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Extraction and Characterization of Hydrocolloid Pectin from Goron Tula (*Azanza garckeana)* fruit

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ABSTRACT

Pectin is a naturally occurring biopolymer and hydrocolloids are polymeric cross-linked network structures, both can be used for food and pharmaceutical applications. This study investigated the effect of temperature, time and pH on the yield, physicochemical characteristics of water soluble pectin extracted from *Azanza garckeana* fruits. The pectin was extracted using the acid extraction method followed by 96% alcohol precipitation. The optimum temperature, time and pH for the extraction of pectin for both dried and wet fruits were determined to be 85^0C, 90 minutes and 2 respectively. The yields of pectin under these optimum conditions were found to be 24.38 and 26.75% for DAG and WAG fruits extracts respectively. Temperature, extraction time and pH showed a significant effect on the pectin yield with the wet sample extracts been the highest. The physicochemical properties determined under these optimum conditions were found to be; equivalent weight; 813.64 and 840.55 mg/mol, methoxyl content: 6.62 and 7.43% anhydrouronic acid content; 60.90 and 66.40% degree of esterification; 72.45 and 85.95%, moisture content; 2.21 and 1.80% and ash content; 0.80 and 0.60% for DAG and WAG fruits extracted pectin respectively. The swelling ratio was observed to increase with increasing temperature, and swelling medium also has significant influence on the swelling ratio, as it increased with high pH due to complete hydrolysis of carboxylate. FTIR was also utilized for characterizing the pectins and hydrocolloid which was favourably compared with the available standards. Generally, the findings of the study showed that the pectin extracted from *Azanza garckeana* fruits can find industrial applications, especially in food processing and pharmaceutical industries.

***Keywords*:** *Azanza garckeana*, Hydrocolloid, polymer, pectin

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1. INTRODUCTION

In Africa, research has shown that a vast number of fruits bearing plants exists and play a significant role in the diet of the populace. Fruits from plants serve as food and source of nutrients, because they provide some of the minerals that are essential for body building and regulate some body functions such as metabolism. Also, they provide energy that is required by the body activities. Some of these plants have been identified, but lack of proper documented data on their chemical composition and some of their possible applications in different fields of human endeavour has limited the prospect of their utilization as it was reported by Benamer [1]. Many reports on some lesser known seeds and fruits indicated that they could be good sources of nutrients for both man and livestock [2].

In Nigeria, wild fruits are commonly consumed by both urban and rural dwellers especially during dry season, although a good number of them can be obtained in the rainy season. Fruits are good sources of proteins, fats and majorly carbohydrate and minerals. Nutritionally, they are also believed to contain beta carotene which acts as antioxidant and potentially offers protections against cancer and the degenerative aspect of aging [3]. Considering the importance and many values of fruits plant, the characterization and the application of pectin is very crucial since hydrocolloids has found wider areas of applications. Therefore, this research work will be focused particularly on the fruits of two indigenous plants *Azanza garckena*

Hydrocolloids or gums are diverse group of long chain polymers characterized by their property of forming viscous dispersions or gels when disperse in water [4]. The occurrence of a large number of hydroxyl groups noticeably increases their affinity for binding water molecules rendering them hydrophilic compounds. Furthermore, they produce a dispersion, which is intermediate between a true solution and a suspension and exhibits the properties of a colloid. Hydrocolloid materials have different functional properties which include; thickening, gelling, surface activity and emulsifying, stabilization, coating etc. Examples of hydrocoloidal materials are carrageenan, cellulose derivatives, chitosan, gum, pectin, starches etc.

Pectins are structural hetero-polysaccharide hydrocolloids contained mainly in the primary cell walls of many plants. It's also a multifunctional food ingredient that is widely used as gelling agent and mostly as stabilizers in food processing industries [5].

Pectin is produced commercially in form of white to light brown powder, mainly extracted from citrus fruits. The traditional application of pectin is as a gelling agent in jams and jellies, but over the past few years pectin has been increasingly used in new applications, not only in the food industry, but also in the pharmaceutical industry. Various properties of pectin, such as gelling, emulsifying, and film forming abilities, in addition to its resistance to degradation in the upper gastro intestinal tract, has allowed the increasing use of pectin in the development of drug delivery systems through encapsulation [6] and [7]. Following the same rationale, pectin has the potential to be used in the encapsulation of unstable food ingredients.
The amount, structure and chemical composition of pectin differs between plants and within plants over time and in different parts of a particular plant. The pectin in fruit part of plant is broken down into parts during ripening by the enzymes called pectinase and pectin esterase, making the fruit to become softer. The highest concentration of pectin can be found in the middle lamella of cell wall with a gradual decrease when moving from the primary cell wall toward the plasma membrane [8]. Despite the fact that pectin occurs commonly in most of the plant tissues, the commercial source of pectin is limited; this is because the ability of pectin to

form gel depends on the molecular size and the degree of esterification. The pectin obtains from various sources differ in their gelling ability due to variation in certain parameters such as temperature and pressure during extraction.

