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Optimization and Quality Characteristics of Mango Peel Pectin

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ABSTRACT

Background: Pectin's are complex carbohydrate molecules mainly used as gelling agents, thickener, emulsifier and stabilizer in the food and beverage industry.

Methods: Pectin was extracted from mango peel powder by acid extraction method with different combinations of precipitation time and sample to solution ratio to optimize highest yield and its quality characteristics were studied in comparison with commercial pectin (CP).

Result: The maximum yield (14.23%) was obtained for C-9 combination. Functional properties such as solubility, swelling index, water absorption and bulk density ranged from 49.74 to 72.27 per cent, 2.89 to 5.22 g/g, 3.21 to 6.82 ml/g and 1.06 to 1.59 g/cm^3. In commercial pectin it was 65.99±0.63 per cent, 2.65±0.14 g/g, 5.79±0.15 ml/g and 1.29±0.07 g/cm^3 respectively. Quality characteristics such as Degree of esterification, equivalent weight, methoxyl content and total anhydrouronic acid ranged from 83.37 to 88.98 per cent, 960.5 to 831, 3.83 to 5.28 per cent and 52.30 to 40.5 respectively. In commercial pectin it was 89.03, 906.5, 4.07 and 42.67 per cent respectively. Findings revealed that pectin extracted from mango peel possess high chances to be exploited and commercialized as most of the functional properties and quality characteristics are on par with commercial pectin.

Key words: Extraction, Functional properties, Pectin yield, Pectin, Quality characteristics.

INTRODUCTION

Pectins, a family of complex polysaccharides present within the primary cell wall and intercellular regions of dicotyledons, are good food additives in jams, soft drinks and milk products (Moelants *et al.,* 2014).

Up to the last decade, most pectin applications stemmed from its gel forming ability, but nowadays, pectin is gradually gaining more acceptance as an effective emulsifier (Ngouemazong, 2015). These functional properties of pectins are highly related to their structure, including the molecular weight (Mw), degree of methylation (DM) *and* protein content, *etc*., which depends on the plant source and the extraction method used (Geerkens, 2015). Currently, citrus peel and apple pomace are the main sources used for the production of commercial pectins. The increasing industrial demand for pectins with varying ability to stabilize products increases the need for novel pectin sources, such as sugar beet residues, tomato waste, papaya peel and cacao pod husks (Vriesmann, 2012) *etc*.

Mango (*Mangifera indica*) is an important tropical fruit *and* India is the largest producer of mango in the world. Due to high perishability of the fruit, its value added products such as mango pulp and mango nectar are of high commercial importance. However, the accruing by-products from industries is 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 pulper and 15-20 per cent is kernel, this solid waste consisting of mango skin, stones, trim and fibrous elements (Gerg, 2016). 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, such as mango peel waste (MPW) hydrolysate proved to be the significant inducible alternative medium without any extra nutrients for the maximum productivity of bacterial cellulose (Hasanin *et al*., 2023). Pectin extracted from mango peel can also be used in production of biodegradable film (Karim *et al*., 2022) The major components of an Indian variety of mango peels consists of 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 fiber such as pectin (Maran *et al*., 2015).

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Extraction is the most important process in the pectin production. Pectic substances are usually extracted by chemical or enzymatic methods, with a process of physical and chemical stages, which involves hydrolysis, extraction and solubilization of macromolecules (Pagan *et al.,* 2001). Extraction with hot water is the simplest and oldest method for recovery of pectic substances from plant tissues (Hermann, 1919). The extraction of pectin involves the hydrolysis of insoluble protopectin into soluble pectins and then leaching them out of fruit tissues. The functionality of the mango peel pectin (MPP) strongly depends on the molecular size and degree of esterification which highlight the importance of isolation and characterization of pectin from this novel resource (Wongkaew, 2021).

The present study was designed to extract pectin from mango peel with acid extraction method and to study functional properties and quality characteristics of mango peel pectin.

MATERIALS AND METHODS

Processing of mango peel

Study was conducted in the university of agricultural sciences, Bangalore, Karnataka, at Department of Food Science and Nutrition during 2020-21. 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. Using processed mango peel powder pectin was extracted (Fig 1) (Plate 1).

