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Comparison of Chemical and Nutritional Values of Extracted Pectin from Selected Local Banana Cultivars of Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Authors BCS and HA designed the study, performed the biochemical and statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author RF edited the manuscript and the literature searches. Authors SKB and ZA managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted to find out the chemical and nutritional values of pectin from selected Banana cultivars in Dinajpur district, Bangladesh. Pectin was extracted from the peels of banana at 1st stage of ripening (light green peel). The result showed that pectin content in banana peels at 1st stage of ripening varied from 36.10% to 46.12% based on cultivar type. The highest pectin content was found in peels of 'Sagor' banana. The pectin from unripe peels (1st stage of ripening) characterized by the moisture (23.29 and 24.75%), ash content (16.67 and 16.24%),equivalent weight (666.67 and 555.56), methoxyl content (26.66 and 12.40%), anhydrouronic acid content (177.76 and 102.08%), degree of esterification (85.15 and 68.97%),

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vitamin C (0.038 and 0.044%), beta carotene (0.73 and 1.01 mg g^{-1}), vitamin A (1.21 and 1.68 mg g^{-1}),and iron (0.26 and 0.47%) for the 'Chinichampa' and 'Sagor', respectively. Therefore, it infers that the extracted pectin from unripe banana peels could be compared as high methoxyl pectin which could be used to produce more-sticky gel from 'Chinichampa' followed by 'Sagor'.

Keywords: Banana; beta carotene; methoxyl content; pectin; vitamin C.

1. INTRODUCTION

Banana (*Musa armaladeal*, family Musaceae) is one of the most important fruit crops of the world. The banana is most widely cultivated in tropical and subtropical countries. Approximately 5.6 million hectares of land are dedicated to banana production globally, according to latest available data from 2017 [1]. Bananas rank as a leading crop in world agricultural production and trade. In response to fast population growth in producing countries as well as expanding global import demand, the crop has seen rapidly increasing production and trade volumes in recent decades. Since the bulk of banana cultivation is conducted informally by smallholder farmers, precise figures on global banana production are, however, difficult to obtain. Available estimates indicate that average global banana production rose from 69 million tonnes in 2000-2002 to 116 million tonnes in 2017-2019, at an approximate value of 31 billion USD [2]. It is possibly one of the world's oldest cultivated plants [3]. Bangladesh produces nearly one million tons of bananas annually [4]. It is also nutritious fruit crop in the world and used both as a staple food and dietary supplements [5]. The foremost banana growing areas in Bangladesh are Narshindi, Gazipur, Tangail, Rangpur, Bogra, Natore, Pabna, Noakhali, Faridpur, and Khulna. Also, Sylhet, Moulvibazar, Netrokona, Rangamati, Khagrachhari, and Bandarban are wild banana growing areas in Bangladesh. In 2017-2018, the total production of banana in Bangladesh was 810347 metric tons and the cultivated area was about 121384 acres [6]. Total global production of bananas and tropical fruits is projected to grow at 1.8 percent per year between 2019 and 2028, after registering 2.3 percent per year growth in the previous decade. Under the baseline scenario, production is expected to slightly exceed 255 million tonnes by 2028. The largest suppliers of these fruits are expected to continue to be in Asia, which is projected to account for 55 percent of world tropical fruit output, down slightly from 56 percent in the base period of 2016-18. Despite losing some market share, India is projected to remain the largest producer of tropical fruits globally, accounting for approximately one quarter of world production in 2028 [2].

It was revealed that the use of by-products of fruits, especially banana, has gained more interest and become a trend as of late and many studies are in progress to evaluate their effects on food properties [7,8]. It is assumed that one-third of banana is lost due to the public tendency to consume only ripened fruit, utilization and application of different parts of the banana at different ripening stages has also gained interest over the past years for different industries [9]. The peels of different fruits contain some valuable biochemical and nutrient compounds like pectin. Pectin has some water soluble pectinic acid (colloidal polygalacturonic acids) of varying methyl ester content and degree of neutralization, which are capable of forming gels with sugar and acids maintaining suitable conditions [10]. Banana fruit peels comprise a significant quality of wastes produced from banana processing, which is equivalent to 40% of the weight of fresh banana. These peels are just left as solid waste at large extent. Thus, the operation of food processing wastes in the industry is now becoming a very serious ecological problem and pollution for environment. Pectin is used as a food additive mainly in the form of gelling agent, and used as stabilizer in fruit juices and milk drinks. Liquid pectin or powdered pectin is used to make jams and jelly at home. Chemically it represents a polysaccharide, which is generally present in different amount in cell walls of all plants.