In medicine, pectin increases viscosity and volume of stool so that it is used against constipation and diarrhea. It has also been used in gentle heavy metal removal from biological systems. In ruminant nutrition, it depends on the extent of lignifications of the cell wall; pectin is up to 90% digestable by bacterial enzymes. The ruminant nutritionists recommend that the digestibility of energy concentration in forage can be improved by increasing pectin concentration in the forage [4].

2. MATERIALS AND METHOD

This research work was carried out between the months of May 2016 to June, 2017 in the Chemistry laboratories, Department of Chemistry, School of Physical Sciences. Modibbo Adama University of Technology, Yola, Adamawa State, and Chemistry laboratories, Department of Chemistry, Gombe State University while other instrumental analyses were acquired at National Research Institute Laboratories Zaria, Kaduna State and American University Yola, Adamawa State, Nigeria.

2. 1. Extraction of water soluble pectin

The extraction of water soluble pectin hydrocolloids from both the dried and wet samples were carried out following standard methods described by Menon *et al*., [10], Srivastava *et al.*, [11], and Tang *et al.*, [12].

2. 2. Yield and characterization of pectin

a. Percentage Yield of Pectin

The percentage yield of the extracted pectin hydrocolloids was calculated using the following equation.

$$\text{Ypec } (\%) = P/Q \times 100$$

where: Ypec (%) is the extracted pectin yield in percent (%), P is the amount of extracted pectin in grams (g) and Q is the initial amount of powder fruit samples (50g).

2. 3. Physicochemical characterization of pectin

The dried pectin samples obtained from the fruit was subjected to quantitative and qualitative test in order to determine its physicochemical characteristics. From the results obtained, the optimal conditions that gave the optimum yield were temperature 85 °C, extraction time 90 minutes and pH 2.0 and these were also used for subsequent analysis.

a. Qualitative Test

Colour: This was done by visual observation

Solubility of Dry pectin in Cold and Hot Water: About 0.25% of the pectin samples were differently placed in a conical flask with 10 mL of 95% ethanol added followed by 50 mL

distilled water. The mixture was shaken vigorously to form a suspension which was then heated at 85 °C for 15 min. [13].

Solubility of Pectin Solution in Cold and Hot Alkali (NaOH): About 1 mL of 0.1 M NaOH was added 5ml pectin solution and then heated at 85 °C for 15 min [14].

pH Determination: The choice of the pH was made by preparing a buffer at pH 7.0 and the temperature adjusted to 28 °C, the glass electrode standardized with standard buffer solution with the electrode rinsed with distilled water before inserting into the pectin solution and pH determined taken from the pH meter.

b. Quantitative Analysis of Extracted Pectin

i. Determination of Ash and Moisture Contents

The moisture and ash content were determined by adopting AOAC method [15]. As explained below:

Ash Content: The ash content of the extracted pectin samples was determined by weighing 1.0 g of pectin in a tared crucible and then heated in a muffle furnace at 550 °C for four hours. The residue was then cooled in a desiccator and weighed to a constant weight for three times. The percentage ash content of the sample was then calculated according to the expression below.

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

Moisture Contents: The moisture content of the pectin samples was determined by weighing 2.0g of the sample into a well dried crucible that was heated in an oven and cooled in a desiccator thereafter, the crucible and sample were heated in an oven set at 105 ±5 °C, which was then removed and cooled in a desiccator and weighed. The process was repeated until a constant weight was obtained for all the samples. The moisture content was calculated from the expression given below:

$$\text{Moisture Content (\%)} = \frac{\text{Weight of the Residue (g)}}{\text{Weight of Pectin (g)}} \times 100$$

ii. Determination of Equivalent Weight

The determination of equivalent weight was carried out according to the method described by Ania *et al.*, [16].

$$\text{Equivalent Weight (mg/mol)} = \frac{\text{Weight of the pectin sample (g)}}{\text{Volume of Alkali (cm}^3) \times \text{ Molarity of Alkali (M)}} \times 100$$

iii. Methoxyl Content Analysis of Extracted Pectin

The determination of the methoxyl (MeO) content of the pectin sample was carried out by adding 25 mL of 0.25M NaOH to the neutralized solution that was utilized for equivalent weight determination above, which was shook thoroughly, and allowed to stand for 30 minutes at room temperature in a stoppered flask. Followed by the addition of 25 mL of

0.25M HCl and titrated to the same end point (pink) as before [16]. The volume of the alkali required for the neutralization reaction was recorded and the methoxyl (MeO) content was calculated from the expression given below:

$$\text{Methoxyl Content (\%)} = \frac{\text{Volume of Alkali (cm}^3) \times \text{ Molarity of NaOH (g)} \times 31 \times 100}{\text{Weight of pectin sample (mg)} \times 1000}$$

where: 31 is the molecular weight of methoxyl (CH_3O)

iv. Anhydrouronic Acid (AUA) Analysis of Extracted Pectin

The Anhydrouronic acid (AUA) analysis was done by using the values of the equivalent weight and the methoxyl content obtained following the method specified by Ania *et al.*, [16]. Thus, the anhydrouronic acid (AUA) content was calculated from the expression given below.