Yield optimization

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 1:20 was tried to obtain maximum yield and analysed for functional properties and quality characteristics.

Functional properties of extracted pectin from mango peel

Swelling index and solubility index

About 0.4 g of sample in a centrifuge tube was treated with 40 cm^3 of distilled water. The slurry was heated at 90°C in a water bath for 30 min. After cooling to room temperature, the solution was centrifuged at 3000 rpm for 15 min. The supernatant was carefully removed and the swollen starch sediment was weighed. Aliquot of the supernatant was then evaporated at 100°C and swelling index and solubility were calculated from equations (Hassan *et al.,* 2013).

$$\text{Swelling index (g/g)} = \frac{\text{Weight of the wet sediment (g)}}{\text{Weight of the dry sample (g)}}$$

$$\text{Solubility (\%)} = \frac{\text{Weight of dry sediment (g)}}{\text{Weight of the dry sample}} \times 100$$

Bulk density

Bulk density was determined by displacement in petroleum ether (40-60°C) method then petroleum ether was transferred into a pre-weighed (W1) volumetric flask. The weight was noted (W2). Repeated the similar procedure after transferring 1 g sample and noted the weight W3 (Baljeet *et al*., 2010).

$$\text{Bulk density} = \frac{\text{Density of petroleum ether} \times \text{Weight of sample}}{\text{Weight of petroleum ether displaced}}$$

Water absorption capacity

One gram sample was mixed with 10 ml of distilled water. The contents were allowed to stand at 30°C in a water bath for 30 minutes and then centrifuged at 3000 to 5000 rpm for 20 to 30 minutes. After centrifuging, the volume of the supernatant was recorded and used for determination of water absorption and results were expressed as g/g sample (Rosario and Flores, 1981).

Quality characteristics of pectin extracted from mango peel

Equivalent weight

Equivalent weight was determined by Ranganna's method (1995). 0.5 g sample was taken in a 250 ml conical flask and 5 ml ethanol was added. 1 g of sodium chloride to sharpen the end point and 100 ml of distilled water were added. Finally, 6 drops of phenol red or Hinton's indicator was added and titrated against 0.1 N NaOH. Titration point was indicated by purple colour. This neutralized solution was stored for determination of methoxyl content. Equivalent weight is used for calculating the anhydrouronic acid content and degree of esterification. It is determined by titration with sodium hydroxide to pH 7.5 using either phenol red or Hinton's red indicator.

$$\text{Equivalent weight} = \frac{\text{Weight of sample} \times 1000}{\text{ml of alkali} \times \text{Normality of alkali}}$$

Degree of esterification

The powdered sample (0.2 g) was added into a conical flask containing 20 ml of distilled water and 3 ml of 96 per cent ethanol and thoroughly dissolved using a vortex mixer at 3000 rpm (VelpScientifica -Z×3, USA). The solution containing few drops of phenolphthalein indicator was titrated against 0.1 M standardized sodium hydroxide (V1). Then, 10 ml of standardized 0.1 M sodium hydroxide was added slowly to the solution while occasional swirling of the flask. After leaving the flask aside for 15 min, 10 ml of standardized 0.1 M hydrochloric acid was added and mixed well. The solution was titrated against 0.1 M standardized sodium hydroxide (V2) using phenolphthalein as the indicator. The degree of esterification (DE) was calculated using the Equation 2 (Pasandide *et al.,* 2017).

$$\text{Degree of esterification} = \frac{V2 \times 100}{V1 + V2}$$

Methoxyl content (MeO)

The methoxyl content or degree of esterification is an important factor in controlling the setting time of pectin, the sensitivity to polyvalent cations and their usefulness in the preparation of low solid gels, fibres and film. It is determined by saponification of the pectin and titration of the liberated carboxyl groups. Determination of MeO was done by using the Ranganna's method (1995). The neutral solution was collected from determination of equivalent weight and 25 ml of sodium hydroxide (0.25 N) was added. The mixed solution was stirred thoroughly and kept at room temperature for 30 min, after 30 min 25 ml of 0.25 N hydrochloric acid was added and titrated against 0.1 N NaOH to the same end point as before like in equivalent weight titration.

