Research Article ISSN 2834-7854

Journal of Nutrition Food Science and Technology

Extraction and Characterization of Pectin from Peels of Selected Fruits

Dawodu, O. G* and Akinbode, O. M

Department of Science Laboratory Technology, Federal Polytechnic Ede, Osun State, Nigeria.

***Corresponding author**

Dawodu, O. G.,
Department of Science Laboratory Technology,
Federal Polytechnic Ede, Osun State,
Nigeria.

Submitted : 27 July 2024; Published : 16 Dec 2024

Citation: Dawodu, O. G. & Akinbode, O. M. (2023). Extraction and Characterization of Pectin from Peels of Selected Fruits. J N food sci tech, 5(4):1-7. DOI : https://doi.org/10.47485/2834-7854.1046

Abstract

Pectin, a polysaccharide is one of the possible products produced from fruit wastes and it finds its usefulness in the food and pharmaceutical industries. The objective of this study was to extract and characterize pectin from banana, orange, mango, watermelon, and pineapple waste peels. The peels of the fruits were collected, dried, and ground into fine powder. Pectin was extracted from the dried powdered peels using a cold extraction method and physiochemical properties and structural analysis via FT-IR spectroscopy were determined. Bananas gave the highest yield of pectin while pineapple gave the lowest. The colour derived from pectin extracted ranged from light to dark brown and in appearance was flakish and powdery. The pectins were found to be HMP i.e. high methoxyl pectins based on their acetyl values. Structural analysis from the Fourier transforms (FT-IR) gave almost the same peaks and functional groups. Conclusively, the pectin extracted from these fruit wastes showed promise as good sources for the pharmaceutical and gelling industries.

Keywords: Fourier transforms, fruit wastes, pectin, physicochemical properties

Introduction

Fruits have been consumed as far as Biblical times, with reference to the biblical Garden of Eden. They form a significant part of human nutrition and are highly recommended for a healthy vitamin-rich diet. Worldwide, over 675 million metric tonnes are produced yearly (www.statista.com). About 40-70% of that is discarded as waste. The major nuisance associated with fruits is their non- edible parts which are classified as fruit waste. A huge percentage of domestic waste comes from fruits and its wet waste gives rise to bad odor leading to unhygienic conditions and thereby a rise in a series of health problems (Suryawanshi *et al.*, 2013). The outer part of most fruits consists of the rind or peel which is most inedible. The peel in some cases has been found to have medicinal properties or even economic value if and when processed. A typical example of a product from the peels of fruit is pectin which is produced industrially from apple pomace and citrus peels and used in the gelling industries all over the world (Suja *et al.*, 2014). Pectin can be obtained from many sources with a variation in the percentage yield. The worldwide annual consumption of pectin is approximately 45 000 tonnes every year, occupying the global market value of at least 400 million Euros (Savary *et al.,* 2003). Pectin is widely used in the food industry as a thickener, emulsifier, texturizer, and stabilizer. It has also been used as a fat substitute in spreads, ice-cream, and salad dressings (Singthong *et al.,* 2005). Pectin is found to lower blood cholesterol levels and low-density lipoprotein cholesterol fractions, which is beneficial for human health (Liu *et al*., 2006). According to the FAO (1995), pectin is considered to be a safe food additive that can be taken daily without limits (Singthong *et al.*, 2005). Pectin can be extracted through various methods, e.g. with mineral acids such as sulfurous, sulfuric, hydrochloric, a combination of hydrochloric with ion-exchange resins or nitric acid and there has been successful extraction of pectin using citric acid and recovery with ethanol (Pinheiro *et al*., 2008; Kulkarni and Vijayanand, 2010; Minjares-Fuentas *et al.*, 2014). Usually, industrial pectin is extracted in a multiple-stage physicochemical process characterized by an extraction step with hot dilute mineral acid and recovery through alcohol precipitation (Mollea *et al*., 2008). Pectin is available as a fine or coarse powder which is odorless. Pectin is characterized based on the following; physicochemical analysis, visual observation, textural or rheological measurement, microstructural image characterization, rheological evaluation, and structural analysis i.e. FT-IR spectroscopy (May, 1997). The aim of this study is to extract and characterize alternative sources of pectin from selected fruit waste peels in abundance in Nigeria.