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

where: Molecular unit of AUA (1 unit) = 176g, z = volume cm^3 (titre) of NaOH from equivalent weight determination, y = volume cm^3 (titre) of NaOH from methoxyl content determination, W = weight of pectin sample

v. Determination of Degree of Esterification

The pectin degree of esterification (DE) was determined by titrimetric method described by Bello *et al.*, [3]. The degree of esterification (DE) was calculated using the following equation.

$$\text{DE (\%)} = \frac{V_2}{V_1 + V_2} \times 100$$

where: V_1 = Volume (cm^3) of sodium hydroxide (0.1M) used in first titration, and
V_2 = Volume (cm^3) of sodium hydroxide (0.1M) used in second titration.

2. 4. Swelling studies of pectin samples

The swelling studies of the extracted pectin samples were carried out in dionized water by gravimetric method. About 2.0g of the extracted pectin sample was weighed and immersed in excess water in a beaker for 30 minutes for different time intervals at 37 °C and then the samples were removed, wiped with tissue paper to remove excess of solvent, and then it was weighed immediately. The difference in weight was calculated to obtain the weight gain at different time intervals [18].

$$\text{Swelling Ratio (\%)} = \frac{W_t - W_d}{W_d} \times 100$$

where: W_t is the weight of the swollen pectin at time, t and W_d is the initial weight of the dried pectin before immersion.

2. 5. FTIR Spectroscopy

The FTIR spectra were used to obtain information on chemical structure of the extracted pectin. Fourier transform infrared data was obtained using the Perkin Elmer, GX spectrum model with wavelengths ranging from 4000-400 cm^{-1}.

3. RESULTS AND DISCUSSION

3. 1. Yield of Extracted Pectin

The yield of pectin from *Azanza garckeana* fruits both dried (DAG) and wet WAG) samples were in the ranges of 4.65 to 24.38 % and 9.82 to 26.75 % respectively.

Table 1. Pectin Yield of *Azanza garckeana* fruit Obtained at Extraction pH 2.0 Under Varying Extraction Temperature and Time, Followed by Precipitation With 96% Ethanol

TIME (mins.)	TEMPERATURE (°C)	PECTIN YIELD (W/W) DAG	WAG
45	70	4.65	9.82
60		9.78	10.60
90		10.26	12.40
45	85	12.54	14.35
60		16.12	18.43
90		24.38	26.75
45	105	23.88	25.92
60		20.22	22.43
90		20.62	21.92

DAG = Dried *Azanza garckeana* fruits, WAG = Wet *Azanza garckeana* fruits

3. 2. Effect of Extraction Process Parameters on Pectin Yield

a. Effect of Extraction Time on the Pectin Yield

From the results shown on Figure 1, the pectin yield was observed increased significantly with the increase in the extraction time, it is clear that the yield of pectin increases up to 90 minutes and thereafter its start declining. This may due to the fact that a relatively long period of extraction would cause a thermal degradation on the extracted pectin, thus causing a decrease in the amount extractable by the alcohol during precipitation process. Apart from that, the color of the pectin extract became dark brown for longer periods of extraction which invariably required a higher number of alcoholic washing of the precipitate. Also, as the extraction proceeds, the concentration of the pectin in the solution will increase and the rate of extraction will also progressively decrease; due to fact that the concentration gradient will be reduced and, consequently, the solution becomes more viscous. Generally, the result shows that the yield increases with increase in extraction time as the proto-pectin naturally present in cells takes time to solubilize and go into the solution**.** However, at longer

extraction time and higher temperatures, the pectin yield begins to decline; this probably could be due to hydrogen bond dissociation as a result of thermal degradation of pectin backbone that may likely occur at high temperatures [19].

From this current work, the optimum pectin yield was obtained at a temperature of 85 °C and extraction time of 90 minutes as 24.38% and 26.75% for DAG and WAG fruits extracts respectively.

