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Extraction and Characterization of Pectin from Orange Peels and Watermelon Rinds

AGU FRANCIS ANEZICHUKWU[1], EDEANI NKIRUKA JUSTINA[2], EJIKEME P.C.N[3]

[1,3]Department of Chemical Engineering, Enugu State University Science and Technology, Agbani Enugu State.

[2]Department of Chemical Engineering, University of Agriculture and Environmental Sciences, Umuagwo. P.M.B. 1038 Owerri, Imo State.

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Abstract: **Pectin was extracted from orange peels (OP) and watermelon rinds (WMR) using acid solvent extraction (ASE) and microwave assisted extraction (MAE) methods. Extraction of pectin from orange peels and watermelon rinds was affected by temperature, duration, acid concentration, and solute/solvent ratio for acid solvent extraction while effect of microwave power level, radiation period, acid concentration, and solute/solvent ratio on extraction of pectin for microwave assisted extraction was also investigated. The four acids used was nitric acid, sulphuric acid, orthophosphoric acid, and hydrochloric acid. Carbohydrate content of orange peels and watermelon rinds, were 69.61 and 55.75% respectively, which was turned into pectin. Results showed that microwave assisted extraction (MAE) method were more effective at extracting pectin to acid solvent extraction (ASE). The microwave aided extraction employing H_3PO_4 produced the maximum pectin yield of 0.2869% and 0.1693% for OP and WMR, respectively at the 15-minute extraction duration. However acid solvent extraction method, yield of pectin increased as the temperature rose until it reached a point at 80 °C with maximum yields of 0.2269% and 0.0993% pectin for OP and WMR respectively.**

Keywords: **Acid, acid solvent extraction, microwave, microwave assisted extraction, pectin, orange peels, watermelon rinds.**

1. INTRODUCTION

Fruit wastes are being produced in vast amounts due to the rise in the production of processed fruit products [1]. Orange peels and watermelon rinds are two examples of these wastes. Every year a sizable amount of trash orange byproducts such peels are produced [2]. Orange peel accumulates in large quantities during the production of orange juice and other orange-based goods, which harms the environment causing pollution and littering. FAO [3] estimated that the food sector generates 1.6 billion tons of food waste and byproducts after processing food.

Pectin is a natural thickener and water-soluble fiber that is frequently utilized in the creation of jams and jellies. It is prevalent in fruits and vegetables as well as in and around plant cell walls. Pectin is a chemically heterogeneous polymer that contains a linear chain of 1-4 linked galacturonic acid, some of the carboxyl acid groups of which are present as methyl esters, and areas of neutral sugars that are crucial to fruit ripening [4,5]. Pectin is primarily used as a thickener, stabilizer, and gelling agent in the pharmaceutical, food, chemical, and biomedical industries [6]. It is used to make a variety of products, including as eatable and biodegradable films, adhesives, paper alternatives, foams and plasticizers, surface modifiers for clinical devices, materials for biomedical implantation, and drug delivery [7]. Mohnen [8] claimed that pectin has a variety of beneficial effects on human flourishing, such as lowering cholesterol and serum glucose levels, preventing cancer, and enhancing the immune system.

Currently, citrus peel or apple pomace, both of which are leftovers from juice production facilities, are the main sources of commercial pectin. Pectin makes up 15–20% of the dry matter in apple pomace. Compared to apple peel, citrus peel contains 20–30% more pectin as a compound. Compounds are separated using the acid solvent extraction method according to their relative solubility. The strongest pectin extracting agents are acids because they make it easier to extract insoluble pectin that is strongly attached to the plant material's cell matrix and increase yields [9,10]. The microwave assisted extraction (MAE) approach uses microwave irradiation to dielectrically heat plant molecules. Due to the dipolar rotation of water caused by microwave radiation absorption, heat is produced inside plant tissues. Many researchers have recently looked into microwave assisted extraction, and they have discovered that it can significantly improve the yield and quality of extracted pectin [11]. Pectin however, is a good raw material for jam production. Pectin extraction is a multi-stage physical-chemical process in which pectin macromolecules are removed from plant tissue, hydrolyzed, and then solubilized. Various extraction parameters have a significant impact on the quality or yield of recovered pectin [12].

Previous works studied the extraction of pectin from orange peels and its physical and chemical characteristic using the technique of water bathing or drying, followed by acid extraction[13]. Pinheiro et al [14] studied also optimized the extraction of high ester pectin from passion fruit peel using response surface method. Jafari et al. [15] investigated pectin from carrot-pomace, optimization of extraction and physicochemical properties. Chan and Choo[16] studied also effect of extraction conditions on the yield and chemical properties of pectin from cocoa husks. Agu et al (17) studied optimization of process parameters for yellow dextrin production.

The aim of this project is to extract pectin from orange peels and watermelon rinds, using acid solvent extraction (ASE) and microwave assisted extraction (MAE) methods and investigate the effect of process factors on pectin yield.

2. MATERIALS AND METHODS

Orange and watermelon were bought at the neighborhood market in Enugu, Nigeria's Ogbete Main Market, as fruits. The oranges were rinsed multiple times with distilled water after being washed several times with tap water. By neutralizing the bacteria and enzymes that could lead to pectin breakdown, the pretreatment aims to strengthen the raw material's stability. To determine the weight percentage of the complete peels to be used, the peels of the cleaned oranges were removed and weighed in an analytical balance. The orange peels were first diced with a knife, dried at 60 °C for 24 hours in a dryer (NSW, India), and then ground into powder using a home mixer grinder. The water melon fruits, on the other hand, were washed to remove dirt and salt particles. The flesh, seeds, and rind of the watermelon fruits were carefully separated from one other. The rinds were gathered and allowed to dry for two hours in a hot air oven at a temperature of 80°C. The cleaned watermelon rinds were then powdered and kept in the freezer until they were needed for the pectin extraction process.