Materials and Methods

Collection and Pre-treatment of the Fruit Wastes

The samples were collected from several fruit vendors in various markets in Osun and Oyo states in Nigeria, these samples were banana, pineapple, orange, pawpaw, mango, and watermelon wastes. The fruit wastes was segregated according to their type and washed with water. The peels were washed with plenty of water and rinsed with distilled water. The washed peels were kept in a tray and sundried. The dried peels were then powdered using a blender.

Methods

The extraction method used for this study was adapted from Kratchanova *et al.*, (2004) as shown below.

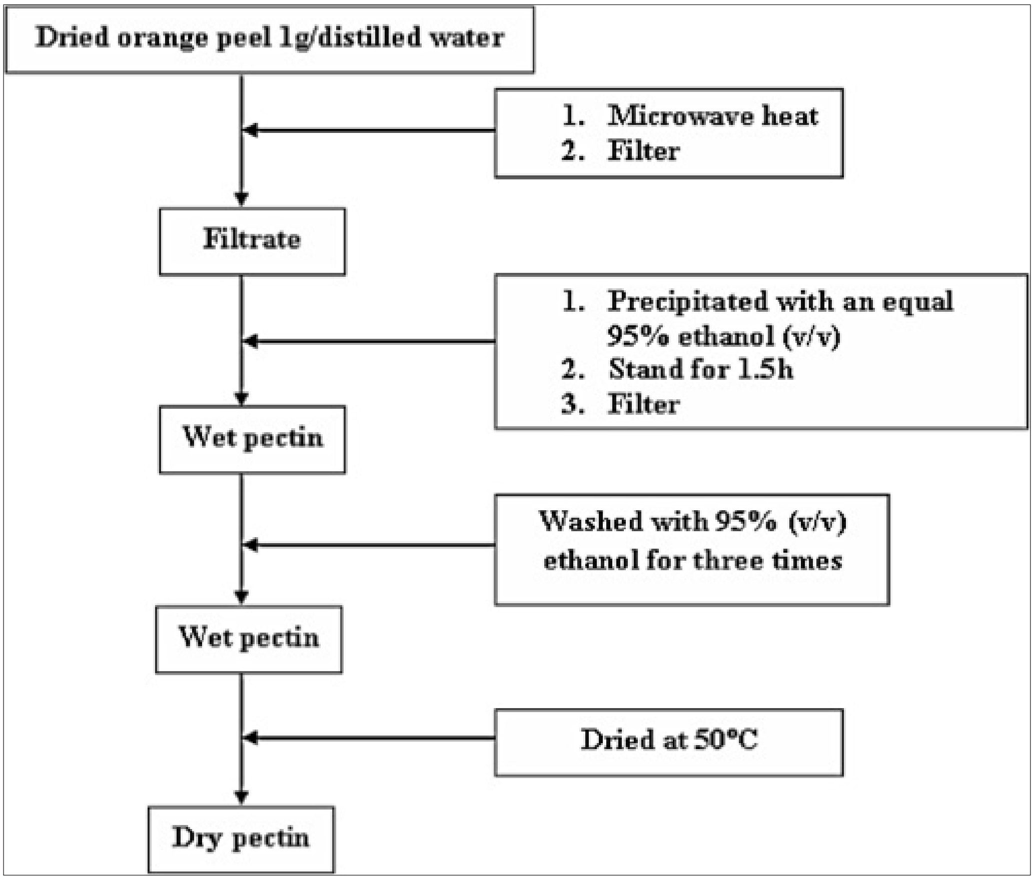

Figure 1: Flowchart for Pectin Extraction (Kratchanova et al., 2004)

Determination of Degree of Esterification (DE)

The degree of esterification (DE) was determined using the potentiometric titration method according to Bochek *et al.,* (2001).

