



## EXTRACTION OF PECTIN FROM BANANA PEELS AND ITS COMPARISON: A REVIEW

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### Abstract:

**Background:** - Annual production of banana in the fiscal year 2020 was approx. 14.2 million tons in India. Banana fruits have 35-40% of peel waste. From an environmental point of view, it is vital that plant byproducts produced by the food industry be reused. One of the best ways to reuse the peel waste is to extract the valuable bio-nutrient from the banana peels. One such bio nutrient is pectin. Since, banana peels have 20.28g pectin/100g of dry matter.

**Objective:** - 1) Study the various methods available for extraction of pectin from banana peels and their yield comparison.

**Conclusion:** - Methods compared in this study is 1) solvent extraction 2) microwave-assisted extraction 3) ultrasound-assisted extraction 4) enzymatic extraction. All methods have successfully extracted pectin. The hot acid method has given the maximum yield. kepok banana peel has shown great potential for use in the food industry. Thus, on further purification and optimization banana peel extracted pectin can be used in the food industry

**Index Terms**—pectin; Banana peels; Extraction; kepok banana peels.

### I. INTRODUCTION

Pectin is a natural complex hetero-polysaccharide that features a functional moiety of the first cell walls of terrestrial plants. With the increase within the processed food industries, fruit waste generated is increasing tremendously. The pectin is typically used for preparing jelly. Jellies made using pectin from fruit wastes found to possess good quality. Those jellies with defects are purified and worked upon to get rid of the defect. Pectin, in recent years, gained importance. the benefits of natural pectin are also appreciated by scientists due to its biodegradability. Pectin is that the methylated ester of poly-galacturonic acid (pranati Srivastava et al., 2011) it's commercially extracted from citrus peels and apple pomace under mildly acidic conditions. Pectin is divided into two groups on grounds of its degree of esterification (DE). The association of pectin chains leads to the formation of the three-dimensional networks that involve in gel formation. Pectin has been utilized the uses in foods for several years. Mostly within the conserves and preserves industries, the development of pectin has been done to impart texture in high sugar systems. Over 50 years, much scientific information has described the composition of pectin isolated from various plants. Pectic substances are heterogeneous consisting essentially of (1–4) D-galacturonic acid residues (Antony Allwyn Sundarraaj et al., 2018). Pectin polysaccharides are of relatively higher molecular mass and strongly linked with other polymer components inside cell walls, which reduce their release from the cell matrix. Nanoemulsions are submicron-sized systems utilized within the food and pharmaceutical industries for the delivery of active ingredients (Allwyn SUNDARRAJ Antony et al., 2018). Compared to other emulsion-based systems, Nanoemulsions have shown to be more stable to environmental, and process load because of their large active area, but are also on the verge of destabilization, after prolonged storage at non-optimal temperatures, from some mechanisms (Allwyn SUNDARRAJ Antony et al., 2018). Several studies are conducted to improve the stableness of Nanoemulsions, like adding carbohydrates to the formulation. the foremost potential application of pectin, an anionic polysaccharide, for the stabilization of Nanoemulsion systems. A large number of food wastes and by-products are produced from farm to plate. However, nowadays, the number of novel waste material and byproducts sources for pectin extraction is increasing. Moreover, the applying of innovative approaches is vital because of the limitation of conventional processes. the following review will consider the quality and innovative processing techniques (microwave extraction, enzymatic extraction, and ultrasound-assisted extraction [UAE]) to extract pectin from different variants of banana peels. The pectin extraction differs according to the matrix studied also as pH, temperature, time, solid to liquid, and solvents. They represent valuable sources for the assembly of high-added value compounds like pectin. Pectin is the methylated ester of poly-galacturonic acid and presents a decent range of applications in pharmaceutical and cosmetic products moreover as in the food industry such as a gelling agent in fruit-based products, stabilizer in fruit and milk beverages and fruit filling and confectionery products, and among others. Therefore, pectin recovery is of great importance. Moreover, the mixture of solvent modeling and the use of particular extraction processes can enable the selective recovery of pectin.

## 2. METHODS

### 2.1 Solvent extraction

A total mass of peel powder measured on a scale was blended with distilled water and acidified with diluted acid to satisfy the designed pH. The mixture was then stirred employing a stirrer until all the banana peel powder was evenly wetted by acidified water in homogenous form (Pratik.B.Kamble et al.,2017). The pectin extraction procedure was continued treating the acidified samples at temperature during a stirring hot plate fixed period. the extract was then cooled and filtered through a standard screen with 1- mm mesh size with two-layer cheesecloth. The filtrate was collected then added with twice the amount of its volume of ethanol. The precipitated pectin was obtained, so it was recovered by centrifuge. The resulted pectin substance was dried during a conventional oven until fixed weight was reached.