2.1 Proximate Analysis

2.1.1 Moisture content determination

3g sample of each substrate was weighed into a dry, clean, known-weight petri plate. The sample was then placed in a hot air oven that had been preheated to 100°C, where it was allowed to dry for two hours. The petri dish was then moved from the oven to working desiccators and allowed to cool for three hours. Following the procedure, the final weight was recorded and the moisture content was calculated gravimetrically [18];

$$\%\text{Moisture content} = \frac{W - W_1}{W} \times \frac{100}{1} \qquad (1)$$

W = Weight of the fresh sample, W_1 = Weight of the dried sample

2.1.2 Ash content determination

3g of sample (W_1) was weighed into the crucible and cooked at 600°C for three hours in a muffle furnace. It was weighed after cooling in the desiccator (W_2).

$$\%\text{Ash} = \frac{W_2 - W_1}{W} \times \frac{100}{1} \qquad (2)$$

Where

W_2 = Overall dish and ash weight, W_1 = Dish Weight, W = Sample Weight

2.1.3 Protein content determination

According to the AOAC method, the semi-micro kjeldahl distillation was used to determine the protein concentration [17]. 1g of defatted orange peel powder was dissolved in 5ml of concentrated H_2SO_4 and 1g of catalyst. Hydrochloric acid was titrated into the distillate until the blue color vanished.

The following formula was used to determine the protein content.

$$\%N = \frac{(S-B)\times N\times 14.007\times \text{Volume made}(ML)}{\text{Weight of sample}(g)\times \text{Volume taken}(ML)} \times \frac{100}{1} \quad (3)$$

S is the volume of HCl needed to titrate the sample.

B is the amount of HCl needed for the blank titration.

Nitrogen (%) = Protein (%) + N = Normality of HCl 6.25

The protein calculation factor is 6.25.

2.1.4 Carbohydrate content

The formula used to determine the amount of carbohydrates was:

$$\text{Carbohydrate} = 100 - (\text{moisture} + \text{Fat} + \text{Protein} + \text{Ash})\% \quad (4)$$

2.1.5 Fat content

Fat content was determined using the Pearson method [18]. The extraction flask was weighed (A). 1g of the grounded food sample (B) was accurately weighed and transferred into a rolled filter paper and then placed inside the extraction thimble. The thimble was placed inside the extractor. 90ml of petroleum ether as solvent was poured inside the extraction flask (C). The condenser and the flask were connected to the extractor. The whole unit was place on a heating mantle for 4hours after which the petroleum ether was recovered. The oil collected in the flask was dried in an oven at 105°C. It was then weighed and the percentage fat calculated as shown below

$$\%Fat = \frac{C - A}{B} \times \frac{100}{1} \quad (5)$$

Where, C = weight of flask +oil. A = weight of empty flask. B = weight of original sample.

2.2 Extraction of Pectin from Orange Peels and Watermelon Rinds

Acid solvent extraction (ASE) and microwave-assisted extraction (MAE) methods were utilized to extract pectin from orange peels and watermelon rinds.

2.2.1 Acid Solvent Extraction of Pectin

5g of orange peel powder and watermelon rinds powder was weighed and transferred into beakers respectively. 100ml of H_2SO_4 was added and the mixture was then heated in a hot water bath to 60°C, 70°C, 80°C, and 90°C for 5, 10, 15, and 20 minutes, respectively. Then, cheese cloth was used to filter the solution. After cooling to room temperature, the pectin extract obtained from the various extraction methods was precipitated with 96% ethanol and left for an hour at room temperature to complete pectin precipitation. Re-filtration was carried out to separate the coagulated pectin, and the soluble contaminants were then removed by washing with 75% ethanol and 100% ethanol. The coagulated pectin was then stored in the oven for 24 hours at 50°C to dry.

2.2.2 Microwave-assisted Extraction of Pectin

At a solid/solvent ratio of 1:50 g/ml, a known weight of the substrate(orange peel and watermelon rinds powder) was introduced to a known quantities of the acid (1 – 5M). The combination was cooked using various microwave powers (W) and irradiation times in a microwave oven (Scanfrost: SFMW020CM) (5 – 25 mins). It was cooled after the extraction, and then it was pressed in a cheese cloth bag. When the alcohol to juice ratio was 2:1 (V/V), the pectin was precipitated. To enable pectin to float, the solvent and precipitate mixture was agitated for 10 minutes and then permitted to sit for 1

International Journal of Novel Research in Interdisciplinary Studies
Vol. 13, Issue 2, pp: (24-35), Month: March – April 2026, Available at: www.noveltyjournals.com

hour. The pectin ingredient is still on the surface of the alcohol/water mixture at this phase, making removal easy. To remove too much acid and pressure, the floating pectin was strained through cheesecloth and washed with alcohol. In a desiccator, the pressed pectin was cooled to a constant weight at 55ºC, dried to that weight, and the % yield was computed.

$$\text{Yield\%} = \frac{\text{Final weight of pectin}}{\text{initial weight}} \times \frac{100}{1} \quad (6)$$