Keeping in view the importance of pectin as a high value functional food ingredient because of its excellent emulsifying properties and stability the present study was conducted to quantify and compare the chemical and nutritional values of pectin from peels of selected banana fruits.

2. MATERIALS AND METHODS

2.1 Materials

The investigation was carried out in the Department of Agricultural Chemistry, Hajee

Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. The tested banana cultivars were a) Chinichampa and b) Sagor. The fresh unripe banana fruits were purchased as a test material from the local market in Dinajpur, Bangladesh. Chemicals and other reagents used for the study were from analytical reagent grade.

2.2 Preparation of Unripe Banana Peel Powder

Banana peels were soaked in 0.05% sodium metabisulfite for an hour to prevent discoloration. Thereafter, they were dried in an oven at 55°C for 24 hours. The dried peels were then cooled at ambient temperature and were made into flour using a grinding machine. The powdered banana peels were stored in polyethylene bags at ambient temperature (25^{o}C) with cool and dry condition. Fig. 1 shows the steps for the preparation of the banana peel powder.

2.3 Extraction of Pectin from Banana Peels

A total of 20 g of dried banana peel powder was homogenized with 500 mL distilled water. The pH of homogeneous mixture was adjusted to 2.5 with hydrochloric acid. Thereafter, the mixture was heated at 90°C for two hours with continuous stirring.The mixture was cooled at ambient temperature and filtered through an ordinary screen with 1 mm mesh size with two-layer muslin cloth. The filtrate was collected followed by addition of double volume of absolute ethanol. The precipitated pectin was filtered through a muslin cloth. The resulted pectin was then oven dried for 2 days at 55°C and weighed. The pectin yield was calculated based on the percentage of dry weight (% DW) using the following equation:

$$\text{Pectin yield (g/100g)} = \frac{\text{Weight of extracted pectin (g)}}{\text{Total weight of dried banana peel powder taken for extraction (g)}} \times 100$$

2.4 Characterization of Pectin

The extracted pectin was characterized in terms of amide content**, %**moisture, ash content, equivalent weight, methoxyl content, anhydrouronic acid (AUA), degree of etherification, vitamin C, beta carotene**,** vitamin A, and iron content.

2.5 Determination of Amide

A 0.1 g of sample was added to the 0.1 N NaOH solutions and heated strongly. Odor of NH_3 indicates the formation of amide. Heat was applied until no more NH_3 was evolved. Then, few drops of concentrated HCl were added. Absence of precipitate indicated there was presence of aliphatic amide.

$$CH_3CONH_2 + NaOH \rightarrow CH_3COONa + NH_3$$
$$CH_3COONa + HCl \rightarrow CH_3COOH + NaOH$$

2.6 Determination of Ash Content

The ash content of pectin was estimated by Ranganna's method [11].

$$\text{Ash content (\%)} = \frac{\text{Weight of Ash (g)}}{\text{Weight of Pectin (g)}} \times 100$$

2.7 Moisture Content

Moisture content of pectin was calculated using the following equation.-

$$\text{Moisture content (\%)} = \frac{\text{Weight of residue (g)}}{\text{Weight of sample (g)}} \times 100$$

2.8 Equivalent Weight

Equivalent weight was determined by Ranganna's method [11].

$$\text{Equivalent weight (EW)} = \frac{\text{Weight of pectin sample (g)} \times 1000}{\text{Volume of alkali (ml)} \times \text{N of alkali}}$$

Fig. 1. Unripe banana peel powder preparation: a) Unripe banana peel before drying, b) Dried banana peels in cabinet dryer, c) Prepared banana peel powder

2.9 Methoxyl Content (MeO)

The methoxyl content is an important factor in controlling the setting time of pectins. Determination of MeO was done according to the Ranganna's method [11].