The degree of esterification was calculated using the equation below.

% DE = FT / FT - IT X 100

Determination of Acetyl Value

The acetyl value (AcOH) of pectin samples was determined by the colorimetric method based on hydroxamic acid reaction (Ranganna, 1977).

Determination of Viscosity of Pectin

The viscosities of the samples were determined using a viscometer and the readings taken. The method of Rao (1993) was used for this determination.

Color Evaluation

The visual observation of the extracted pectin was done and the color was recorded.

Determination of the pH of the Pectin Samples

The pH readings of the samples were taken and recorded.

FT-IR Analysis of the Extracted Pectin

The method (Saptri, 2003), was used for the FT-IR analysis of the pectin extracted from the samples. 1g each pectin powder was mixed with 3g of potassium bromide salt, pressed into a disc and analyzed with a Shimadzu FT-IR machine, scanned from 5000-400 per cm at the resolution of 1 cm^{-1}, and 45 scans were collected to obtain a high signal to noise ratio and the FT-IR spectra for each sample was recorded.

Results and Discussion

This study successfully extracted pectin using a cold extraction method with ethanol as the main reagent used. Several studies have extracted pectin with hot mineral acids followed by alcohol precipitation (Mollea *et al.*, 2008), some have used citric acid and recovery with ethanol (Pinheiro *et al.,* 2008; Kulkarni and Vijayanand, 2010; Minjares-Fuentas *et al.,* 2014). The ease of this study is the total use of ethanol with gave a good yield and an acceptable level of purity, making somewhat applicable even for household preparation.

Figure 2 shows each dried fruit waste with the pectin extracted from them. Pectin was extracted from all the peels of the fruit waste samples except for pineapple which had a very minute quantity of pectin which could not be extracted. Pectin for each fruit waste differed in terms of color and appearance.

Figure 2: Dried Fruit wastes and their respective extracted pectin.