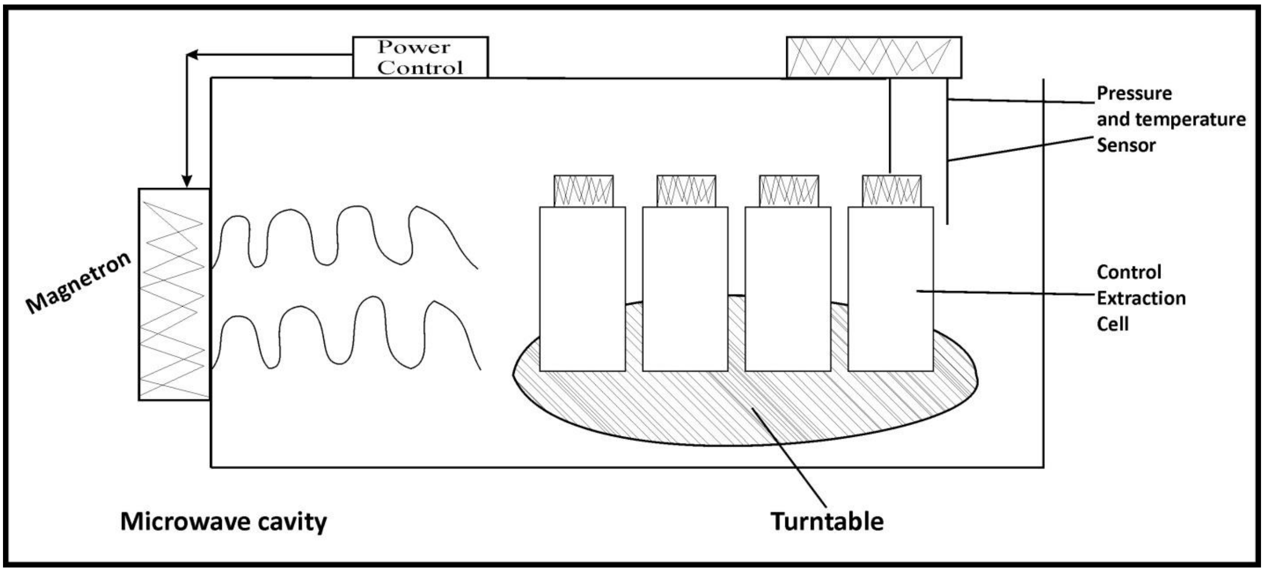

Fig.2.1: The working of the microwave assisted extraction

2.3 Characterization of the Extracted Pectin

Fourier Transform Infrared (FTIR) spectroscopy was utilized to confirm the chemical composition of the extracted material and surface functional groups. The FTIR spectra were acquired at the absorbance mode in the range of 500 - 4000cm-1 with an FTIR vertex 70V Bruker instrument. The spectra were scanned at a wavelength of 500 - 4000cm^{-1} to produce the spectra lines (Billerica, MA, USA). Every measurement represents the average of numerous subsequent acquisitions. For comparison, commercial pectin was investigated.

2.3.1 Determination of Equivalent Weight

1g of pectin sample and 5 ml of 96% ethanol were measured into 250 ml conical flask. Six drops of phenol red indicator were then added after adding another 1.2g of sodium chloride and 100ml of distilled water. The samples of pectin were quickly mixed to dissolve. The addition of 0.1N NaOH was used to carry out the titration process. The endpoint was signified by the appearance of the color purple. Consequently, the equation used to determine the equivalent weight.

$$\text{Equivalent weight} = \frac{\text{weight of sample}}{\text{vol.of base} \times \text{normality of base}} \times \frac{100}{1} \quad (7)$$

2.3.2 Determination of the Solubility of the Extracted Pectin

With 50ml of water and 10ml of 95% ethanol, 0.25kg of pectin was dissolved. Any substance that wasn't soluble in the solution was filtered out after the combination was shaken ferociously.

$$Solubility = \frac{initial\ weight\ of\ pectin - undissolved\ weight}{initial\ weight} \times \frac{100}{1} \quad (8)$$

To determine whether there was any insoluble material present, the suspension was then heated at 85 to 95 degrees Celsius for 15 minutes. The solubility in hot water was then estimated.

2.3.3 Determination of the Precipitation of the Pectin

In this experiment, alcohol was added to a pectin solution, and the development of a stingy, gelatinous deposit served as a sign of a successful reaction.

2.3.4 Effect of Process factors on Pectin Extraction using Acid solvent extraction Method

The extraction of pectin from orange peels and watermelon rinds is affected by temperature, duration, acid concentration, and solute/solvent ratio. The four acids namely Nitric acid, Sulphuric acid, Orthophosphoric acid, and Hydrochloric acid was used for extraction.

Effect of temperature (60, 70, 80, and 90 degrees Celsuis) was examined at various levels of each, while other variables such as time, 0.5M acid concentration, and the solute to solvent ratio,1g:50mls were held constant at 1 hour, The amount of pectin extracted was calculated at the conclusion.

At various time intervals of 20, 40, 60, and 80 minutes, the impact of time on pectin extraction was investigated. Process variables were held constant at 80°C, 0.5M acid concentration, and a 1g:50mls solute/solvent ratio. The amount of pectin removed was measured at the conclusion of the extraction.

At different concentrations of 0.3, 0.4, 0.5, and 0.6M, the impact of acid concentration on pectin extraction from the substrates was investigated. Process variables were held constant at 80°C, 0.5M acid concentration, and a 1g:50mls solute/solvent ratio.

At constant values for other variables, the effect of the solute-solvent ratio was examined at varied ratios of 1 g/30 ml, 1 g/40 ml, 1 g/50 ml, and 1 g/60 ml. The conditions were maintained at 80°C, 1 hour, and 0.5M acid concentration. The amount of pectin extracted was calculated.

2.3.5 Effect of Process Factors on Pectin yield using Microwave Assisted Method

Effect of microwave power level, radiation period, acid concentration, and solute/solvent ratio on the extraction of pectin from orange and watermelon rinds was investigated The four acids namely nitric acid, sulphuric acid, orthophosphoric acid, and hydrochloric acid was used for extraction.

Effect of microwave power level was examined at various values of.18%, 32%, 58%, and 100%. while other parameters, such as acid concentration of 0.5M and solute/solvent ratio of 1g:50ml, were held constant for a period of 10 minutes. The amount of pectin extracted was calculated at the conclusion.

At various radiation time intervals of 5, 10, 15, and 20 minutes, the impact of radiation time on pectin extraction was examined. Other process variables were held constant at a 58% power level, a 0.5M acid concentration, and a 1g:50mls solute/solvent ratio. The amount of pectin removed was measured at the conclusion of the extraction.

At different concentrations of 0.3, 0.4, 0.5, and 0.6 M, the impact of acid concentration on pectin extraction from the substrates was investigated. Other process variables were held constant at a 58% power level, a 10 minute radiation cycle, and a 1g:50mls solute/solvent ratio. The amount of pectin removed was measured at the conclusion of the extraction.

At constant values for other variables, the effect of the solute-solvent ratio was examined at varied ratios of 1 g/30 ml, 1 g/40 ml, 1 g/50 ml, and 1 g/60 ml. With a radiation time of 10 minutes and an acid concentration of 0.5 M, the power level was kept constant at 58%. The amount of pectin extracted was calculated at the conclusion.

3. RESULTS AND DISCUSSION

3.1 Physicochemical properties of orange peels and watermelon rinds

Table 3.1 showed the findings of the physicochemical examination of orange peels (OP) and watermelon rinds (WMR).

Table 3.1: Result of the proximate analysis of the Orange peel and watermelon rind

Parameters (%)	Dry OP	Dry WMR
Moisture	8.13	7.90
Fat	3.71	2.57

International Journal of Novel Research in Interdisciplinary Studies
Vol. 13, Issue 2, pp: (24-35), Month: March – April 2026, Available at: www.noveltyjournals.com

Protein	1.05	0.35
Ash	7.24	16.31
Fibre	10.27	17.12
Carbohydrate	69.61	55.75

The outcome verified that orange peels and watermelon rinds include moisture, fat, fiber, protein, carbohydrate, and ash content. The two substrates' moisture contents, which assessed the amount of water they contained, were examined. The results showed that the moisture contents of orange and watermelon rinds, respectively, are 8.13% and 7.90%. Since the samples were dried to lower their moisture content. The obtained result, however, was quite comparable to other publications{19.20], which showed that the moisture content of orange peels was respectively 9.2% and 10.01%. Ash content reveals the amount of minerals in diet [21]. For OP and WMR, the ash content result was determined to be 7.24% and 16.31%, respectively.