$$\text{Methoxyl content (\%)} = \frac{\text{ml of alkali} \times \text{Normality of alkali} \times 3.1}{\text{Weight of sample}}$$

Total anhydrouronic acid content

Estimation of anhydrouronic acid content (AUA) is essential to determine the purity and degree of esterification and to evaluate the physical properties. Pectin, which is a partly esterified polygalacturonide, contains 10 per cent or more of organic material composed of arabinose, galactose and perhaps sugars. Making use of titre value of the equivalent weight and methoxyl content the total AUA of pectin was obtained by the following formula (Mohamed and Hasan, 1995). Where molecular unit of AUA (1 unit) = 176 g.

Where,
z = ml (titre) of NaOH from equivalent weight determination.
y = ml (titre) of NaOH from methoxyl content determination.
w = Weight of sample (Ranganna, 1995).

$$\% \text{ AUA} = \frac{176 \times 0.1z \times 100}{w \times 1000} + \frac{176 \times 0.1y \times 100}{w \times 1000}$$

RESULTS AND DISCUSSION

Pectin extraction 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 Fig 2. 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) 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 90°C) and time (45, 90 and 135 minutes).The findings of the present study commemorate with that reported by Aida and Zailan (2019), who reported pectin yield of 15.4 per cent from mango peel powder extracted by using 0.1 N HCL at 70°C for 75 minutes and precipitated by 95 per cent ethanol. Similarly, Ismail *et al.* (2012) reported pectin yield of 14.96 per cent from dragon fruit peel extracted with different pH, acid and temperature levels. However lower pectin yield 10.45 per cent was reported by Sommano *et al.* (2018) for pectin extracted from mango peel by conventional and phase commercial pectin microwave assisted extraction method. Similarly, Masmoudi *et al*. (2008) reported lower pectin yield of 11.21 per cent extracted from

Known weight of the sample (stabilized peel powder)

⇩

Stirring with 0.05N Hcl (1:10, 1:15, 1:20w/v) for 2 hours in boiling water bath

⇩

Filtration by using muslin cloth

⇩

Precipitation (2,4,6 hours) of pectin from the extract by adding alcohol to the filtrate

⇩

Separation of filtration using muslin cloth

⇩

Drying the residue using oven at 45°C & stored at room temperature

(Kratchanova *et al*., 2010).

Fig 1: Protocol for extraction of pectin from mango peel powder.

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.

Functional properties of mango peel pectin

Functional properties of pectin are very important in determining its applicability in food products. It helps in selection of pectin extraction method among the different combinations used to extract pectin from mango peel.

Solubility

The solubility of pectin is one of important factor to anticipate desired quality in end products. Higher the solubility better the product quality as more soluble pectin can bring desirable changes in structural and other quality parameters of the product.

The solubility of pectin extracted from different combinations ranged from 49.74 (C-3) to 72.27 (C-7) per cent. The solubility of pectin's extracted in the combinations from C-4 to C-7 was similar or more compared to commercial pectin (65.99±0.63%). Significant difference was observed for extracted pectin with respect to solubility (Table 1).

Solubility of mango peel pectin ranged from 80 to 98.3 per cent in a study reported by Aida and Zailan (2019).