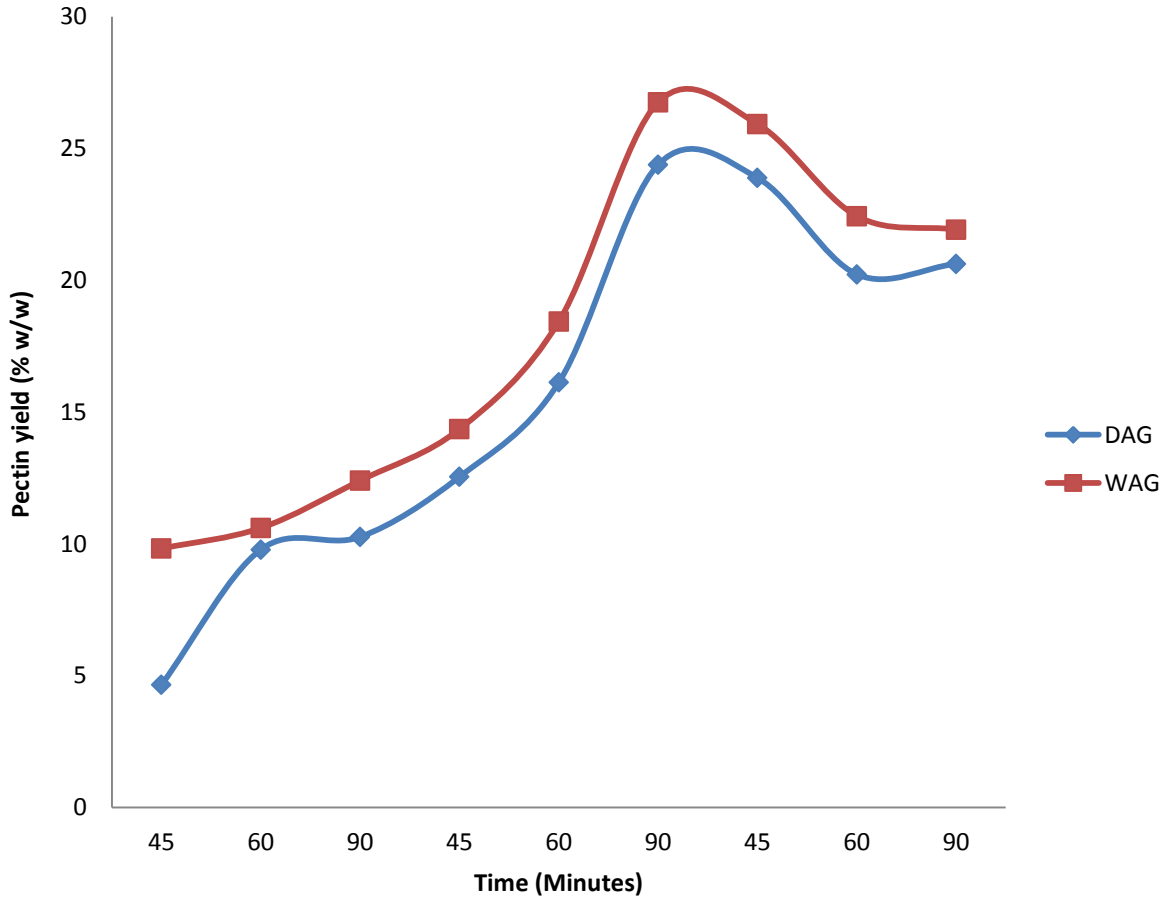

Figure 1. Effect of Extraction Time on the Pectin Yield

b. Effects of Temperature on Pectin Extraction Yield

As shown on Table 1 the pectin yield is greatly influenced by temperature. The yield increases with the increasing temperature for *Azanza garckeana* fruits samples until the temperature above 85 °C. Because increasing the extraction temperature would increase the solubility of the extracted pectin, giving a higher rate of extraction. However, further increase in temperature from 85 to 105 °C shows a declining tendency of pectin yield, since too high temperature would lead to break down of pectin molecules as pectin is composed of α-(1-4) linked units of galacturonic acid or methyl ester resulting in pectin of lower molecular size which is not stable and extractable with alcohol and consequently, the pectin yield declined. Also, high temperature encourages energy loss through vaporization and increases the cost of

extraction process from the industrial point of view. At lower temperature, the lower viscosity of pectin might cause poor diffusion between the phases that could cause slower rate of extraction leading to low yield of pectin.

From the previous research works, it was shown that temperature; extraction time and pH had notable influence on the pectin yields. This is why these conditions were chosen and monitored. Thus, the results obtained were similar and agreed with those obtained by other researchers [17], [20], and [16], it could be seen that low pH gives high pectin yield, although it also depends on the plant materials this is why a low pH of 2.0 was chosen for this research work while other parameters were varied.

3. 3. Physicochemical Characterization of Pectin

a. Qualitative Test of Extracted Pectin

The qualitative test for all the samples were given under Table 2. It was observed that in cold water, the pectic sample were insoluble but dissolved slightly and forms suspension after vigorous shaking for about 15mins for both dried and wet samples. However, when the temperature was raised to 85 °C, the solubility was gradually increased.

Table 2. Quantitative Test for Pectin Extracted at 85 °C, pH 2.0 and 90 minutes Extraction time.