Methoxyl content (%) =

$$\frac{\text{Volume of alkali (ml)} \times \text{Normality of alkali} \times 3.1}{\text{Weight of pectin sample (g)}} \text{ x100}$$

2.10 Total Anhydrouronic Acid Content (AUA)

Estimation of anhydrouronic acid content is essential to determine the purity and degree of esterification, and to evaluate the physical properties. Total AUA of pectin was obtained using the following equation [12]

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

2.11 Degree of Esterification (DE)

The degree of esterification (DE) was measured on the basis of methoxyl and AUA content [12] and calculated using following equation:

$$\text{DE (\%)} = \frac{176\times \%\text{MeO}}{31\times \%\text{AUA}} \times 100$$

2.12 Vitamin C

Vitamin C or L-Ascorbic acid was determined by following the method [11]:

%Vitamin C=

$$\frac{\text{Titrate value x dye factor x volume of sample made up x 100}}{\text{volume of sample used x weight of pectin sample x 1000}}$$

2.13 Beta Carotene, Vitamin A and Iron

Beta carotene content was estimated in mg g^{-1} or mg/100 ml using the following equation [13,14].

β-Carotene = 0.216x A_{663}- 0.304 x A_{505} + 0.452 x A_{453} (mg/g)/ (mg/100 mL if the sample is liquid).

$$\text{Vitamin A (I.U)} = \frac{\text{betacarotene (mg/g)}}{0.6} \text{ [15]}$$

Iron content was measured using redox titration method. The extraction was prepared in phosphoric acid and titration was done using $KMnO_4$ as an oxidizing agent.

2.14 Statistical Analysis

A statistical analysis was performed among the different parameters estimated using Pearson's correlation coefficient. This was done to investigate whether any relationship between the parameters existed or not.

3. RESULTS AND DISCUSSION

3.1 Yield of Pectin

Pectin was extracted from unripe banana peel and characterization of extracted pectin was done. The yields of pectin from two different banana cultivars were presented in Table 1. Banana peels of two tested cultivars at unripen stage (1st stage of ripen) were compared. It was evident that varietal differences could also affect the pectin yield as the amounts of pectins vary as the fruit matures. Pectin yield was observed higher at the unripe stage of 'Sagor' compared to 'Chinichampa' (Table 1). This might be due to the varietal differences which was characterized by genetic make-up. Pectin generally increase at first as the fruit peel becomes more green and tender, making the relation between pectins and other cellular compounds more fragile, thus making the pectin easily available for extraction. However, over mature of banana peels may result to a reduce in yield due to the degradation of pectin due to the biochemical activities of enzymes, such as polygalacturonase, pectin methyl esterase or pectatelyase [16]. Report is that unripe banana contained higher pectin than ripeness condition [17]. So, the pectin extraction from the 'Sagor' was more commercially beneficial than those of 'Chinichampa' at green and unripe stage.

3.2 Characteristics of Pectin

3.2.1 Moisture content

Moisture content of pectin extracted from banana peel was varied from 23.29 to 24.75% (Table 2). The moisture content was higher in 'Sagor' (24.75%) and lower in 'Chinichampa' (23.29%). Low moisture content was necessary for quality maintain and safe storage as well as to inhibit the microbial growth that can affect the quality due to the production of pectinase enzymes [18]. The pectin was very hygroscopic. For this reason, it must be preserved in closed dry atmosphere.

3.2.2 Ash content

The ash content of the pectin varied from 16.24 to 16.67% (Table 2). Banana 'Chinichampa' had the highest ash content (16.67%) while 'Sagor' had the lower content (16.24%). The maximum

limit though, for good quality gel was 30%. That was lower than that of unripe peels (16.67%). Thus, the gel quality that will be produced from this pectin would vary, with banana peel pectin expected to be of lower quality [19]. The Lower ash content was also obtained from unripe peels which implies that it can form better gels than that from the ripe peels, the maximum limit though, for good quality gel is 10% [19], which is lower than that of unripe peels. Thus, the gel quality that will be produced from these pectins would vary, with banana peel pectin expected to be of lower quality.

3.2.3 Methoxyl content

The methoxylcontents of the extracted pectin was within the range of 12.40 to 26.66 % (Table 2). The 'Chinichampa' contained the higher methoxyl content (26.66%) and banana 'Sagor' contained the lower methoxyl content (12.40%). The methoxyl content of commercial pectins generally varies from 10 to 40% and can form high sugar gels (>65% sugar). On the other hand, low methoxylpectins (less than 7.0%) can form gels with lower concentrations of sugars. Therefore, it can be concluded that pectin obtained from banana peels has property to gel form with lower concentrations of sugars [20].

3.2.4 Equivalent weight

The equivalent weight of pectin ranged from 555.56 to 666.67 (Table 2). The equivalent weight was high in 'Chinichampa' (666.67) and lower in 'Sagor' (555.56). The equivalent weight of pectin was another indicator of its jelly forming ability, high molecular weight pectin had better jelly forming ability [21].