According to the results table, the crude protein content for OP and WMR is 1.05% and 0.35%, respectively. Adewole et al.[20] reported a higher protein content of OP with a value of 16.51+0.40% in their research effort. Sulekha and Gade [19]reported a protein content range of 12%–13% on a dry weight basis (DW) for OP. Crude fat controls a product's free fatty lipid content (also known as neutral fats and triglycerides). The results for OP and WMR's fat content were 3.71% and 2.57%, respectively. In this investigation, the fat value of OP was slightly greater than the finding (2.78+0.01) obtained by Adewole [20]. Crude fibre content for OP sample gave greater fibre content (12.47+ 0.54) but a lower value than the WMR experimented with in the current study (17.12%). The fibre value of 10.27% for OP in this research is in contradiction to the fiber content of OP sample reported by Adewole et al.[20]. For OP and WMR, the carbohydrate content was discovered to be 69.61% and 55.75%, respectively. These findings were equivalent to the difference in OP's carbohydrate content reported by Sulekha and Gade [19]. The amount of carbohydrates in OP was comparable to the value that Adewole et al [20] reported.

The high carbohydrate content of OP and WMR, respectively, as shown in Table 3.1, is therefore a good indication that the above mentioned substrates can readily be used for extracting pectin for jam manufacture. Pectin is a carbohydrate that is present in and around the cell walls of plants.

3.2 The effect of process parameters on pectin yield for microwave assisted extraction method

3.2.1 Effect of time for pectin yield

The results of effect of process parameters for microwave assisted extraction method was shown in Fig 3.1 to 3.4. The graphs showed the effects of time, solute/solvent ratio, power level, and acid concentration on the yield of pectin from OP and WMR.

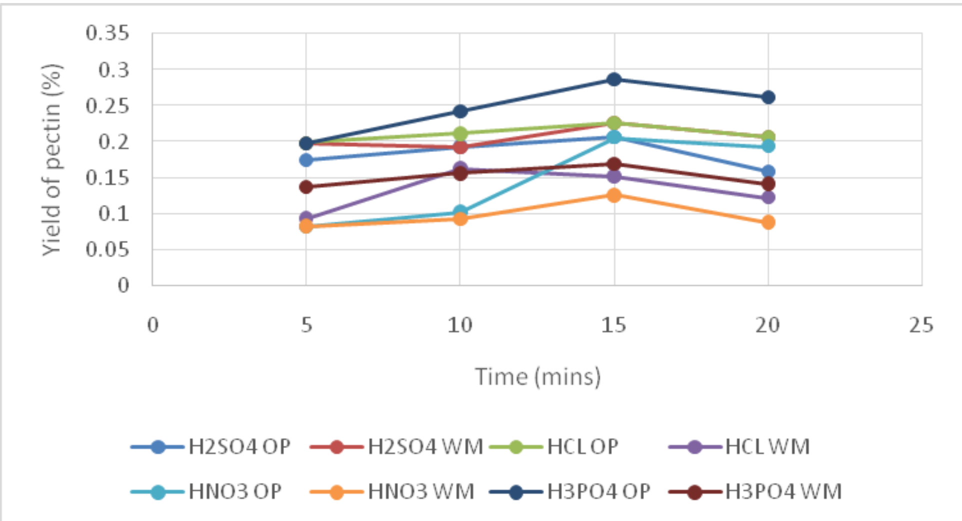

Fig 3.1: Effect of time on microwave assisted extraction method for pectin yield

The microwave technique of extraction employing H_3PO_4 produced the maximum pectin yield (0.2869% and 0.1693% for OP and WMR, respectively) at the 15-minute extraction duration. Additionally, pectin yield from OP and WMR employing H_2SO_4, HCl, HNO_3 and H_3PO_4 peaked at about 15 minutes as compared to the other extraction durations. This work was consistent with other findings [22.23,24,25]. The amount of protopectin naturally present in cells takes time to dissolve and enter solution, so the longer the exposure, the larger the extraction yield; this relationship between extraction yield and irradiation period is positive linear [26]. However, the extraction yield only rose with time up to 15 minutes, after which it dropped due to the heat breakdown of the extracted pectin. To avoid acid breaking the glycoside and ester linkage, which could influence the molecular weight of pectin and its gelling properties, the addition of acid to the substrate and ethanol precipitation should be carried out in a brief period of time during extraction [27].

3.2.2. Effect of Acid Concentration and Type for pectin yield

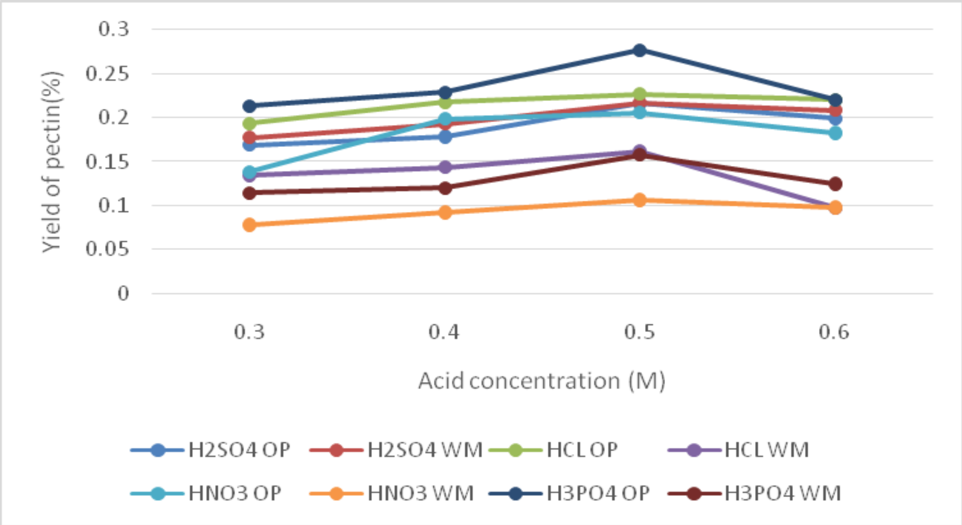

Fig 3.2: Effect of acid concentration on microwave assisted extraction method for pectin yield

The pectin yield is significantly influenced by various types of acid. In this investigation, the application of H_3PO_4 acid produced the greatest pectin yields for OP and WMR, respectively, of 0.27691% and 0.1573%. According to the experimental results, the pectin yield from OP and WMR increased with an increase in acid concentration from 0.3M to 0.5M, and then dropped with an increase in acid concentration from 0.6M for all four acids employed. This is consistent with other findings,[23] according to which pectin extraction increases with acid concentration up to 0.5 M of sulphuric acid before starting to decline.