Parameter	Pectin Source	
	DAG	WAG
Solubility in cold water	Insoluble, forms suspension after vigorous shaking	Insoluble, forms suspension after vigorous shaking
Solubility in water at 85 °C for 15 minutes	The mixture dissolved gradually	The mixture dissolved gradually
Solubility of pectin solution in cold alkali (NaOH) 0.1M	A yellow precipitate was formed	A yellow precipitate was formed
Solubility of pectin solution in hot alkali (NaOH, 0.1M) at 40 °C for 10mins	The yellow precipitate dissolved and turned milky	The yellow precipitate dissolved and turned milky
Colour	Whitish - Brown	Whitish - Brown

DAG = Dried *Azanza garckeana* fruits, WAG = Wet *Azanza garckeana* fruits

The solubility of the pectic substance in an alkaline medium was investigated, the test shows that the pectin suspension forms a yellow precipitate in cold alkali medium whereas, in an elevated temperature, the suspension dissolved and turned milky, this could indicate the breaking of backbone chain of the functionality especially the esters, $RCOOCH_3$ with

evolution of CO_2. Since this is a general qualitative test, it shows similar properties for the pectin extracted from plant fruits of *Azanza garckeana* both on the dry and wet basis. The results obtained in this research work shows a similar characteristic with that of earlier researchers [17] and that of [22] which stated that pectin is unstable under alkaline solution, this agrees with what was obtained from this work.

3. 4. Quantitative Analysis of the Extracted Pectin

A. Physicochemical Characterizations

Physicochemical Characterizations of the extracted pectin were carried out for various parameters in other to evaluate its suitability in industrial applications. The extraction time and pH had significance effect on the degree of esterification and moisture content of all the samples. The physicochemical characterizations of pectin depend mainly on the raw material source and conditions selected for isolation and purification. Table 3 gives a brief summary of the parameters that were determined in other to evaluate the physicochemical quality characteristics of *Azanza garckeana* fruits pectin. The values of equivalent weight of *Azanza garckeana* fruits pectin were slightly higher than those obtained from *Limonia acidissima* fruits obtained by the same reasercher. Methoxyl content is an important factor in controlling the setting time of pectin and the ability of the pectin to form gels [16]. The values of methoxyl contents obtained were 6.62 and 7.43% for DAG and WAG respectively. Which is within the range, from previous study literature had it that methoxyl content of extracted pectin vary from 0.2-12% depending on the source and mode of extraction. Since all the values obtained experimentally were below 7.5 %, hence the pectin was of low ester content, which is a characteristic indicating that the pectin obtained is good in terms of quality [4].

Table 3. Physicochemical Composition of the Extracted Pectin under Optimum Conditions of 85 °C, 90 minutes and pH 2.0

Composition	Pectin source	
	DAG	WAG
Yield of Pectin (% w/w)	24.38	26.75
Moisture content (% w/w)	2.21	1.80
Ash content (% w/w)	0.80	0.64
Equivalent weight (g/ml)	813.64	840.55
Methoxyl content (%)	6.62	7.43
Anhydrouronic Acid (% AUA)	60.90	66.40
Degree of Esterification (% DE)	72.45	85.95
pH	4.6	4.2

DAG = Dried *Azanza garckeana* fruits, WAG = Wet *Azanza garckeana* fruits

Degree of methylation and pectin yield are important factors in determining the firmness of the gel and, subsequently, the value and possible use of raw material in the food industry and other applications.

Extraction that aims to obtain a higher yield and better characteristic properties of pectin in terms of degree of methylation is a useful tool for technological purposes. The pectin extracted from *Azanza garckeana* fruits under the optimum conditions of temperature, 85 °C and time, 90 minutes in solutions at pH 2 were used for this analysis and the results obtained were given on Table 3. The moisture and ash content of 2.21, 1.80, and 0.80, 0.64 (% w/w) for DAG and WAG respectively were obtained in these extracting conditions. The results showed that pectin samples have a minimal moisture content and low ash content which are very important factors required for checking quality of pectin for both utilization and storage. Anhydrouronic acid content and degree of esterification in the samples were found to be 60.90, 66.40, 72.45 and 85.95 % respectively for both dry and wet samples of *Azanza garckeana* fruits pectin. According to FAO, the content of galacturonide expressed as galacturonic acid, $C_6H_{10}O_7$ (M W 194.1) must be at least 65 % on sugar, ash and moisture free basis. It was also observed that the hot acid extraction, usually utilized for commercial pectin production, is highly suitable for the recovery of pectin from *Azanza garckeana* and the potential of this fruit as an alternate source for commercial production of pectin.

The anhydrouronic Acid (AUA) indicates the purity of the extracted pectin and its value should not be less than 65% [9]. In this study the highest AUA content of *Azanza garckeana* fruit pectin was within the acceptable limits of pectin purity. There is a significant difference between the wet and dried samples of *Azanza garckeana* pectin in terms of degree of esterification. Although both fall within the of high methoxyl pectin, based on DE pectin can be classified as low methoxyl pectin with ≤ 50% DE and high methoxyl pectin with > 50% DE. Therefore, in this study indicates that all extracted pectin can be categorized as high methoxyl pectin. The maximum value of moisture content of *Azanza garckeana* pectin was slightly higher. Low moisture content is required for pectin for safe storage as well as to inhibit the growth of microorganisms that can affect the quality due to the production of pectinase enzymes. There is no significant difference of the ash content between dried and wet *Azanza garckeana* pectin. The upper limit of ash content for good-quality pectin is considered to be 10% from the view point of gel-formation [17].