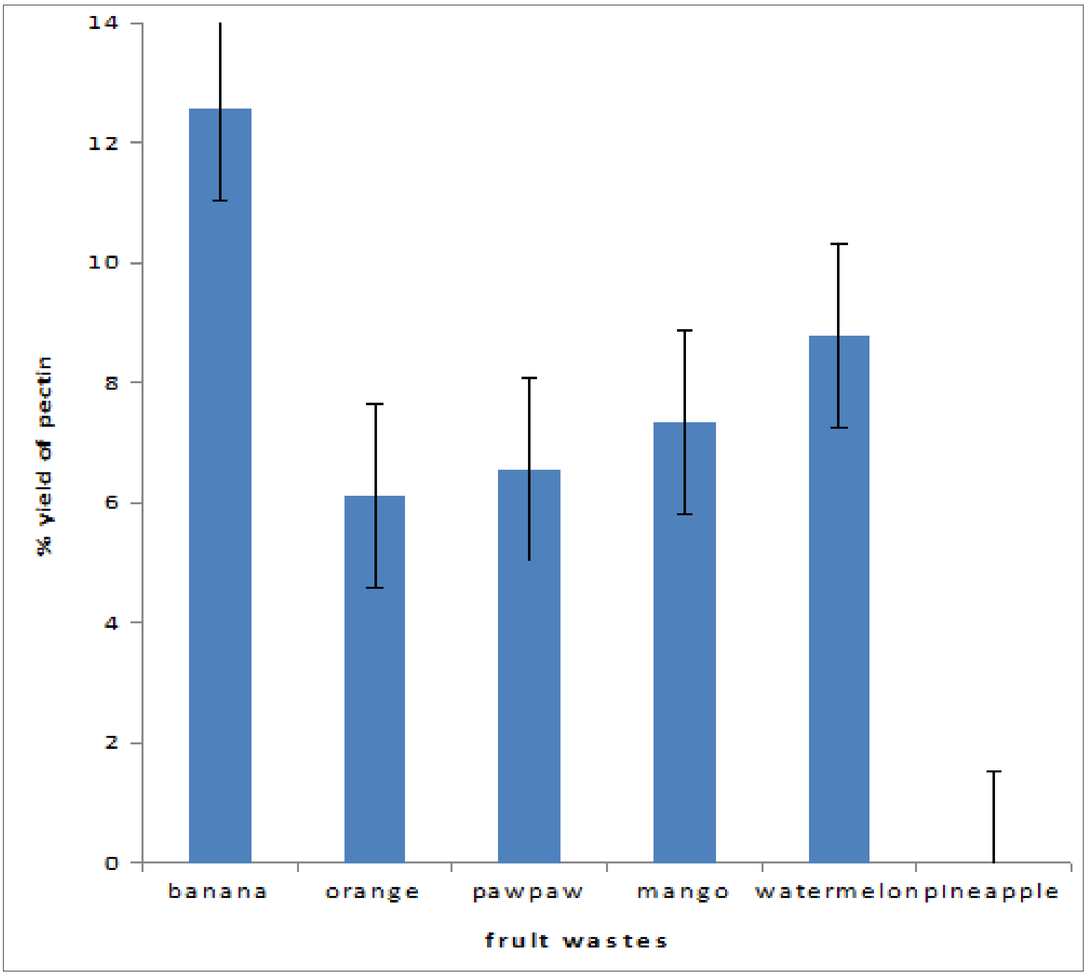

Figure 3: Percentage Yield of Pectin from Selected fruit peels.

In the figure above, banana fruit peel gave the highest yield of pectin (%), followed by watermelon, mango, pawpaw, and orange per 25g of the dried and ground fruit waste peels. The percentage yield of the extracted pectin ranged between 6-13% which was high, hence labeling these fruit wastes as possible sources of futuristic pectin production (Suja *et al.,* 2014). Bananas gave the highest yield with the cold extraction method used in this study, while acidic extraction method of Panchani and Gunasekaran (2017) using HCL, the highest yield was obtained with citrus peels.

Table 1: Physicochemical Parameters of the Extracted Pectin.

Fruit Peel	Color	Form/appearance	DE	AcOH	Viscosity	pH
Banana	Dark brown	Powder	109.30	0.86	11	1.1
Orange	Light brown	Pellet	128.94	0.43	40	0.9
Pawpaw	Brownish	Pellet	111.99	0.52	18	1.3
Mango	Dark brown	Flakes	105.58	0.60	60	0.9
Watermelon	Light brown	Powder	104.31	0.78	19	1.0
Pineapple	**	**	**	**	**	**

Key: DE-degree of esterification, AcOH- acetyl values, **-no pectin extracted

The table above reveals the physicochemical parameters of the extracted pectin. In terms of color, banana, and mango were dark brown, orange and watermelon were light brown while pawpaw was brownish. In terms of appearance, banana, and watermelon were in powdered form, orange, and pawpaw were in pellet form while mango was in flakes (Chin et al., 2014).

As pectin solutions are stable under acidic condition (pH between 3.2 and 4.5), high methoxyl pectin form thermostable gels when the pH was low i.e. less than 3 (Endress, 1991; Hendrickx et al., 2009). In terms of dissolution, the extracted pectin samples were soluble in water. This was in agreement with Endress (1991), who reported that pectin which is easy to handle must have the following characteristics: good dispersibility, high dissolution rate, and maximum solubility. Pectin extracted from pawpaw had the highest pH value and orange and mango have the lowest. These values are in agreement with Endress (1991) who reported that the pH of high methoxyl pectins is less than 3.5.