3.2.3 Effect of Solute/Solvent ratio for pectin yield

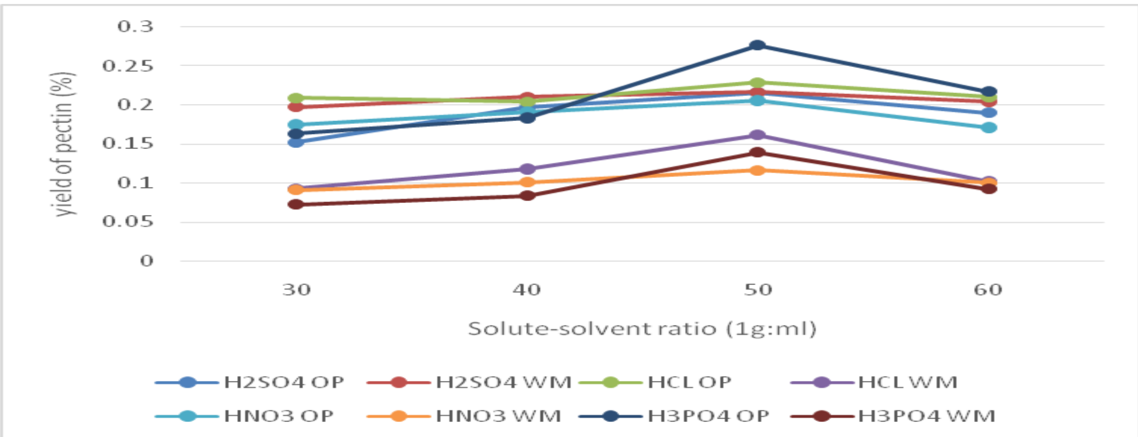

Fig 3.3: Effect of solute-solvent ratio on microwave assisted extraction method for pectin yield.

International Journal of Novel Research in Interdisciplinary Studies
Vol. 13, Issue 2, pp: (24-35), Month: March – April 2026, Available at: www.noveltyjournals.com

These results showed the impact of varying the solute/solvent ratio (1g: 30ml, 1g: 40ml, 1g: 50ml, and 1g: 60ml). According to Fig. 3.3, the best pectin yield from OP and WMR was 0.2769 and 0.1393 percent, respectively, during an extraction duration of 10 minutes using H_3PO_4 acid and a solute/solvent ratio of 1g: 50ml. The extraction yield of pectin rises with an increased solid-liquid ratio up to 1: 8, at which point the yield begins to decline, according to other fingings [23]. A higher liquid-solid ratio results in a higher pectin production. Because the liquid's volume is larger, the larger solid-liquid ratio affects the extraction contact area. Higher extraction efficiency is a result of a larger extraction contact area.

3.2.4 Effect of Power level for pectin yield

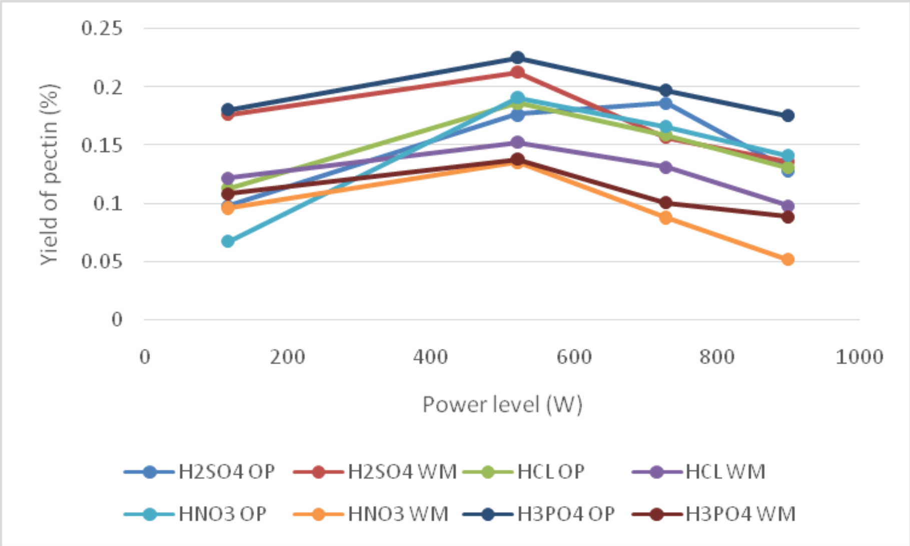

Fig 3.4: Effect of power level on microwave assisted extraction method for pectin yield

The pectin yield values grew as the microwave power increased, and the greatest pectin yield was quickly discovered at microwave of 522W (Medium; 58%). Isobel et al. [28] showed that substantial quantities of pectin were obtained when PPP were extracted under medium power level, provide support for the findings. The obtained data also showed that pectin yield decreased as power level was raised over the Medium level. Increases in power level will therefore often increase the yield of the extraction and shorten the extraction time [29].

3.3. Effect of process parameters for acid solvent extraction method

The results of effect of process parameters for ASE method was shown in Fig 3.5 to 3.8.