Gel-setting time is a function of DE, with rapid-set pectin possessing a DE of 72 to 75%, medium-set pectin a DE of 68 to 7l%, and slow-set pectin a DE of 62 to 66% [21]. Such distinctions are of value in processing where speeds of gelation can influence product quality. Rapid-set pectins are useful in the manufacture of jams and ensure uniform dispersal of fruit pieces and prevent floating. When flotation of fruit is not a problem, such as in clear jellies, then slow-set pectin is preferable because they allow entrained air bubbles to rise before gelation. From the above, it can be observed that the pectin obtained in this analysis is high methoxy pectin with rapid-set pectin based on the value of degree of esterification obtained is above 70%. The results also indicated high methoxyl pectin with the fresh or wet samples having the highest values.

Therefore, with respect to this parameter, the pectin extracted in this study may be considered to be of satisfactorily good quality. The inorganic impurities in pectin were indicated by the ash content. Lower ash content indicates good quality of pectin. The ash content of extracted pectin was close to the reported values by other researchers.

B. Swelling Studies of Pectin Samples

Pectin is soluble in water but not in organic solvents. Therefore, the swelling study was conducted in water. The presence of carboxylic acid groups makes pectin a polyelectorolyte and a weak organic acid. When pectin is added to water, carboxylic acid groups dissociate and the pectin molecules become negatively charged. Solubility is increased by all factors diminishing possibilities of intermolecular association.

From the results obtained, it showed that the pectin swelling increases with increasing temperatures as seen from Figure 2. The swelling value at 60 °C is twice as big as the value at 30 °C. It is possible to suggest that the H-bonds inside the pectin sample were broken due to temperature rise and thus increase the amount of swelling. Also, the increase in swelling value with increasing temperature of the pectin might be caused by the increase in thermal mobility of polymer molecules inside the pectic substance [22]. The WAG sample shows higher swelling capacity compared to other samples, however the swelling increases steadily from the initial up till 240 minutes for all samples and then it tends to be constant beyond this period. This could indicate that the sample has absorbed enough water and can no longer absorbed, which means it has reach it swelling equilibrium. The samples exhibited the characteristic absorption of water.

