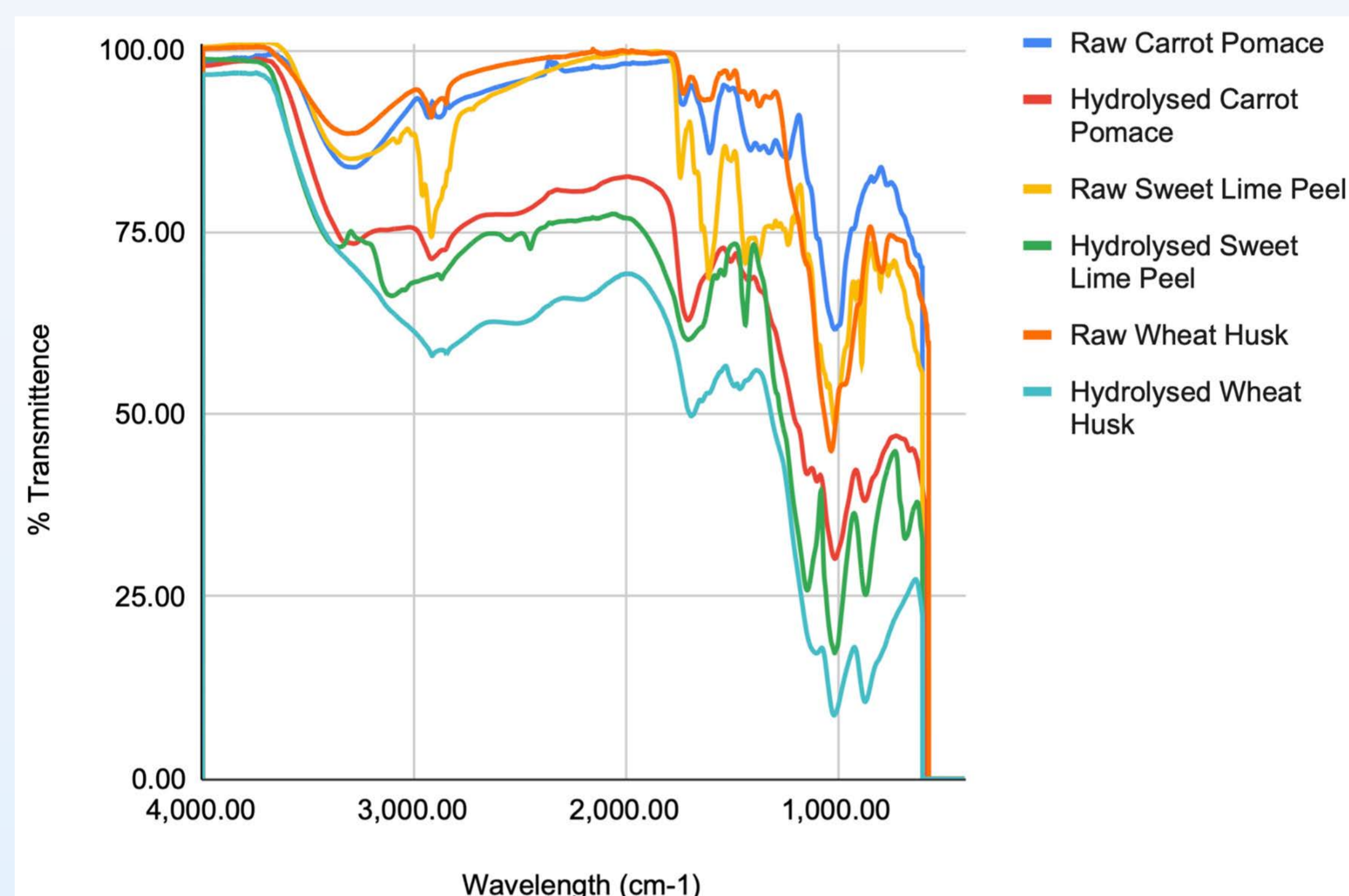


### Purpose & Methodology

The purpose of this study is to turn biowaste into valuable bio-based compounds for improving sustainability in the industry. For this project, the goal is to extract glucose from wheat husk, sweet lime peel and carrot pomace biowastes. The glucose extracted is aimed to be used as raw material in fiber production by KordSa. Methodology of the project includes performing acid hydrolysis to extract glucose and to perform FTIR, XRD and TG analysis as qualitative analysis.