3.3.1 Effect of Temperature

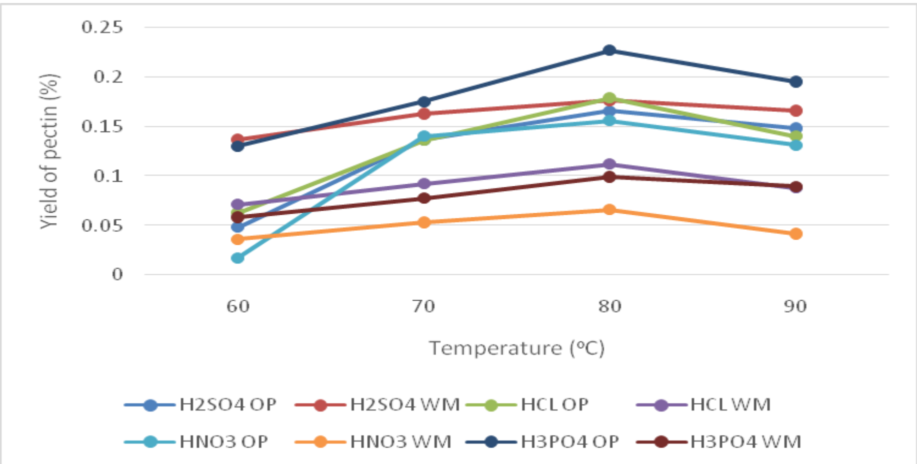

Fig 3.5: Effect of temperature on acid solvent extraction method for pectin yield

International Journal of Novel Research in Interdisciplinary Studies
Vol. 13, Issue 2, pp: (24-35), Month: March – April 2026, Available at: www.noveltyjournals.com

Figure 3.5 demonstrates that when the temperature rose, the pectin yield first climbed before decreasing. The yield of pectin increased as the temperature rose until it reached a point at 80 °C, when the maximum yields of 0.2269% and 0.0993% pectin, respectively, were obtained from orange peels and watermelon rinds, using the H_3PO_4 solvent. Pectin yield with H_2SO_4, HCl, HNO_3, and H_3PO_4 achieved its maximum at about 80°C since this temperature is favorable for pectin hydrolysis. This is consistent with other finding[30] which identified the temperature range of 80 to 83ºC as the ideal temperature for pectin hydrolysis. Other studies also noted that warmth increases the extraction yield[31].

3.3.2 Effect of Acid Concentration

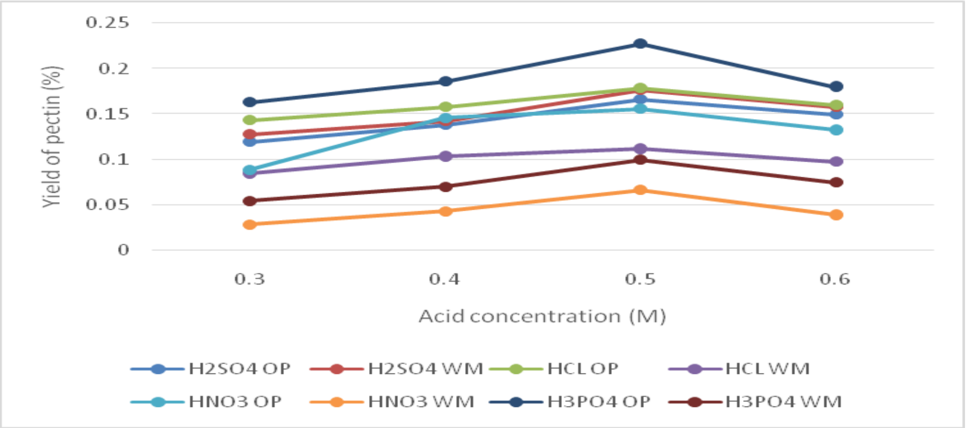

Fig 3.6: Effect of acid concentration on acid solvent extraction method for pectin yield

According to the experimental results, the pectin yield from OP and WMR increased with an increase in acid concentration from 0.3M to 0.5M, and then dropped with an increase in acid concentration from 0.6M for all four acids employed. This is consistent with Hartati & Subekti's report [20] that pectin extraction extraction increases with increasing acid concentration up to 0.5 M of sulphuric acid and then starts to decline after that. In this investigation, the application of H_3PO_4 acid produced the greatest pectin yields for OP and WMR, respectively, of 0.2264% and 0.0993%. However, the HCl acid has better yield than H_2SO_4 acid and it's better than HNO_3.

3.3.3 Effect of time

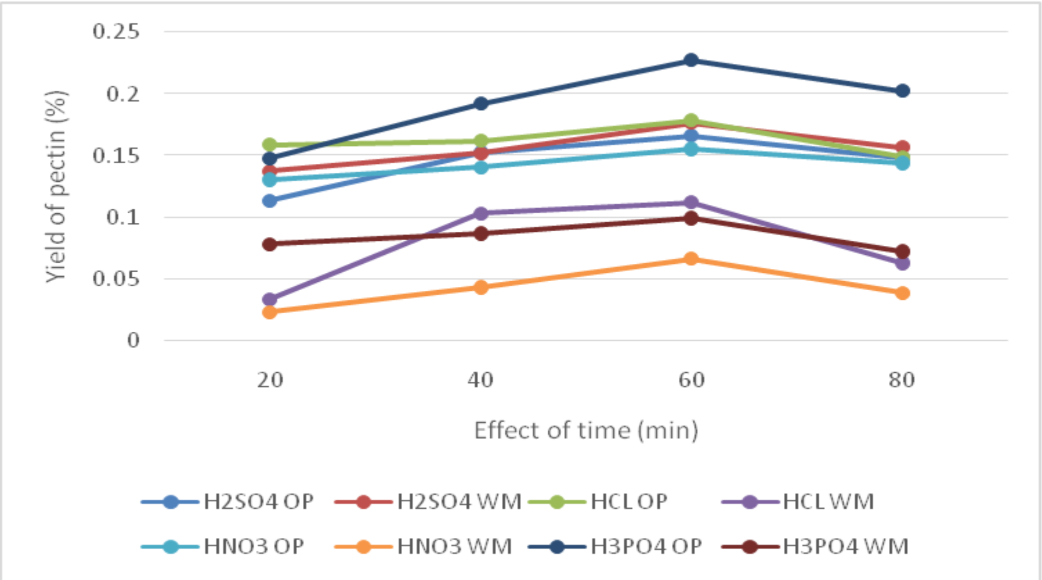

Fig 3.7: Effect of time on acid solvent extraction method for pectin yield

International Journal of Novel Research in Interdisciplinary Studies
Vol. 13, Issue 2, pp: (24-35), Month: March – April 2026, Available at: www.noveltyjournals.com

Figure 3.7 demonstrated that the pectin product grew initially before declining after reaching its high. It was shown that pectin extraction yield rose as extraction duration increased. The H_3PO_4-based acid solvent extraction method produced the maximum pectin yield during the 60-minute extraction time (0.2269 and 0.0993% for OP and WMR, respectively). In comparison to the microwave aided extraction approach, the acid solvent extraction method required more time to reach the best pectin yield. Additionally, pectin yield from OP and WMR employing H_2SO_4, HCL, HNO_3 and H_3PO_4 peaked at about 60 minutes compared to the other extraction durations. This was consistent with [26].