The degree of viscosity of the extracted pectin was the highest in mango and lowest in banana.

The DE values showed that the pectin extracted from orange had the highest value, followed by pawpaw, banana, mango, and watermelon. These values correlate with the values of Endress (1991) whose findings reported that high methoxyl pectins are pectins in which the degree of esterification is equal to or greater than 50, all these pectin samples have a degree of esterification greater than 50 which makes them high methoxyl pectins.

The result for acetyl value showed that watermelon had the highest acetyl value, followed by banana, pawpaw, mango, and lastly, orange. Pectins with high acetyl content exhibit poor gelling properties i.e. the degree of acetyl esterification (DAc) > 10 – 40. The pectin extracted from these fruit wastes had low acetyl values indicating their proper use in the gelling industries.

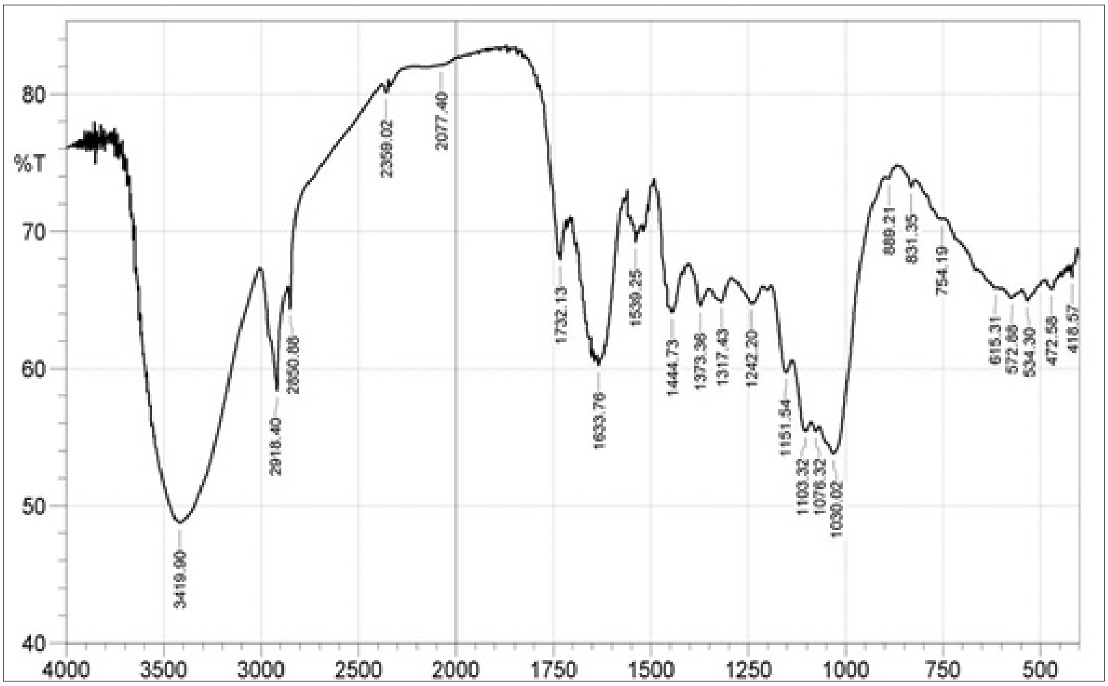

Figure 4: FT-IR Spectrogram of the extracted pectin from banana fruit waste peel.