### FTIR Analysis Before & After Hydrolysis

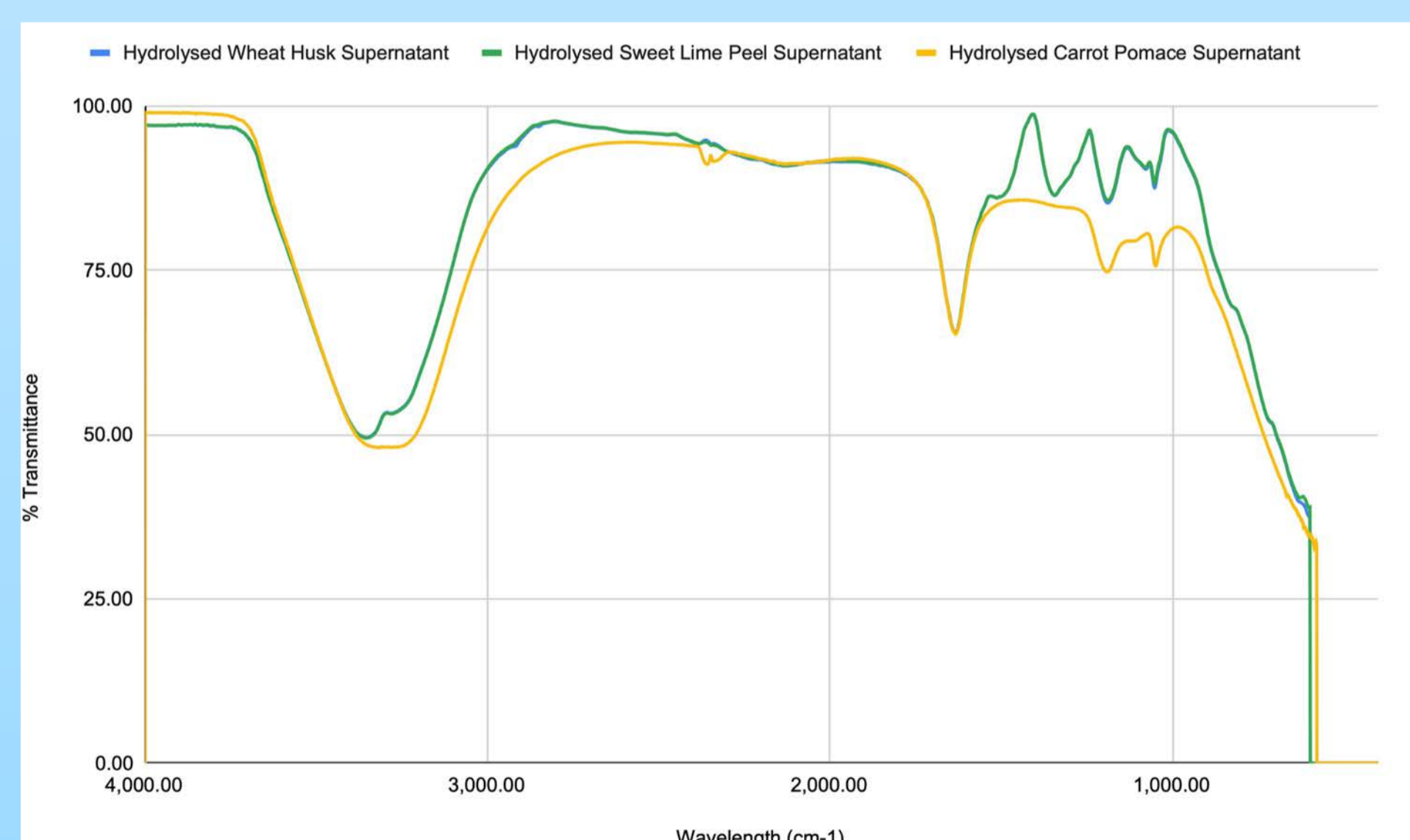


The FTIR spectrum of raw wheat husk reveals significant lignin-related absorption peaks at 1728.27 cm<sup>-1</sup>, 1631.15 cm<sup>-1</sup>, and 1370.75 cm<sup>-1</sup>. The peaks at 3303.29 cm<sup>-1</sup>, 2919.86 cm<sup>-1</sup>, 1435.53 cm<sup>-1</sup>, 1375.49 cm<sup>-1</sup>, 1013.90 cm<sup>-1</sup> are related to the existence of cellulose. The peaks at 1743.69 cm<sup>-1</sup>, 1435.53 cm<sup>-1</sup> and 1375.49 cm<sup>-1</sup> are associated with hemicellulose. The peaks at 1608.59 cm<sup>-1</sup>, 1435.53 cm<sup>-1</sup>, 913.90 cm<sup>-1</sup> are associated with lignin. The peaks at 886.10 cm<sup>-1</sup> and 797.56 cm<sup>-1</sup> are related to C-H deformation. The FTIR spectrum of wheat husk after acid hydrolysis shows new peaks at 1101.57 cm<sup>-1</sup>, 1017.08 cm<sup>-1</sup>, and 870.29 cm<sup>-1</sup> related to glucose.