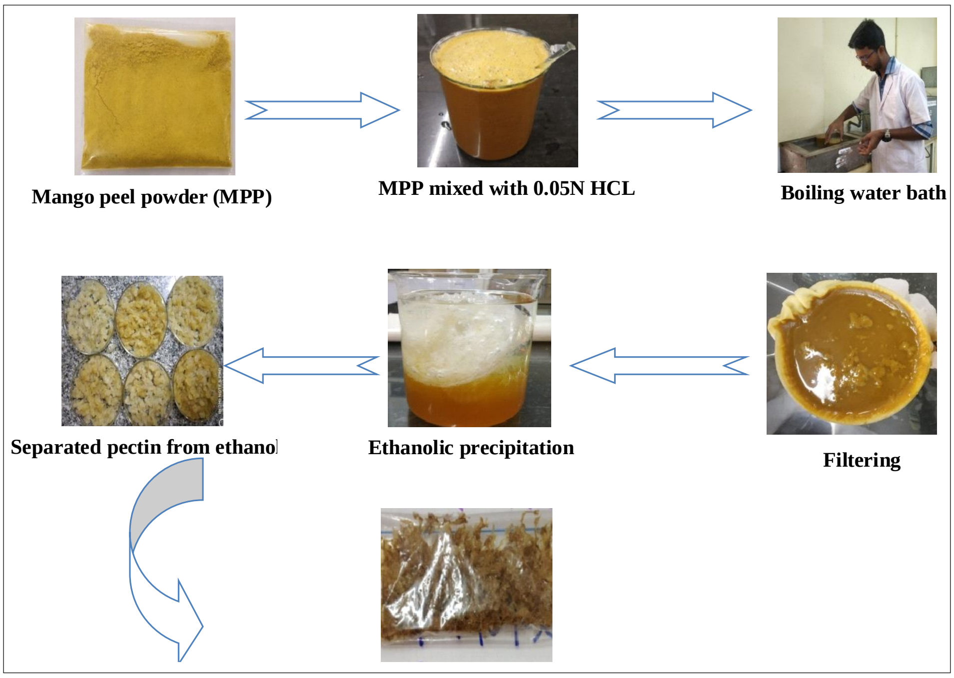

Plate 1: Extraction of pectin from mango peel powder.

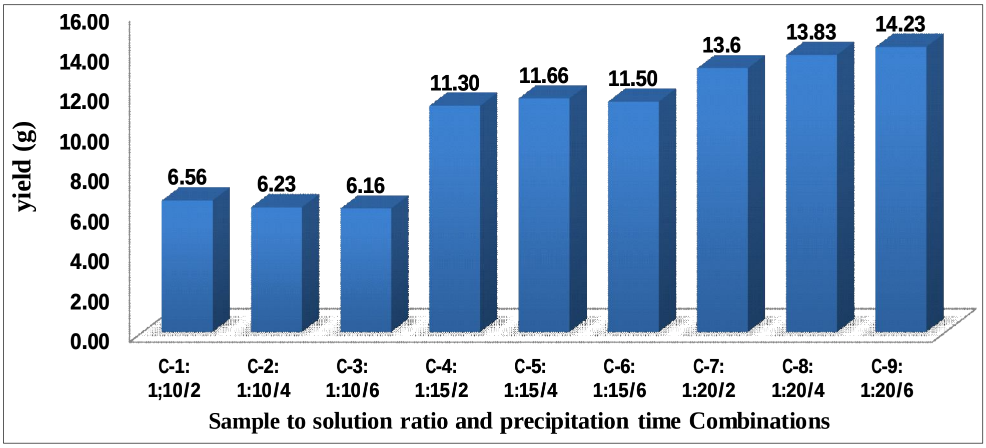

Fig 2: Yield of pectin from different extraction combination.

Nguyen *et al*. (2019) reported 81.7 to 87.4 per cent of solubility for pectin extracted from pre-mature, mature and ripe stages of Vietnamese mango peel and which was higher than the present findings. However, method of pectin extraction, type of peel used for extraction and maturity stage of fruit may also influence on solubility of pectin (Begum *et al.,* 2017 and Nguyen *et al.,* 2019).

Swelling index

Swelling index of mango peel pectin is ranged from 2.89 (C-4) to 5.22 g/g (C-6). Highest was observed for C-6 followed by C-2 and C-7. It was interesting to note that pectin extracted from all combinations of MPP, have higher swelling index compared to commercial pectin (2.65±0.14 g/g) and the difference was found to be statistically significant ($p<0.01$). Tyagi (2016) reported swelling index ranging from 3.96 to 6.47(g/g) in orange peel pectin. Findings of which is in tune with present results. Higher the swelling index, absorption of more water molecules will be more and attributes for preparation of good quality jam and jelly.