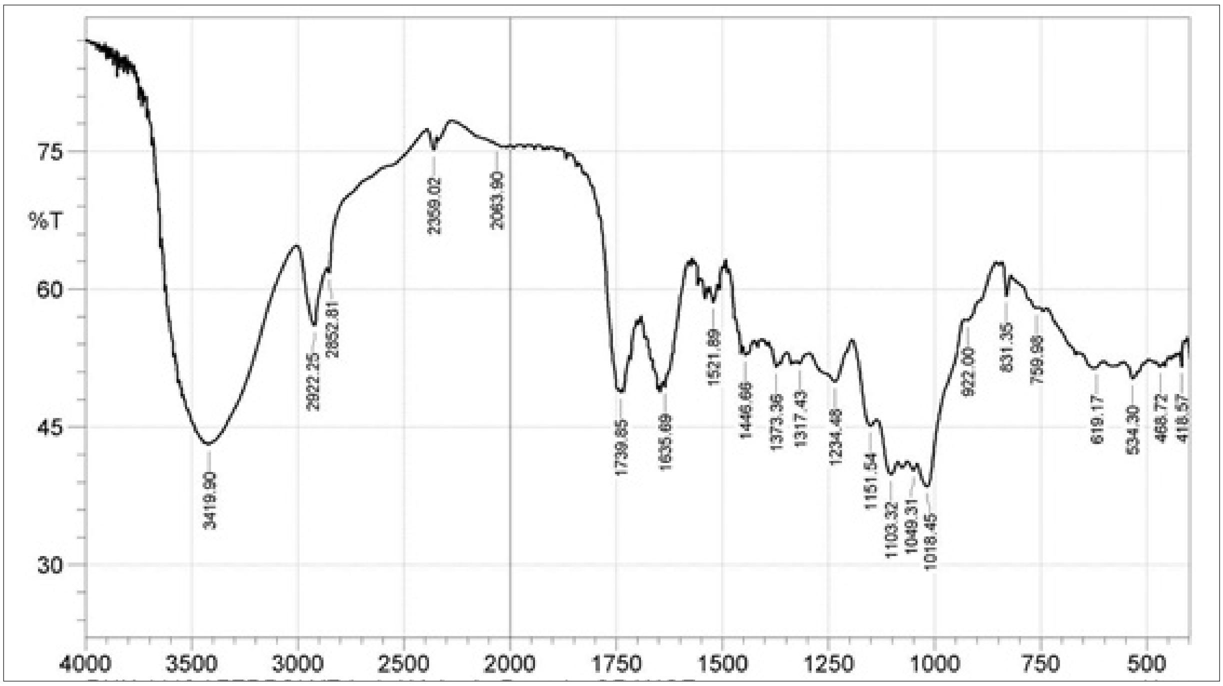

Figure 5: FT-IR Spectrogram of the extracted pectin from orange fruit waste peel.