The FTIR spectrum of sweet lime peel shows the 3303.29 cm<sup>-1</sup>, 2919.86 cm<sup>-1</sup>, 1435.53 cm<sup>-1</sup>, 1375.49 cm<sup>-1</sup> and 1013.90 cm<sup>-1</sup> peaks in cellulose. The 1743.69 cm<sup>-1</sup>, 1435.53 cm<sup>-1</sup> and 1375.49 cm<sup>-1</sup> peaks are observed in hemicellulose. The 1608.59 cm<sup>-1</sup>, 1435.53 cm<sup>-1</sup> and 913.90 cm<sup>-1</sup> peaks are associated with lignin. At 1233.98 cm<sup>-1</sup>, a C-O stretch and O-H in-plane bending in polysaccharides are observed. The 886.10 cm<sup>-1</sup> peak corresponds to C1-H deformation in cellulose. 797.56 cm<sup>-1</sup> peak is identified with C-H deformation. The treated sweet lime samples has characteristic peaks at 3308.01 cm<sup>-1</sup>, 3338.81 cm<sup>-1</sup>, 2919.87 cm<sup>-1</sup>, 1434.98 cm<sup>-1</sup>, 1159.38 cm<sup>-1</sup> and 1103.57 cm<sup>-1</sup> associated with cellulose. The 1634.69 cm<sup>-1</sup>, 1515.89 cm<sup>-1</sup> and 1262.60 cm<sup>-1</sup> peaks indicate presence of lignin. The 1316.46 cm<sup>-1</sup> peak is associated with hemicellulose. The 1054.77 cm<sup>-1</sup> and 1032.44 cm<sup>-1</sup> peaks depict the composite matrix of cellulose, hemicelluloses, and lignin.