3.3.4 Effect of solute-solvent ratio

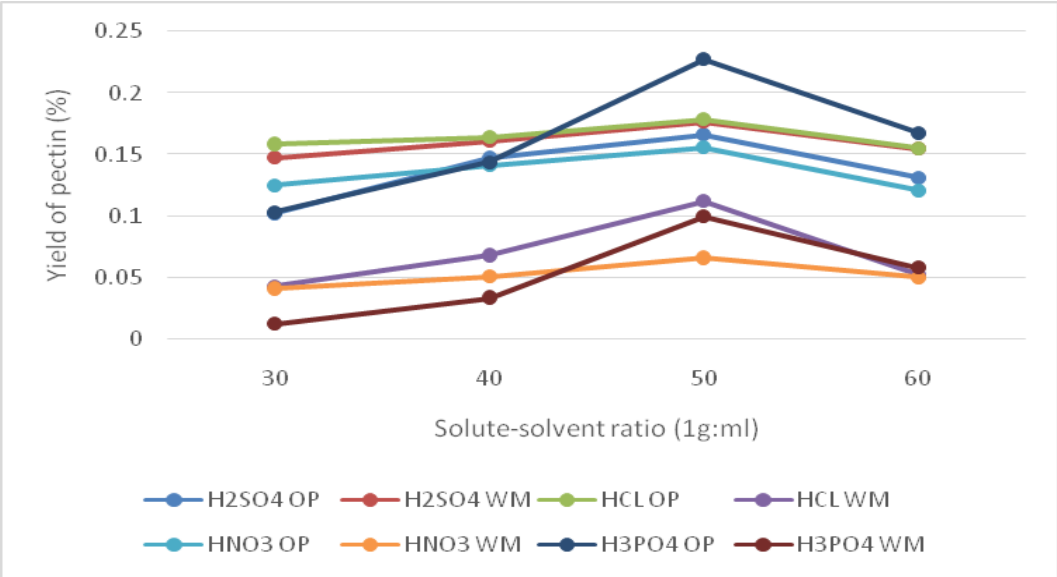

Fig 3.8: Effect of solute-solvent ratio on acid solvent extraction method for pectin yield at 80^oC, 1hr and 0.5M

According to the acid extraction method, the best pectin yields were 0.2269% and 0.0993% for OP and WMR, respectively, during the extraction period of 1 hour at 80^oC using H_3PO_4 acid, as shown in Fig. 3.8.On the other hand, as compared to the microwave-assisted extraction method, the best pectin yield from OP and WMR was 0.2769 and 0.1393%, respectively, on the solute/solvent ratio of 1g: 50ml at the extraction period of 10 minutes using H_3PO_4 acid. The extraction yield of pectin rises with an increased solid-liquid ratio up to 1: 8 before it starts to decline [23]. A higher liquid-solid ratio results in a higher pectin production. Because the liquid's volume is larger, the larger solid-liquid ratio affects the extraction contact area. Higher extraction efficiency is a result of a larger extraction contact area.

4. CONCLUSION

The findings of this study indicated that high carbohydrate content of 69.61% and 55.75% for orange peels and watermelon rinds respectively showed that they are good sources of pectin. The output of pectin from orange peels was higher than the yield from watermelon rinds. The microwave assisted extraction employed H_3PO_4, produced maximum pectin yield of 0.2869% and 0.1693% for orange peels (OP) and watermelon rinds (WMR) respectively at the 15-minute extraction duration. The application of H_3PO_4 acid produced the greatest pectin yields for OP and WMR. According to the experimental results, the pectin yield from OP and WMR increased with an increase in acid concentration from 0.3M to 0.5M, and then dropped with an increase in acid concentration from 0.6M for all four acids employed. There is a relationship between extraction yield and acid solution concentration: the greater the acid concentration, the higher the extraction yield. The pectin yield from OP and WMR during an extraction duration of 10 minutes using H_3PO_4 acid and a solute/solvent ratio of 1g: 50ml was 0.2769 and 0.1393 percent, respectively. A higher liquid-solid ratio results in a higher pectin production. Because the liquid's volume is larger, the larger solid-liquid ratio affects the extraction contact area. Higher extraction efficiency is a result of a larger extraction contact area. High pectin yield was discovered at microwave of 522W (Medium; 58%). microwave power increases the skin tissues and exposes them to it by loosening the cell wall matrix and destroying the parenchyma cells. This may result in a more effective extraction process between the extracting solvent and the sample material. As a result, the extracting solvent will penetrate more deeply, increasing the extraction yield of pectin For acid solvent extraction method, yield of pectin increased as the temperature rose until it reached a point at 80 °C with maximum yields of 0.2269% and 0.0993% pectin, for OP and WMR respectively. The H_3PO_4-based acid solvent extraction method produced the maximum pectin yield during the 60-minute extraction time. In comparison to the microwave aided extraction approach, the acid solvent extraction method required more time to reach the best pectin yield.

REFERENCES

[1] ShwetaSuri, AnupamaSingh , PrabhatK. Nema, (2022).Current applications of citrus Fruit processing waste: A scientific outlook. Applied Food Research 2, 100050 https://doi.org/10.1016/j.afres.2022.100050

[2] Manthey .A and K. Grohmann. (2001) Phenols in citrus peel byproducts: concentrations of hydroxycinnamates and polymethoxylated flavones in citrus peel molasses. *Journal of Agric. Food Chem*. 49 pp. 3268

[3] FAO. (2013). Food wastage foodprint: Impact on natural resources. Summary report Ferreira, S, Bruns, R., Ferreira,, H. , Malos, G., David, J., Brandao, G. , Silva, E. , Portugal.

[4] Kanmani P, Dhivya E, Aravind J and Kumaresan K, (2014).Extractionand Analysis of Pectin from Citrus Peels: Augmenting the Yield from Citrus limon Using Statistical Experimental Design. *Iranica Journal of Energy & Environment*.5 (3).pp. 303-312. DOI:10.5829/idosi.ijee.2014.05.03.10

[5] Sundari N,(2015) "Extracation of Pectin from Waste Peels: A Review. *Research Journal of Pharmaceutical, Biological and Chemical Sciences.* 6(2), pp. 1842 – 1848.