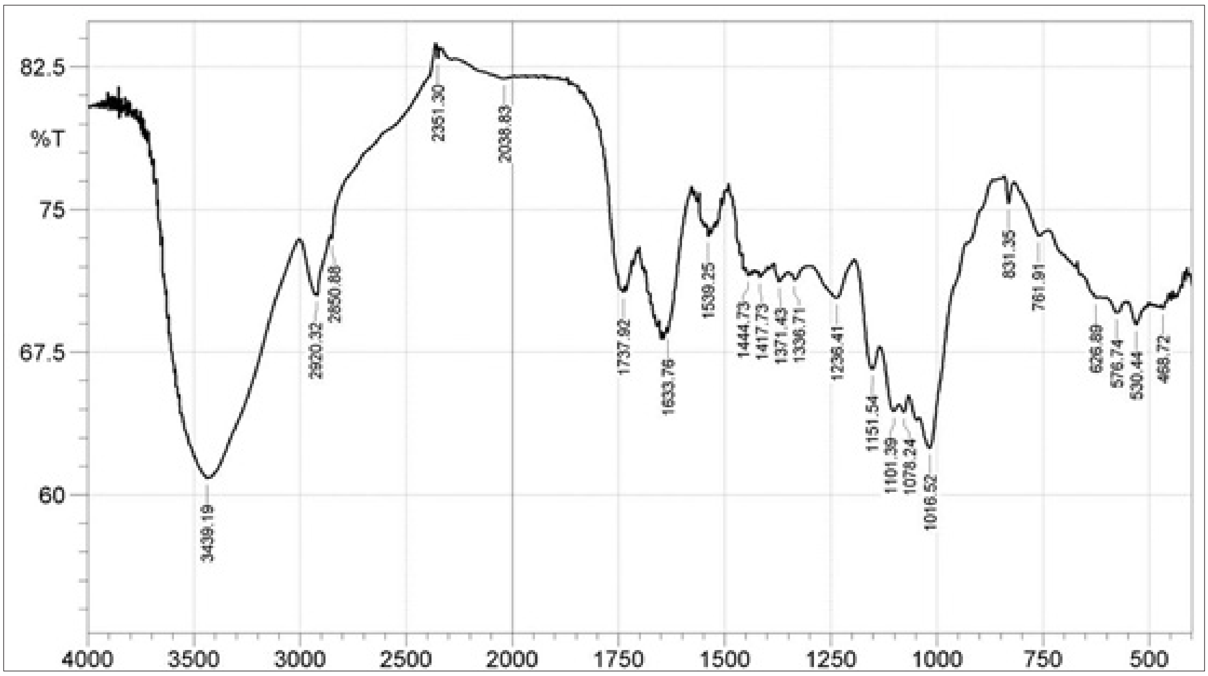

Figure 6: FT-IR Spectrogram of the extracted pectin from pawpaw fruit waste peel.

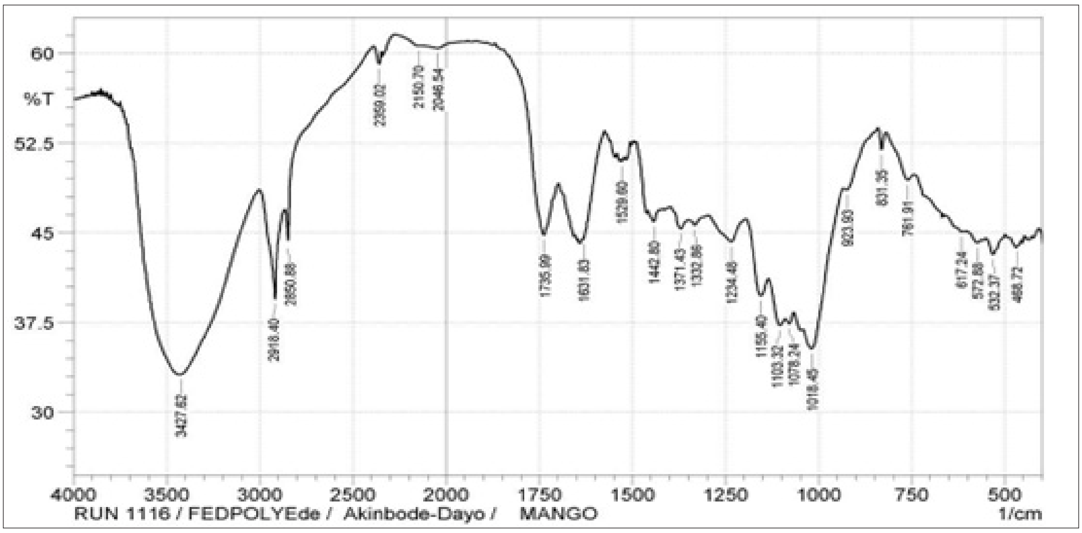

Figure 7: FT-IR Spectrogram of the extracted pectin from mango fruit waste peel.