### 2.2 Microwave assisted extraction

Microwave-Assisted Extraction of peel Waste. The extraction of pectin was done employing a microwave digester (Ethos UP High-Performance Microwave Digestion System, Milestone Srl, Italy) with adjustable temperature and irradiation time counting on the SLR as per the experimental design, powdered peel waste was added to acid of various pH. The mixture is placed within the middle of the microwave digester's rotating disc and so exposed to varying temperatures within a specified length time. Microwave power, the reserved energy, was set at 1,000 Watts (Joel P. rivadeneria et al.,2020) After the extraction process, the mixture was cooled and filtered using a Grade 1 qualitative paper . The filtrate was separated, and an equal volume of 95% (v/v) ethanol was slowly added with continuous mixing. The mixture was incubated at fixed temperature for fixed period of time (xing-zilin et al.,2001). The resulting microwave-extracted pectin (MEP) was recovered by filtration(Joel P. rivadeneria et al.,2020). it had been washed twice with the identical volume of 95% (w/w) ethanol and so dried at until constant weight.

### 2.3 Ultrasound assisted extraction

Ultrasound-assisted extraction (UAE) could be a good process to attain high valuable compounds and will involve to the rise within the estimate of some food by-products when used as sources of natural compounds or material ( Bhaskaracharya et al.,2009). the key importance is a simpler extraction, so saving energy, and also the employment of mean temperatures, which is useful for heat-sensitive combinations. This system was developed in 1950 at laboratory apparatus (Vinatoru et al.,2001). Ultrasound allows selective and intensification of essential oils extraction by release from material when employed in combination with other techniques for instance solvent extraction and Ultrasound technology has been featured as significant method in food processes and plants (Bhaskaracharya et al.,2009). In these applications the facility ultrasound increases the surface wetness evaporation average and causes oscillating velocities at the interfaces, which can affect the diffusion physical phenomenon and generate rapid series of other expansions of the material (Hesham H.A. rassem et al.,2016), affecting cluster transfer (García-Pérez et al.,2006). The plants material is immersed in water or another solvent (Methanol or ethanol or anyone from the solvents) and at the identical time, it's subjected to the work of ultrasound (Karim et al., 2012). this method has been used for the extraction of the many essential oils especially from the flower, leaves or seeds (Sereshti et al.,2012) (karimassami et al.,2012)

### 2.4 Enzyme assisted extraction

A carefully measured crude enzyme (10 mL) was introduced to 250 mL Erlenmeyer flasks and 140 mL of 0.05 M sodium acetate buffer (pH 5.5) was added to obtain 150 mL extraction media. This solution was incubated in a shaking incubator (HB-201SL, Hanbaek, Bucheon, South Korea) at 323 K at 150 rpm as suggested by Dinu et al. and Locatelli et al. . Upon the achievement of desired temperature, a carefully weighed banana peel wastes flour (5 g) was introduced to the extraction media and let to hydrolysed for 360 minutes. The hydrolysates were taken at 30 minutes interval for pectin analysis after being filtered using Whatman No. 2 filter paper. Similar procedure was applied for the study of the effect of substrate concentrations (5 to 18.5 g banana peel flour), which coincide with 0.03 to 0.13 g/mL substrate concentrations.

## 3. FINDINGS AND DISCUSSION

The following review has compared the literature available for extraction of pectin from the banana peels. And summarises them the compared their yield and also check their characteristics based on equivalent weight AUA /GALA acid methoxy content etc and also study whether they be used in food industry etc.

Equivalent Weight the higher weight of the pectin value was equal to the effect of better gel formation. Methoxyl content the methoxyl content in pectin is defined as the number of moles of methyl alcohol in 100 mL galacturonic acid. The methoxyl content in pectin is important for controlling strength in gels, time management, sensitivity to metal ions, and for identifying pectin solvent features and the structure of pectin gels. Furthermore states, that Pectin will be classified as methoxyl whose content is equal to 7% or higher. If the methoxyl content is less than 7%, then it will be classified as low in methoxyl pectin. AUA (Galacturonic acid) to maintain the purity of the extracted pectin, it is recommended to maintain AUA no more than 65%. Degree of Esterification pectin with esterification degree <50% is known as low methoxyl pectin while pectin with esterification level> 50% is known as high methoxyl pectin. In these review various case study was studied and is summarized in the form of the passage and is segregated according to the method used .later on it was also represented in tabular format