Water absorption

Water absorption of mango peel pectin ranged from 3.21 to 6.82 (ml/g). Highest water absorption capacity was observed in C-1 followed by C-2 (5.86±0.15) and C-9 (5.74±0.52). Water absorption in the present study showed significant difference among different combinations and with commercial pectin (5.79±0.15 ml/g). Tyagi (2016) reported water absorption value of 4.5 to 8.4 ml/g. for orange peel pectin which is slightly higher than the present findings. Extraction method and type of peel used will affect the structural properties of the pectin, which is directly related to water uptake. Different drying methods may influence on hygroscopic nature of pectin leading to variation in water absorption.

Bulk density

Bulk density of mango peel pectin ranged from 1.06 (C-6) to 1.59 (C-7) g/cm^3. Pectin extracted from different combinations C-7 had significantly higher bulk density (1.59 g/cm^3) as compared to bulk density of commercial pectin (1.29±0.07 g/cm^3). Statistically significant difference was observed for bulk density between different combinations of MPP. In agreement to this Tyagi (2016) reported bulk density of orange peel pectin ranging from0.75 to 0.79 (g/cm^3). The density depends on attractive antiparticle force, particle size, shape and number of contact positions. The reduced particle size of spray dried and freeze dried pectins significantly change the bulk density of pectins (Begum *et al*., 2017).

Correlation between yield and functional properties of mango peel pectin

Correlation between yield and functional properties of mango peel pectin is presented in Table 2. Results revealed that, solubility and swelling index are positively correlated with yield, however, water absorption and bulk density were negatively correlated. But these findings were observed to be statistically nonsignificant.

Quality characteristics of mango peel pectin

Pectin is an important food ingredient used in manufacturing different food products. Degree of esterification, Equivalent weight, Methoxyl content and total anhydrouronic acid are the important factors which determines the quality of pectin and these quality characteristics were assessed and presented in the Table 3.

Table 1: Functional properties of mango peel pectin.

Combinations (C)	Extraction conditions		Solubility (%)	Swelling index (g/g)	Water absorption (ml/g)	Bulk density (g/cm^3)
	Sample to solution ratio	Precipitation time (hrs)	Mean±SD	Mean± SD	Mean± SD	Mean± SD
C-1	1:10	2	50.26±0.66	4.41±0.39	6.82±0.24	1.15±0.06
C-2	1:10	4	54.73±0.37	4.86±0.04	5.86±0.15	1.48±0.14
C-3	1:10	6	49.74±0.82	3.68±0.27	4.36±0.47	1.42±0.36
C-4	1:15	2	67.58±0.30	2.89±1.64	3.97±0.25	1.29±0.23
C-5	1:15	4	67.63±0.22	3.81±0.14	5.03±0.22	1.4±0.13
C-6	1:15	6	65.41±0.52	5.22±0.28	3.21±0.35	1.06±0.42
C-7	1:20	2	72.27±0.24	4.74±0.34	3.38±0.33	1.59±0.29
C-8	1:20	4	61.83±0.70	2.92±0.49	5.34±0.32	1.12±0.26
C-9	1:20	6	66.46±0.66	3.63±0.31	5.74±0.52	1.33±0.28
Commercial pectin	-		65.99±0.63	2.65±0.14	5.79±0.15	1.29±0.07
	F-value		**	**	**	**
	SE (m)		0.17	0.33	0.15	0.09
	CD @ 1%		1.48	2.85	1.32	0.78

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

Degree of esterification (DE)

The gelling properties of pectin are important to produce high quality pectin. It can be divided into two categories, high methoxyl pectin (HM) which is pectin with a degree of esterification more than 50 per cent and low methoxyl pectin (LM) with less than 50 per cent of DE.

Degree of esterification of MPP ranged from 83.37 (C-1) to 88.98 per cent (C-8). The highest DE (89.03%) was noted for commercial pectin, however these differences among the different combinations were found to be nonsignificant. Since, pectin from all the combinations had more than 50 per cent DE, they are considered as high methoxyl content pectin and recommended for product development (Aid and zailan, 2019).