[6] Sathish S., Narendrakumar G, Sundari N, MohindraAmarnath, Philip J Thayyil (2016).Extraction of Pectin from used Citrus Limon and optimization of process parameters using Response Surface Methodology. *Research J. Pharm.and Tech. 9(12)*

[7] Roy, M., Alam, M., Saied, A., Das, B., Mia, M, Rahman, M., Eun, J., & Ahmed, M, (2017). Extraction and Characterization of Pectin from Pomelo peel and its impact on nutritional properties of Carrot Jam during Storage.

[8] Mohnen, D. (2018). Pectin Structure and Biosynthesis. *Current Opinion in Plant Biology*, 11(3), 266-277.

[9] Maria B, Gama V, Silvab C, Silvab L.M, Abudc A, (2015). Extraction and characterization of pectin from citric waste. *Chemical Engineering Transaction* 44: 259-264

[10] Sandarani MDJC (2017). A Review: Different Extraction Techniques of Pectin. *J Pharmacogn Nat Prod* 3: 143, doi:10.4172/2472-0992.1000143

[11] Routray W, Orsat V, (2012). Microwave-assisted extraction of flavonoids: A review, *Food and Bioprocess Technology* 5: 409-424.

[12] Davi, W.E., Shukla, R.N., Abraham, A., Japula, S. and Kaushik, U. (2014). Optimised extraction conditions and characterisation of pectin from orange peel. *International Journal of Research in Engineering & Advanced Technology*, 2(2), 2320-8791.

[13] Enkuahone A. A.(2018) Extraction of Pectin from orange peels and characterizing, its physical and chemical properties. *American Journal of Applied Chemistry*, Vol. 6 No. 2. Pp. 51-56, doi:10.11648/j.ajac.20180602.13

[14] Pinheiro, E.R , Silva, I.M.D.A., Gonzaga,L,V., Amante, E.R., Teofilo, R.F., Ferreira, M.M.C. and Ambone, R,D.M,C.(2008) Optimization of extraction of high-ester pectin from passion fruit peel with citric acid by using response surface methodology. *Bioresource Technology*., 99; 5561-5566.

[15] Jafari, F., Khodaijan, F. , Kiani, H., & Hosswini, S.(2016). Pectin from Carrot-Pomace: Optimization of extraction and physicochemical properties. Carbohydrate Polymers. 157(5), 1315 – 1322

[16] Chan, S. and Choo, W., (2013), Effect of extraction conditions on the yield and chemical properties of pectin from cocoa husks. Food chemistry, 141(4), 3752-3758.

[17] Agu, F.A., Edeani, N.J., and Nwaeze, C.M. (2025). Optimization of Process Parameters for Yellow Dextrin Production. International Journal of Novel Research in Engineering and Science. 12(1)pp20-29

[18] Edeani, N. J., Eze, K.A. and Chukwu, M.M.(2023). Thermodynamic properties and Drying kinetics of potato slices using hot air drying. International Journal of Advanced Science and Engineering. 10(1) pp 3224-3236.

[19] Anil B, Kate Debandya Mohapatra, Nachuket Kotwaliwale, Saroj kumar Giri, B. P. Sawant (2019), Characterization of pectin extraction from orange powder using microwave-assisted and acid extraction methods. *National Academy of Agricultural sciences*, pp, 241-248.

[20] Sulekha G. and J. Gade (2018). Orange Peel: A Potential Source of Phytochemical Compounds.*International Journal of ChemTech Research, 2018,11(02): 240-243.* doi http://dx.doi.org/10.20902/IJCTR.2018.110229

[21] Adewole E, Adewumi D.F., Jonathan J and Fadaka (2014). Phytochemical Constituents and Proximate Analysis of Orange Peel (*citrus Fruit*), Journal of Advanced Botany and Zoology Volume 1/ Issue 3 ISSN: 2348 – 7313

[22] Ishiwu, C. N., Ukpong, E. S. and Akah, H. F. (2020). Production and optimization of physical and chemical properties of cookies from mixture of malted sorghum, whole wheat and tiger nut flours Randomized Trials. *American Journal of Food Science and Nutrition***2**(1): 47 – 60.

[23] Anuthida P. (2019), Optimisation of pectin extraction assisted by microwave from banana (*musasapientum*l.) fruit peels using response surface methodology. Carpathian Journal of Food Science and Technology,11(2), 127-140

[24] Hartati, I. and Subekti, E. (2015), Microwave assisted extraction of watermelon rinds pectin. International journal of Chemistry Technology Research, 8(11), 163-170.

[25] Khan, M., Bibi, N. and Zeb, A. (2015), Optimization of process conditions for pectin extraction from citrus peels. Science Technology and Development, 34(1), 9-15

[26] Yeoh, S., Shi, J. and Langrish, T.A.G. (2008).Comparison between different techniques for water based extraction of pectin from orange peels. Desalination, 218, 229-237

[27] Girma, E. and Worku, T., (2016), Extraction and characterisation of pectin from selected fruit peels waste. International journal of Scientific and Research publication, 6(2), 447-454

[28] Hamidon, N. H., and Zaidel, D.N.A (1017), Effect of extraction conditions on pectin yield extracted from sweet potato peels residues using hydrochloric acid. Chemical Engineering Transactions, 56, 979-984

[29] Isobel L. G. L., Tsietsie E. K., Mpho E. M. Afam I. O.J. (2021), Physicochemical properties of South African prickly pear fruit and peel: Extraction and characterisation of pectin from the peel. Open Agriculture; 6: 178–191, https://doi.org/10.1515/opag-2021-0216

[30] Marran, J.P., Sivakumar, V., Thirugnanasambandham, K., and Sridhar, R. (2014). Microwave assisted extraction of pectin from waste citrulluslanatus fruit rinds. Carbohydrate Polymers, 101, 786-791

[31] Rajibulkarim, M. Burhanuddin, M.D. Fahadjubayer (2014). Optimization of pectin isolation method from pineapple (*ananascomosus*l.) Waste *Carpathian Journal of Food Science and Technology, 6(2), 116-122*

[32] Bayar, N., Bouallegue, T., Achour, M., Bougatef, A., and Kammoun, R. (2017). Ultrasonic extraction of pectin from opuntiaficusindica cladodes after mucilage removal: optimization of experimental conditions and evaluation of chemical and functional properties. Food chemistry, 235, 275-282.