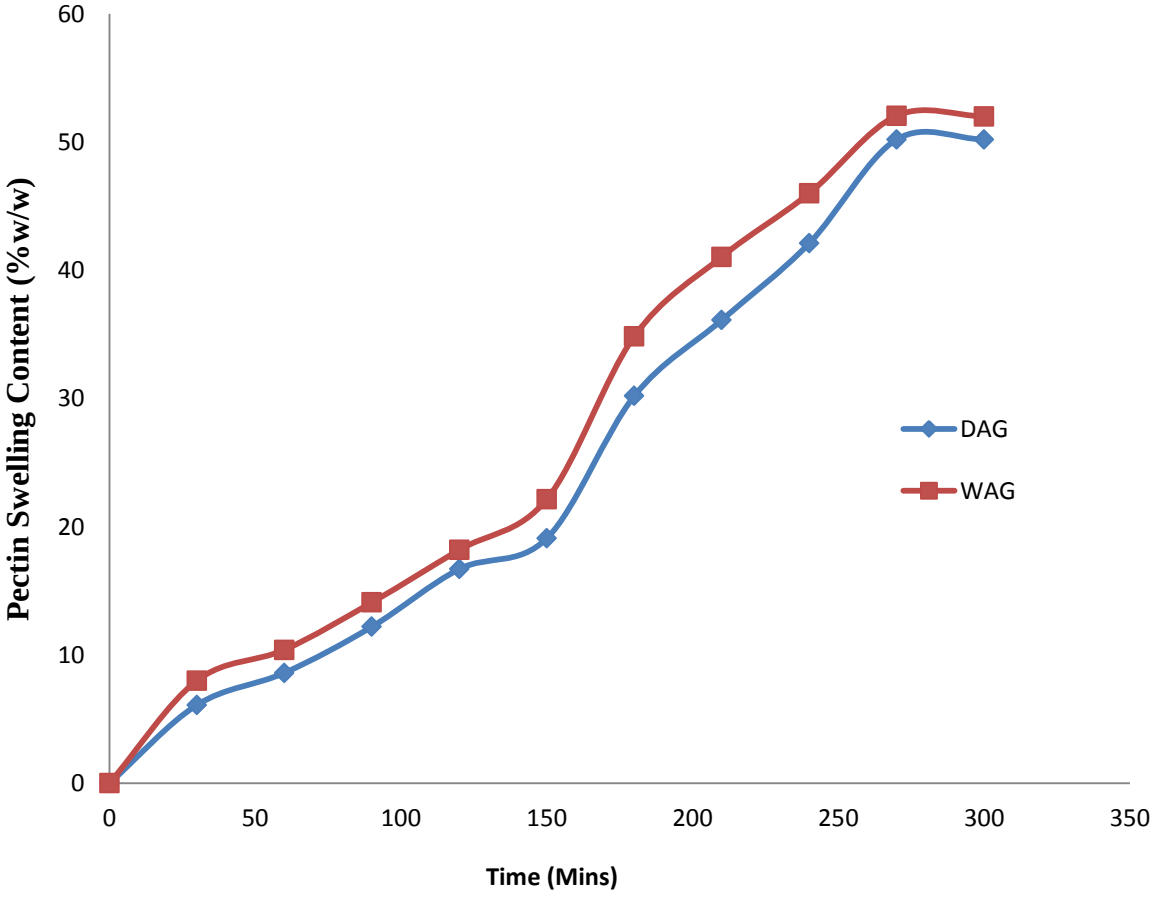

Figure 2. % Swelling ratio of Pectin Extracted at 85 °C as a function of time.

C. FT-IR Spectroscopy

The FT-IR spectra of extracted pectin from the fruits of *Azanza garckeana* was presented in Figure 4 and the assigned functional groups been given on tables listed in the appendices with the spectral of commercial apple pectin presented on Figure 3 for comparison.

Figure 4 overlayed as **A** and **B** gives the characteristic absorption peaks for DAG fruits extracted pectin which is presented as **A**. The broad band at 3415.19 cm^{-1} could due to sp C-H stretching vibration, 2935.40 cm^{-1} may probably due to sp^3 C-H, 2380.32 is likely to be C=C stretching vibration, the absorption band at 1639.02 through 1737.56 cm^{-1} may probably due to C=O stretching vibration mode, 1533.85 cm^{-1} is likely due to the presence of N-H bending motion of the amine, 1380.87 through 1460.29 cm^{-1} is due to sp^3 CH_2 of methylene bridge, 1059.13 through 1246.46 cm^{-1} is likely due to C-O and 769.51 cm^{-1} is due to sp^2 C-H bending vibrations.

From Figure 4, the spectra represented as **B**, it gives the characteristic absorption peaks for WAG, the broad band at 3418.18 cm^{-1} is due to O-H stretching vibration, 2936.69 cm^{-1} is due to sp^3 C-H, 2362.31 is due to C=C stretching vibration, 1630.49 through 1741.05 cm^{-1} is due to C=O stretching vibration, 1532.86 cm^{-1} is due to N-H bending motion of the amine, 1380.66 through 1439.91 cm^{-1} is due to sp^3 CH_2 of methylene bridge, 1058.44 through 1247.18 cm^{-1} due to C-O stretching vibration and 770.29 is due to sp^2 C-H bending vibrations.