Degree of esterification (DE) of mango peel pectin ranged from 83.3 and 87.5 per cent is reported by Sangheetha *et al.* (2018), whereas Wang *et al.* (2016) reported 78 to 88.38 per cent. These findings are in line with the present findings. DE actually depends on species, tissues and stages of maturity of fruit peels (Sundarraj *et al.,* 2012).

Equivalent weight (EW)

Equivalent weight is generally used to test the gel- forming effect of pectin. High equivalent weight would have higher gel-forming effect equivalent or combining weight in the range of 250-350 will form the gel in the presence of calcium or magnesium ion regardless of whether sugar is present or not (Nguyen and Pirak, 2019).

Among the different combinations, highest equivalent weight was observed for C-2 (960.5), followed by C-3 (922.5) and C-7 (905.5) and Least was observed for C-5 (831). Whereas for commercial pectin it was found to be 906.5.

The increase or decrease of the EW depends upon the amount of free acid (Wahengbam *et al*., 2014) present in the pectin. Present findings reveals that, different combinations of sample to solution ratio and precipitation time has influenced the amount of free acids in pectin, leading to variations in equivalent weight. Raj and Rubilla (2012) reported equivalent weight for mango and orange peel as 973 and 930 respectively. Which was slightly higher compared to present findings. These variations are attributed to method and the nature of the fruits used for extraction.

Methoxyl content (%)

Methoxyl content of pectin is important to commercial pectin the gel strength, the setting time, the sensitivity to metal ions and to determine the functional properties of pectin solutions and ability of the pectin to form gels (Constenla and Lozano, 2003).

Table 2: Correlation between yield and functional properties of mango peel pectin.

	Yield	Solubility	Swelling index	Water absorption	Bulk density
Yield	1	-	-	-	-
Solubility	0.460	1	-	-	-
Swelling index	0.193	-0.070	1	-	-
Water absorption	-0.461	-0.592	-0.412	1	-
Bulk density	-0.050	0.155	0.126	-0.120	1

Table 3: Quality characteristics of mango peel pectin.

Combinations (C)	Extraction conditions		Yield	Degree of esterification (%)	Equivalent weight	Methoxyl content (%)	Total anhydrouronic acid (%)
	Sample to solution ratio	Precipitation time (hrs)	Mean values	Mean values	Mean values	Mean values	Mean values
C-1	1:10	2	$6.56^{b}\pm0.11$	$83.37^{a}\pm0.72$	$873b^{de}\pm1.41$	$4.07^{cd}\pm0.03$	$42.52^{de}\pm0.04$
C-2	1:10	4	$6.23^{b}\pm0.25$	$88.79^{a}\pm0.62$	$960.5^{a}\pm2.12$	$3.91^{d}\pm0.01$	$41.01^{ef}\pm0.12$
C-3	1:10	6	$6.16^{b}\pm0.28$	$88.31^{a}\pm0.77$	$922.5^{b}\pm1.41$	$3.83^{d}\pm0.01$	$40.50^{f}\pm0.21$
C-4	1:15	2	$11.3^{a}\pm0.26$	$88.47^{a}\pm0.17$	$860.5^{e}\pm0.70$	$5.06^{a}\pm0.02$	$48.72^{b}\pm0.41$
C-5	1:15	4	$11.66^{a}\pm0.76$	$87.99^{a}\pm0.84$	$831.00^{f}\pm00$	$5.28^{a}\pm0.014$	$52.30^{a}\pm0.14$
C-6	1:15	6	$11.50^{a}\pm0.5$	$88.68^{a}\pm1.10$	$872.5^{de}\pm2.12$	$5.13^{a}\pm0.04$	$49.38^{b}\pm0.42$
C-7	1:20	2	$13.60^{a}\pm0.28$	$87.84^{a}\pm0.81$	$905.5^{c}\pm0.70$	$4.3^{bc}\pm0.014$	$44.2^{bcd}\pm0.21$
C-8	1:20	4	$13.83^{a}\pm0.76$	$88.98^{a}\pm0.42$	$861^{e}\pm1.41$	$4.4^{b}\pm0.03$	$45.34^{c}\pm1.02$
C-9	1:20	6	$14.23^{a}\pm0.25$	$88.53^{a}\pm0.60$	$876^{d}\pm2.12$	$4.54^{b}\pm0.01$	$45.57^{c}\pm0.14$
Commercial pectin				$89.03^{a}\pm0.77$	$906.5^{c}\pm0.70$	$4.07^{cd}\pm$	$42.67^{de}\pm$

