musambi, Malta and Feutral lies in the range of 9.4- 10.0 per cent respectively(Rehman and Salariya., 2005) [16].

The ash content of MPP extracted from different combinations of sample to solution ratio and precipitation time ranged from 0.12 to 0.33 per cent (Table 6). Higher ash content was found for C-8 whereas, lowest was observed in C-1 and C-2. These values were observed to be significantly lower compared to commercial pectin (1.18±0.15). A study by Aida and Zailan (2019) [1] on Physicochemical Properties of Pectin Extracted from Selected Local Fruits By-Product reported least ash content for mango peel pectin (0.12%), compared to banana (4.60), papaya (1.2%) and commercial pectin (2.4%).

According to Nguyen and Pirak (2019) [13], low ash content (below 10%) is one of the good criteria for gel formation. The ash content of MPP extracted from different combinations had very low ash content (below 0.33%), which is one of the desirable character for gel formation and suitable for commercialization.

Table 2: Moisture and ash content of mango peel pectin

Combinations (C)	Extraction conditions		Moisture (%) Mean±SD	Ash (%) Mean±SD
	Sample to solution ratio	Precipitation time (hrs)		
C-1	1:10	2	9.14±0.22	0.12±0.5
C-2	1:10	4	8.42±0.03	0.12±0.3
C-3	1:10	6	8.80±0.01	0.20±0.2
C-4	1:15	2	10.50±0.07	0.25±0.50
C-5	1:15	4	9.83±0.07	0.24±0.25
C-6	1:15	6	11.38±0.17	0.27±0.08
C-7	1:20	2	11.95±0.07	0.30±0.10
C-8	1:20	4	12.16±0.013	0.33±0.12
C-9	1:20	6	13.93±0.06	0.26±0.11
Commercial pectin	-		13.28±0.01	1.18±0.15
	F-value		**	**
	SE(m)		0.04	0.04
	CD@1%		0.36	0.39

** Significant @1% level ($p< 0.01$)

3.2.3 pH of mango peel pectin

The pH of mango peel pectin extracted with different sample to solution ratio and precipitation time is presented in table 7. The pH of mango peel pectin ranged from 2.24 (C-7) to 3.25 (C-2), whereas in commercial pectin it was 3.77±0.07. The pH of pectin decreased with increase in sample to solution ratio and precipitation time. Statistical analysis revealed that, pectin extracted from all the combination had significantly lower pH compared to commercial pectin. Tyagi S. (2016) [19] reported pH of 4.36 to 4.56±0.5 for pectin extracted from orange peel and Bagde *et al. (*2017) [3] reported pH of 3.9 to 4.5, for lemon peel pectin which are higher compared to present findings. Malviya and Kulkarni (2012) also reported higher values (4.15) for pH in a study on extraction and characterization of mango peel pectin as pharmaceutical excipient. These variations could be attributed to galacturonic acid content of the pectin, as higher the acid content lower will be the pH of the pectin. In present study, all the extracted pectin samples had desirable pH range required for commercialization of pectin.

Table 3: pH of mango peel pectin

Combinations (C)	Extraction conditions		pH (Mean±SD)
	Sample to solution ratio	Precipitation time(hours)	
C-1	1:10	2	3.24±0.14
C-2	1:10	4	3.25±0.13
C-3	1:10	6	2.85±0.08
C-4	1:15	2	2.79±0.07
C-5	1:15	4	2.53±0.18
C-6	1:15	6	2.87±0.04
C-7	1:20	2	2.24±0.05
C-8	1:20	4	2.88±0.04
C-9	1:20	6	2.75±0.05
Commercial pectin	-		3.77±0.07
	F-value		**
	SE(m)		0.058
	CD@1%		0.48

**Significant @1% level ($p< 0.01$)

3.2.4 Correlation between yield and physico-chemical properties of mango peel pectin

Correlation between yield and physico-chemical properties of mango peel pectin is as presented in table 8. Results revealed that pectin yield was negatively correlated with pH and colour *(L*)*, which was observed to be significant at one per cent and five per cent respectively. Ash content of the pectin had positive correlation with colour (*L**). From the previous tables (5 & 7), it is evident that, pH of the pectin decreased with increase in yield and colour lightness (*L**) value decreased with increase yield of the pectin. Negative correlation between yield and pH is desirable as combinations which are yielding high pectin will be having low pH, which is good for gel formation. However, very low colour (*L**) value of pectin are not desired as they impart or may affect colour of the food product. Hence, pectin extraction combination must be selected with good colour (*L**) value and yield.

Table 4: Correlation between yield and physicochemical properties of mango peel pectin

	Yield	pH	Moisture	Ash	L*	a*	b*
Yield	1	-	-	-	-	-	-
pH	-0.855**	1	-	-	-	-	-
Moisture	0.190	-0.004	1		-	-	-
Ash	-0.600	0.625	0.628	1	-	-	-
L	-0.727*	0.280	0.574	0.762*	1	-	-
A	0.325	-0.418	0.150	-0.206	-0.273	1	-
B	-0.145	0.231	-0.226	-0.194	0.241	0.165	1

4. Conclusion

Among new natural sources of extractable pectin, mango peel has a promising potential as a raw material for the food industry, due to its worldwide production capacity and to the tremendous amounts of mango peel produced every year as unused bio-waste. The different sample to solution ratio and precipitation time that we tested in this study have been successfully assessed as complementary methods for the extraction of mango peel pectin. Results reveals that appreciable amount of good quality pectin can be extracted from mango peel. The mango peel pectin (MPP) exhibited very good physicochemical properties (colour, moisture ash and pH) when compared to commercial pectin. Pectin occupied a prominent place due to diverse pharmaceutical, therapeutic and functional applications in food and pharmaceutical industries. Excess utilization of pectin, the gap between production and demand is widening. Extraction of pectin from new sources like mango peel can fulfil this gap.

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