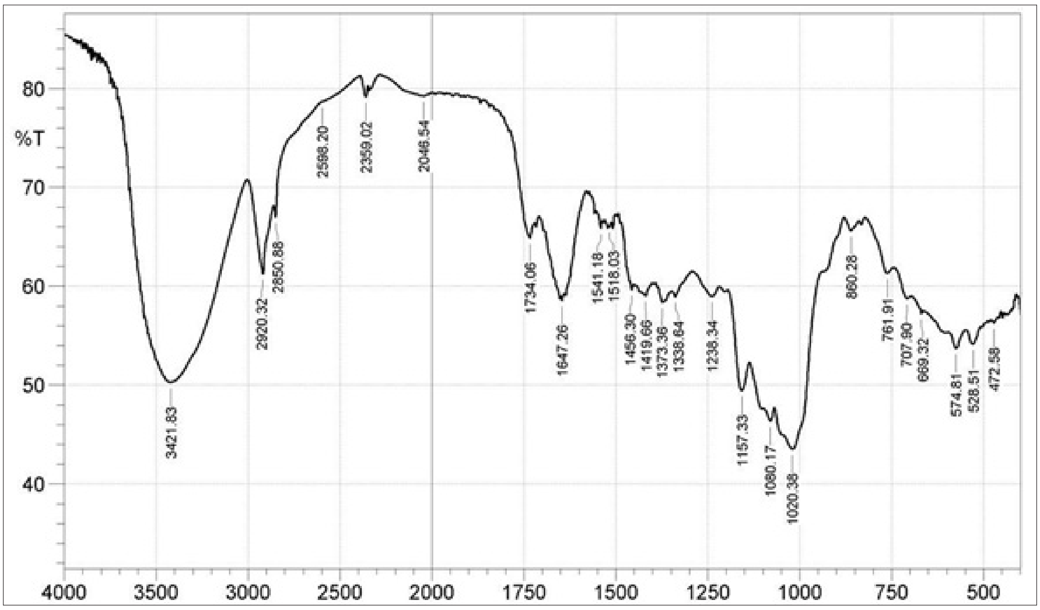

Figure 8: FT-IR Spectrogram of the extracted pectin from watermelon fruit waste peel.

The FT-IR peaks in the pectin samples as shown in the figures above (Figures 4-8) were typical of polysaccharides and the following distinctive absorption band maxima were identified, 1200 to 1000cm^{-1} in all samples. The band patterns in this region have been made for various polysaccharides as revealed by (Kacuracova et al., 2000). This region was reported to be dominated by ring vibrations overlapped with stretching vibrations of (C-OH) side groups and the (C-O-C) glycosidic bond vibration.

Pectin extracted from the samples studied showed peaks at 1730 cm^{-1} with medium intensity. This signifies the presence of the COOH (Carboxyl) group. This band indicates that the sample may contain some free uronic acids or acetyl ester groups which are predominantly found in pectin substances and acetylated acidic polysaccharides (Ben-Nwauzo, 2003).
The sample studied also shows an absorption band at around 16000cm^{-1} which may be associated with the C=O stretching bond.

The FTIR spectra of the sample also showed the band at around 34000cm^{-1}, which indicated the presence of OH group. The FTIR spectra indicated that all the extracted fruit waste samples were pectins (i.e. polysaccharides).

The result also showed the presence of the functional groups which included: Alcohol OH, Alkyl C-H, Ester C=O, and Amide C=O stretches. All spectra were similar showing characteristics bands in the range of 3419 – 3439 cm^{-1} [OH], 2918 -2922 cm^{-1} [CH], 1732 -1739 cm^{-1} [{C=O, COOMe], 1631- 1647 cm^{-1}[COO-]. These values are in agreement with those represented by Fishman *et al*., (2000).

Conclusion

Five fruit waste peels found abundantly in Nigeria were used to produce pectin. The pectin produced had qualities resembling that of apple pomace and showed Fourier transforms aligning with the pectin polysaccharide. This pectin production success makes it a possible alternative to the pectin used in gelling industries locally.

Recommendation

This study hereby recommends that industries should be encouraged into pectin production from domestic fruit waste peel. This will generate the much-needed foreign exchange in the country and also make our country pollution friendly in terms of domestic waste reduction. As pectin is of great economic importance, it will serve as employment opportunities for budding young entrepreneurs of science.

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