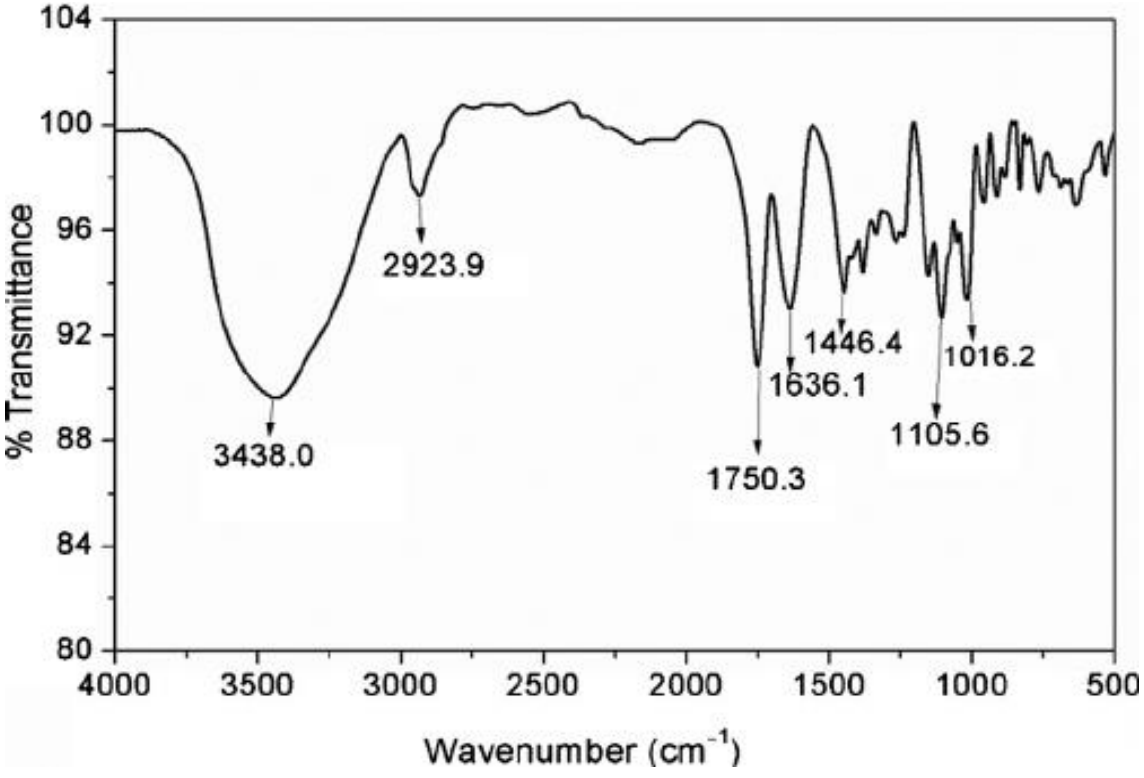

Figure 3. FTIR Spectra of Commercial Pectin Molecule Extracted from Apple (Adopted from Saviour *et al.*, 2015).

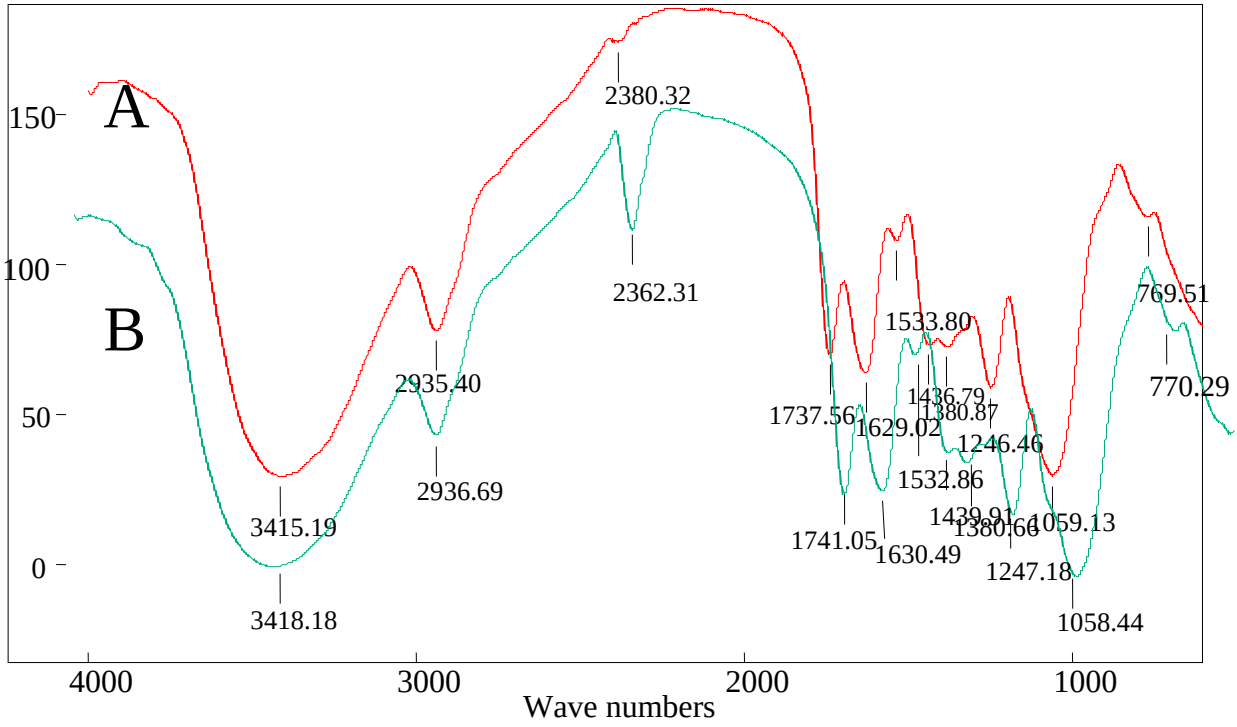

Figure 4. FTIR Spectra of pectin extracted from (A) DAG fruits and (B) WAG fruits

4. CONCLUSIONS

This research work showed that *Azanza garckeana* fruit can serve as a good alternative source of pectin for commercial purpose which is a potential raw material for food and Pharmaceutical industries. Considering the fact that a reasonable percentage yield was obtained under optimal conditions of temperature, extraction time and pH and these conditions are technologically attainable.

The physico-chemical characteristic properties were found to be within the commercially available products and this can be utilized for the formulation of natural hydrocolloid polymer instead of synthetic ones which the cross-linking agents needed to be removed before it application. Pectins and hydrocolloid have wide fields of application such as food industries, pharmaceutical industries and water treatment, since it has the potential of removing metals like lead and mercury. Therefore, this research work has unveiled an area of exploit for these plants to be used in other to enhanced economical development, in Nigeria and the world at large.

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