### 3.1 SOLVENT EXTRACTION OF PECTIN FROM BANANA PEELS

The pH, temperature, and time effects on the extraction of pectin was studied. These studies conclude that the pH has the most influence on the extraction of pectin low pH values affected the GalA acid negatively in the pectin but increasing the yield percentage. Also, the values of the degree of methylation were decreasing with an increase in temp and time. Also pH influenced the avg molecular weight of pectin has observed that the optimum condition was obtained at pH 2 for 1 hour at 90°C. also having a large range of pectin degree of methylation, the pectin extracted probably gel with calcium or with high sugar concentration in acidic conditions of pectin was study. These studies conclude that the pH has the most influence on the extraction of pectin low pH values affected the GalA acid negatively in the pectin but increasing the yield percentage. Also, the values of degree of methylation were decreasing with increase in temp and time. Also, pH influenced the avg molecular weight of pectin has observed that the optimum condition was obtained at pH 2 for 1 hour at 90°C. also having a large range of pectin degree of methylation, the pectin extracted probably gel with calcium or with high sugar concentration in acidic conditions. (Emaga, 2007)

These study was conducted to determine the quality of pectin extracted from kepok banana peel using extraction method also optimisation was done which gives yield of 22.57% at 2.5 pH at 100°C having equivalent weight value 862.07g/ mol methoxyl content 3.6% GalA as 77.44% degree of esterification is 37.17 % pectin extracted also showed presence of arabinose, maltose, cellulose, fructose, glucose, galactose . FTIR characterisation showed that the pectin extracted has alcohol carbonyl, cyclic group present in it. (Pagarra, 2020)

A study was conducted in which the banana peels were proved as a potential source of dietary fiber and pectin. Also, in these studies, the yield at various maturation stages was studied which showed that the maturation stage doesn't affect the yield in a particular manner. Sequential extraction of pectin has proved that acid extraction is best to isolate pectin. The quantity of pectin increased till stage 5 where the banana Peel variant of GN showed a 21.7% of yield and the variant of FC showed a yield of 14.6% this can be because at stage 5 the banana peel is more fragile. (Emaga, 2007)

In another study effect of extraction parameter on Kauai Nam wa and also experiment has been carried on whether it can be used as a fat replacer in a salad. Banana peels were extracted using HCL of 1.5 pH for 30-120 min at 90°C having yield is 7 -11% extraction pectin having GalA is 42-47% degree of methylation (DM) is 57-61% but it has a lower DM but high GalA, molecular weight. The cream separation was successfully stored for 3 weeks. Also, 50 penalties reported that there was no sensory difference between Normal fat replacer and has overall acceptability as a reduced-fat salad cream. (Maneerat1, 2006)

The study was done to optimize the results of pectin by RSM. The model used for predicting is central commission Design (CCD) with DX6. 0.4 software the optimum parameter was pH 2.5 temperature of 100°C giving a yield of 22.57%. Analysis was done for variance adj R<sup>2</sup> and R<sup>2</sup> model and p-value which shows the temperature of extraction and the pH has the most influence on extraction of pectin since R<sup>2</sup> has a value of 96.01% (Pagarra, 2019)

Pectin was extracted from saba banana peels under two different extraction conditions one with 0.5N 1.5 pH of HCL acid and the other of 0.5 N 1.7 pH of citric acid highest yield was found as 17.05% dry basis for HCL at 4 h and 90°C . These studies also showed that their yield is high at the unripe stage. Characterization of saba banana peel shown that the ash content of ripe peels was 11.15% and unripe banana peel 13.83% was higher than that of commercial citrus pectin (1.76%). Methoxyl content and AUA acid percentage are lower than commercial pectin. Also extracted pectin was used in a strawberry jam in order to find its potential as a gelling agent and the result confirmed that there was no sensory difference (Castillo-Israel, 2015)

A study was conducted where the various peel was used to extract the pectin. Since the focus of these studies is the pectin extracted from banana peels. The pectin was extracted using 7.5g/kg of citric acid having 53 % of AUA, methoxyl content of 7.05%, and 99% of gel grade % thus it shows that the following can be used in the food industry. (Oliveira, 2015)

The aim of this particular study was to find the optimum condition of pH, temperature, acid normality, concentration on the pectin extracted from banana peels. The extraction was carried on using two different acids. ( Citric, phosphoric acid ) the optimum conditions for citric acid is 90°C having an extraction time of 15 min, using 50 ml of 0.4 % ( w/v) citric acid giving the highest yield of 1.94% and at 90°C, 15 min extraction time using phosphoric acid of 50 ml (0.1%) giving a yield of 1.4%. (Maw1, 2019)