3.2.5 Anhydrouronic acid content

Table 2 showed that the anhydrouronic acid (AUA) content of pectin extracted from banana peelsvaried from 102.08 to 177.76%. Banana 'Chinichampa' contained the higher anhydrouronic acid content (177.76%) and banana 'Sagor' contained the lower anhydrouronic acid content (102.08%). The anhydrouronic acid (%) was essential to determine the purity and degree of esterification and to evaluate physical properties. It indicated the purity of extracted pectin if it was not less than 65%. The pectins from banana peels had low purity with AUA contain greater than 65% [19].

3.2.6 Degree of esterification

Degree of esterification (DE) values in extracted pectin were within the range of 68.97 to 85.15% (Table 2) which was generally found in plant tissues [21]. As shown in Table 2, the DE values of pectin extracted form banana peels were greater than 75%. The pectin from 'Chinichampa' had the highest degree of esterification (85.15%), while it was lower (68.97%) from 'Sagor' cultivar.

Table 1. The yield of pectin from two different banana cultivars

Cultivar name	Initial weight of sample (g)	Weight of pectin obtained (g)	Yield of pectin (%)
'Chinichampa'	20±2.5	7.219±.54	36.10±1.53
'Sagor'	20±1.8	10.15±.71	-50.73±2.97

±Values indicate standard deviation

Table 2. Characteristics of pectin from two different banana cultivars

Parameter	Cultivar name	
	'Chinichampa'	'Sagor'
Moisture content (%)	23.29	24.75
Ash (%)	16.67	16.24
Equaivalent Weight	666.67	555.56
Methoxyl Content (MeO) (%)	26.66	12.40
Anhydrouronic Acid (AUA) (%)	177.76	102.08
Degree of Esterification (DE) (%)	85.15	68.97
Vitamin-C (%)	0.038	0.044
Beta-Carotene (mg/g)	0.73	1.01
Vitamin-A (mg/g)	1.21	1.68
Iron (%)	0.26	0.47

3.2.7 Vitamin-C

The banana contained a marked amount of Vitamin-C or L ascorbic acid at unripe stage. Vitamain-C is an important for antioxidant activities, disease resistance, and some other purposes. The vitamin-C content of extracted pectin from banana peels was higher in 'Sagor' (0.044%), while 'Chinichampa'showedthe lower amount (0.038%) (Table 2). Considering Vitamin-C, 'Sagor' banana might be the better choice for food process industries if it is processed at unripe stage and might help for health benefits of human.

3.2.8 Beta carotene (β-carotene) and vitamin A

The highest β-carotene (1.01 mg g^{-1}) and Vitamin-A (1.68 mg g^{-1}) contentswere observed in pectin extracted from 'Sagor' banana peels (Table 2). The pectin extracted from 'Chinichampa' banana contained the lower values of β-carotene (0.73 mg g^{-1}) and vitamin A (1.21 mg g^{-1}) contents. The higher β-carotene and vitamin A contentsare more desirable for the nutritional point of view. The result was conformed by the findings of Bhat and [22], that reported the pectin from 'Sagor' banana peels contained greater amount of β-carotene.

3.2.9 Iron

Iron is very important for the human blood. As shown in Table 2, the iron content in pectin extracted from 'Sagor' banana (0.47%) was higher compared to that from 'Chinichampa' banana peels (0.26%). This higher content was might due to genetic make-up. The results showed that the iron content gradually increased from 0.26 to 0.47 %. This was due to the fact that banana local cultivars contained much amount of iron concentration.

3.3 Correlation Matrix Analysis

3.3.1 Correlation analysis of weight (g) and yield of pectin (%)

The relationship between the weight of pectin (g) and yield of pectin(%) was examined. This section deals with the findings of the relationships between the selected dependent and independent variables of the study. Pearson's correlation of co-efficient (r) was used to determine the relationships between the selected dependent and independent variables and accept or reject the null hypothesis. One percent (0.01) level of significance was used as the basis for acceptance or rejection of a null hypothesis.

The relationship between the yield of pectin (%) and weight of pectin was 0.994**. Based on the computed 'r' value, the relationship between yield of pectin (%) with weight of pectin was significant at 0.01 level of significant with 13 degrees of freedom and followed a positive relationship. Hence, the concerned null hypothesis could be rejected i.e. if the increased of pectin(%) with the increased of weight of pectin.