Note: Yield- TukeyHSD^{a,b}: The error term is mean square (Error) = 1.050. Uses harmonic mean sample size = 2.000. Alpha = .05.
Degree of esterification (%): The error term is mean square (Error) = 5.506. Uses harmonic mean sample size = 2.000. Alpha = .05.
Equivalent weight: The error term is mean square (Error) = 13.900. Uses harmonic mean sample size = 2.000. Alpha = .05.
Methoxyl content (%): The error term is mean square (Error) = .004. Uses harmonic mean sample size = 2.000 Alpha = .05.
Total anhydrouronic acid (%): The error term is mean square (Error) = .240. Uses harmonic mean sample size = 2.000 Alpha

Table 4: Correlation between yield and quality characteristics of mango peel pectin.

	Yield	Equivalent weight	Methoxyl content	Anhydrouronic acid	Degree of esterification
Yield	1	-	-	-	-
Equivalent weight	0.028	1	-	-	-
Methoxyl content	0.583	.0030	1	-	-
Anhydrouronic acid	0.328	0.156	0.497	1	-
Degree of esterification	0.181	0.922**	0.248	0.171	1

**Correlation is significant @ 1%.

Methoxyl content of MPP is presented in Table 3. Findings revealed that, combinations from C-4 to C-6 (5.06 to 5.13%) had similar methoxyl content, followed by C-7 to C-9 (4.3to 4.54%) combinations. These combinations had significantly higher methoxyl content compared to commercial pectin (4.07%).

Results are in accordance with the values reported by Nguyen and Pirak (2019) for dragon fruit peel (DFP) pectin (3.69 to 6.76). Methoxyl content for DFP pectin reported by Ismail *et al.* (2012) ranged from 2.98 to 4.34 per cent. High methoxyl pectin (>7%) form gel with higher concentrations of sugar (>65%), on the other hand, low methoxylpectins (less than 7.0%) can form gels with lower concentrations of sugars. In the present study MPP extracted from different combinations were Low MethoxylPectins (LMPs).

Total anhydrouronic acid (AUA)

AUA content indicates the purity of the extracted pectin and is suggested to be not less than 65 per cent (Food Chemical Codex, 1996). The findings of AUA content of MPP from different combinations is presented in Table 4. Compared to different combinations, C-5 (52.30%) had more AUA content followed C-4 (48.72%), C-6 (49.38%) and C-7 (44.2%). It was observed that, all these combinations had significantly more AUA content compared to commercial pectin (42.67%).

Devi *et al.* (2014) conducted study on extraction of pectin from citrus fruit peel and reported AUA content of 51.04 per cent. Virk and Sogi (2004) reported 62.82 per cent in apple peel waste pectin. Low value of AUA means that the extracted pectin might have a high amount of protein, starch and sugars in the precipitated pectins (Ismail *et al.,* 2012).

Extraction conditions (pH, type of acid used, extraction and precipitation time) greatly influence esterification of carboxyl groups. Low value of AUA may be due to presence of high amount of protein, starch and sugars in the precipitated pectins (Ismail *et al.,* 2012). For the different combinations used in the present research, it is necessary to extract pectin under controlled conditions of pH and acid to reduce impurities and to achieve AUA above 65 per cent.

Correlation between yield and quality characteristics of mango peel pectin

Correlation between yield and quality characteristics of mango peel pectin is as presented in Table 4. Findings revealed that, yield was positively correlated with all the quality parameters, however, these findings were statistically non significant. Statistically, significant correlation was observed between the degree of esterification and equivalent weight (r= 0.922**).

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 tested in this study has 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 functional properties (solubility, swelling index, water absorption and bulk density) and quality characteristics (Degree of esterification, equivalent weight, methoxyl content and total anhydrouronic acid)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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