The aim of this work is to study pectin extraction from unripe banana peels using acid extraction. The acid used was HCL acid the optimum condition obtained was at 4h, pH 2 at 90 °C giving a yield of 13%. The product structure was confirmed using FTIR spectroscopy. The characterization of the pectin was also done having AUA was 58.77%, DE as 80.18% thus the pectin extracted has the potential to be used in the food industry. (Pratik.B.Kamble, 2007)

### 3.2 MICROWAVE ASSISTED EXTRACTION

The conditions for the microwave-assisted extraction of pectin were optimized using the RSM method having an optimum yield of 14.8% at 195°C 8% SLR, pH 3 of HCL. The further purification increased the purity of the banana peel extracted pectin by 300%. Pectin extracted was low methoxyl in nature. The pectin extracted was further used to isolate protein and then it was used in orange juice the fluid viscosity was higher. (Rivadeneira, 2020)

In this particular case study, continuous and intermittent micro-assisted extractions are used to extract the pectin from banana peels. In which parameter such as microwave power, pulse ratio, pH was optimized using Box Behnken response surface design (BBD) resulting with the yield as 2.18% microwave power of 900W, pulse ratio of 0.5 and 3 pH. (Swamy, 2016)

### 3.3 EMZYME ASSISTED EXTRACTION

Enzymatic extraction from banana peel was carried out .In which the yield at various substrate concentration , time was check. The optimum condition was found at 328k temperature, 0.13 g/ml of substrate concentration giving 10.8% weight of yield. It has found that yield increase with in hydrolysis time and concentration of substrate but prolonged hydrolysis lead to inhibition of GalA% in the pectin thus decreasing the yield. Pectin extracted was the subject to FTIR analysis where it showed that carbonyl and free carboxyl was present in extracted pectin. (Kumoro, 2005)

Unripe biomass is used to extract pectin. The extraction was done by enzyme assisted method. The biomass then further optimized using BBD factors such as temperature, pH, time was studied. The optimized production is obtained at pH 2,86°C and for 6h giving a yield of 11.63% (marenda, 2019)

These study was conducted to determine the quality of pectin extracted from kepok banana peel using extraction method also optimization was done which gives yield of 22.57%at 2.5 pH at 100°C having equivalent weight value 862.07g/ mol methoxy content 3.6% GalA as 77.44% degree of esterification is 37.17 % pectin extracted also showed presence of arabinose, maltose, cellulose, fructose, glucose , galactose . FTIR characterization showed that the pectin extracted has alcohol carbonyl, cyclic group present in it.

In these particular studies, the combine effect of factors such as pH value, extraction temperature, time on the extraction of pectin from banana peel was studied by RSM. Method temperature and time combine have the most influence on the extraction rate of pectin. The 2nd most influential factor was the combined effects of time and salting-out temperature RSM method suggested that the optimum conditions are 1.5 pH 85.5 extraction temperature for 2 h at 70°C of salting-out temperature. (Qiu, 2020)

In these study the enzyme hydrolysis of banana peels was carried out giving yield of 17.47% which parameters of cellulose concentration of 0.25% , pH 5 , enzyme hydrolysis temperature of 50 °C and enzyme hydrolysis time of 25 min (ZHAO, 2013)

The acid such as nitric acid, citric acid was used to extract pectin at 1 h, 85°C. Results obtained are as follows nitric acid giving 54% yield and citric acid giving 76% they were further aggregate to form pectin nanoparticles. (Arias, 2021)

2 level factorial design (2FLD) was to study various parameters affecting the yield of pectin. Factor studied was temperature, time, pH. The range obtained was pH 1.5 -2.5, the temperature in the range 60-100°C and time 60 - 90 min and yield Range between 3.46% to 18.31 %.(ANOVA) analysis showed that temperature and pH affect them most on the extraction of pectin followed by a combination of temperature and time. Which is then followed by pH, temperature, and time? (Pagarra, 2019)

### 3.4 ULTRASOUND ASSISTED EXTRACTION

The study aimed to find the best drying kinetic model and also to optimize the extraction process of banana peels using the box Behnken response surface design (BBD). The optimum condition was found at oven drying at 50°C due to yield of 2.88% using pH of 1.5, SLR 1.30 g/ml note: - Extraction was done using ultrasound-assisted extraction three drying model was used for drying but page two-term model was best because it gives drying kinetic of banana as 0.9991 R<sup>2</sup> value and RMSE as 0.001. The optimization was done using the RSM method the Design showed an optimum condition of 75°C extraction temperature 23 min and SLR of 1:33:3 g/ml giving a yield of 6.08 %. After optimization, the pectin extracted remained as high methoxyl pectin as DE is more than 50% but the gelling time improved. (Lin, 2018)