3.3.2 Correlation analysis of moisture and ash contents

The computed correlation co-efficient between moisture and ash contents with equivalent weight were 0.328 and 0.565. Based on the computed 'r' value the relationship between moisture and ash contents with equivalent weight were not significant. Hence, the concerned null hypothesis could not be rejected.

The computed correlation co-efficient between ash with moisture content was 0.935*. Based on the computed 'r' value the relationship between ash content with moisture content was significant at 0.05 level of significant with 13 degrees of freedom and followed a positive relationship. Hence, the concerned null hypothesis could be rejected i.e. if the increased of ash content with the increased of moisture content.

3.3.3 Correlation analysis of methoxyl content (MeO) (%), anhydrouronic acid (AUA) (%) and degree of esterification (DE) (%)

Table 3 describes that the computed correlation co-efficient between methoxyl content and total anhydrouronic acid content with degree of esterification status was 0.962* and 0.943*. Based on the computed 'r' value the relationship between methoxyl content and total anhydrouronic acid content with degree of esterification was significant at 0.05 level of significant with 13 degrees of freedom and followed a positive relationship. Hence, the concerned null hypothesis could be rejected i.e. if the increased of methoxyl content and total anhydrouronic acid content with the increased of degree of esterification. The relationship between total anhydrouronic acid content with methoxyl

Table 3. Relationship between of methoxyl content, anhydrouronic acid and degree of esterification

Correlation matrix		
	% Methoxyl content	**Total anhydrouronic acid content (%)**
Total Anhydrouronic Acid content (%)	0.998**	
Degree of esterification (%)	0.962*	0.943*

*** and *indicated significant at p<0.01 and p<0.05, respectively*

Table 4. Relationship between of Vitamin-C, beta-carotene, vitamin-A and iron

Correlation matrix			
	Vitamin-C (%)	**Beta-carotene (mg g^{-1})**	**Vitamin-A (%)**
Beta-carotene (mg g^{-1})	-0.375ns		
Vitamin-A (%)	-0.374ns	1.000**	
Iron (%)	-0.343ns	0.999**	0.999**

*** and ns indicated significant at p<0.01 and not significant, respectively*

content was 0.998**. Based on the computed 'r' value the relationship between total anhydrouronic acid content with methoxyl content was significant at 0.01 level of significant with 13 degrees of freedom and followed a positive relationship. Hence, the concerned null hypothesis could be rejected i.e. if the increased of total anhydrouronic acid content with the increased of methoxyl content.

3.3.4 Correlation analysis of Vitamin-C (%), β-carotene (mg/g), Vitamin-A (mg/g) and Iron (%)

The computed correlation co-efficient between β-carotene, vitamin-A and iron with vitamin-C were -0.375, -0.374 and -0.343. Based on the computed 'r' value the relationship between β-carotene, vitamin-A and iron with vitamin-C were not significant (Table 4). Hence, the concerned null hypothesis considered valid. Based on the computed 'r' value the relationship between vitamin-A and iron with β-carotene and iron with vitamin-A was significant at 0.01 level of significant with 13 degrees of freedom and followed a positive relationship. Hence, the concerned null hypothesis could be rejected i.e. if the increased of vitamin A and iron with the increased of β-carotene and the increased of iron with the increased of vitamin-A.

4. CONCLUSIONS

This research emphasized on the comparison of chemical and nutritional values of pectin extracted from banana fruit peels of two different cultivars, including 'Chinichampa' and 'Sagor'. In the present study, pectin was extracted successfully from banana fruit peels using different extraction conditions. Chemical properties and nutritionalvalues of pectin extracted from banana peels of two different cultivars were varied in some limit. The highest equivalent weight of pectin was found in banana peels of 'Chinichampa' compared to 'Sagor', hence it showed lower partial degradation of pectin. From the result it also concluded that pectin obtained from banana peels of 'Sagor' has low methoxyl content which may results the poor gel formation. Extracted pectin from 'Chinichampa' banana peels contained higher amount of ash content, which good effect for the gel formation. The anhydrouronic acid content was greater in pectin extracted from 'Chinichampa 'banana peels, indicating that pectin may have fewer impurities. This study was intended to identify the potential of banana fruit peels as a source of pectin. From the results obtained, banana peels of 'Chinichampa' and 'Sagor' cultivars provided a significant amount of pectin those can be considered in commercial production of pectin along with other citrus source.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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