Ultrasound-assisted extraction was done using citric acid as a mediator on Musa balbisiana peels it also study the influence of parameters of pH, ultrasound power, time on the extraction of pectin. The optimization was done using central composite design (CCD) under the RSM method the optimum condition was 3.2 pH. Ultrasound power of 323W, time 27 min SLR of 1.15 g/ml giving yield of 8.99 %. (Maran, 2016)

table no 1: yield pectin extracted from banana peels using various methods

METHODS USED	PEELS VARIANTS	TEMPERATURE	TIME	pH	YEILD	*INF0RATION	REMARKS
EAE	-	328 K	2h	-	10.8%	SUBSTRATE O.13g/ml	-
SE	MUSA AAA	90 C	1h	2	53mg/g (AIS)	-	Can be gelled with the high sugar
SE	KEPOK	100 C	1h	2.5	22.5%	-	Can be used in food industry
SE	GN	-	-	-	21.7%	-	Acid extraction is the best method
SE	FC	-	-	-	14.6%	-	Pectin are low methoxyl pectin
UAE	-	75 C	23 min	1.5	6.08%	SLR 1.30 g/ml	Used in straw berry jam and has no sensory difference
METHODS USED	PEELS VARIANTS	TEMPERATURE	TIME	pH	YEILD	*INF0RATION	remarks
SE	NAM WA	-	30-120 min	1.5	7-11%	-	Used in orange peels and has increased the fluid viscosity
MAE	SABA	195 C	-	3	14.8%	SLR 8%	
EAE	-	85.5%	2h	1.5	-	-	-
SE(HCL)	KEPOK	100 C	90 min	2.5	22.57%	-	-
MAE	-	-	100s	3	2.18%	PULSE RATIO 0.5	-
SE(HCL)	SABA	90 C	4h	1.5	17.05%	-	-
UAE	BALBIS INIANA	-	27 min	3.2	8.99%	SLR 1.15 ,U.P 323W	-
SE(CITRIC ) ACID	-	-	-	-	-	AUA METHOXYL CONTENT 7.03%	-
SE (CITRIC ACID )	-	90 C	15 min	-	1.94%	CITRIC ACID 0.4%	-
SE (PHOSPHORI C ACID)	-	90 C	15 min	-	1.4%	PHOSPHORIC ACID 0.1%	-
SE (HCL)	-	90 C	4h	2	13%	-	-
SE	-	70 C	90 min	1	16.57%	-	-
EAE	-	50 C	25 min	5	17.47%	-	-
SE(NITRIC ACID)	-	85 C	1h	2	54%	-	-
SE (CITRIC ACID)	-	85 C	1h	3	76%	-	-
SE	KEPOK	100 C	60-90m	1.5- 2.5	18.31%	-	-

NOTE: - THESE TABLE WAS MADE ONLY TAKENING THE OPTIMUM CONDITION OF EACH CASE STUDY MENTION BELOW

\*ESSENTAIL INFORMATION

SE= SOLVENT EXTRACTION, EAE = ENZYME ASSISTED EXTRACTION, MAE = MICROWAVE ASSISTED EXTRACTION, UAE = ULTRASOUND ASSISTED EXTRACTION

#### 4. CONCLUSION

The pectin extracted from the banana peels can be used in food industry also the pectin extracted can also be complete with the commercial pectin. kepok banana peels has shown the most potential for extraction of pectin. The solvent extraction has given the most yields followed by the enzyme assisted pectin extracted. MAE and UAE can method can also be used to extract pectin but these method needs to be optimized. the RSM method has consistent proved the best technique for optimization. pH time and temperature are the most influence factor in almost all the case study studied. The yield of unripe banana peels was more than the ripe banana peels. The solvent extraction process is used to extracted commercially sold pectin. Enzyme assisted extraction can also be used to extracted the pectin only problem is the yield of the pectin is less as compared to the solvent extracted process. further studied need to be conducted on the factors flour size, pH, temperature, enzyme loading and pectin purification and their influence on the extraction rate of pectin from banana peels.

Also, very less research has been done on the process such as the MAE and UAE method. the factors influencing their yield can also be studied in more depth. From the above review we have conclude that the unripe banana peels have more yield than ripe banana peels but very less has done on unripe banana peels these could be great area of research. Kepok banana peels has shown the most potential thus the research can also be done on the unripe kepok banana peels and its characterization .

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