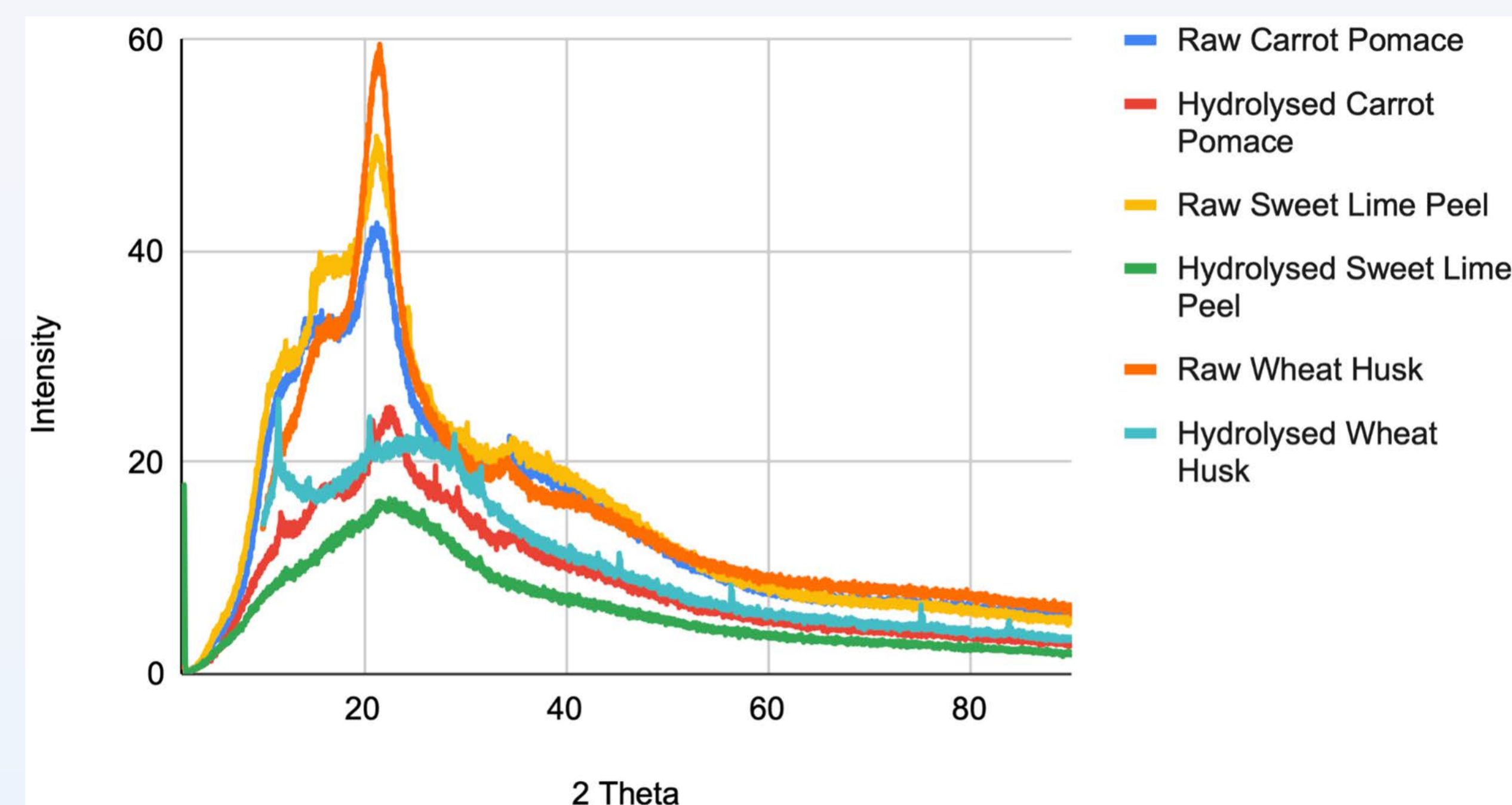
The FTIR spectrum of carrot pomace has absorption peaks assigned to cellulose at 3286.80 cm<sup>-1</sup>, 2933.07 cm<sup>-1</sup>, 1323.48 cm<sup>-1</sup> and at 1011.78 cm<sup>-1</sup>. Carrot pomace also shows FTIR absorption peaks assigned to hemicellulose at 2933.07 cm<sup>-1</sup>, 1729.66 cm<sup>-1</sup> and at 1604.56 cm<sup>-1</sup>. Carrot pomace shows absorption peaks assigned to lignin at 2933.07 cm<sup>-1</sup>, 1729.66 cm<sup>-1</sup> and at 1237.28 cm<sup>-1</sup>. The 2884.86 cm<sup>-1</sup> peak is assigned to aliphatic-CH<sub>2</sub>. The FTIR spectrum of acid hydrolysed carrot pomace has absorption peaks assigned to cellulose at 3286.24 cm<sup>-1</sup>, 2918.65 cm<sup>-1</sup>. Hydrolysed carrot pomace shows hemicellulose and lignin peaks at 2918.65 cm<sup>-1</sup>, 1707.50 cm<sup>-1</sup> and at 1506.00 cm<sup>-1</sup>. Carrot pomace shows new glucose peaks at 1098.11 cm<sup>-1</sup>, 1012.94 cm<sup>-1</sup>, 1144.13 cm<sup>-1</sup>, 871.96 cm<sup>-1</sup> and at 659.11 cm<sup>-1</sup>.

### FTIR Analysis of Supernatants from Acid Hydrolysed Samples



The FTIR spectrum of supernatant from acid hydrolyzed wheat husk has absorption peaks assigned to glucose at 3355.74 cm<sup>-1</sup>, 2129.27 cm<sup>-1</sup>, 1345.08 cm<sup>-1</sup>, 1190.11 cm<sup>-1</sup>, 1078.53 cm<sup>-1</sup>, and at 1053.07 cm<sup>-1</sup>. The FTIR spectrum of supernatant from acid hydrolyzed sweet lime peel has peaks assigned to glucose at 3356.23 cm<sup>-1</sup>, 2129.48 cm<sup>-1</sup>, 1635.32 cm<sup>-1</sup>, 1345.06 cm<sup>-1</sup>, 1190.24 cm<sup>-1</sup>, 1079.05 cm<sup>-1</sup> and 1053.20 cm<sup>-1</sup>. The FTIR spectrum of supernatant from carrot pomace has absorption peaks assigned to glucose at 3319.80 cm<sup>-1</sup>, 2359.46 cm<sup>-1</sup>, 2125.32 cm<sup>-1</sup>, 1634.32 cm<sup>-1</sup>, and at 1050.14 cm<sup>-1</sup>. Therefore, with this experiment, glucose is successfully extracted from biowastes with acid hydrolysis procedure.

### XRD Analysis Before & After Hydrolysis

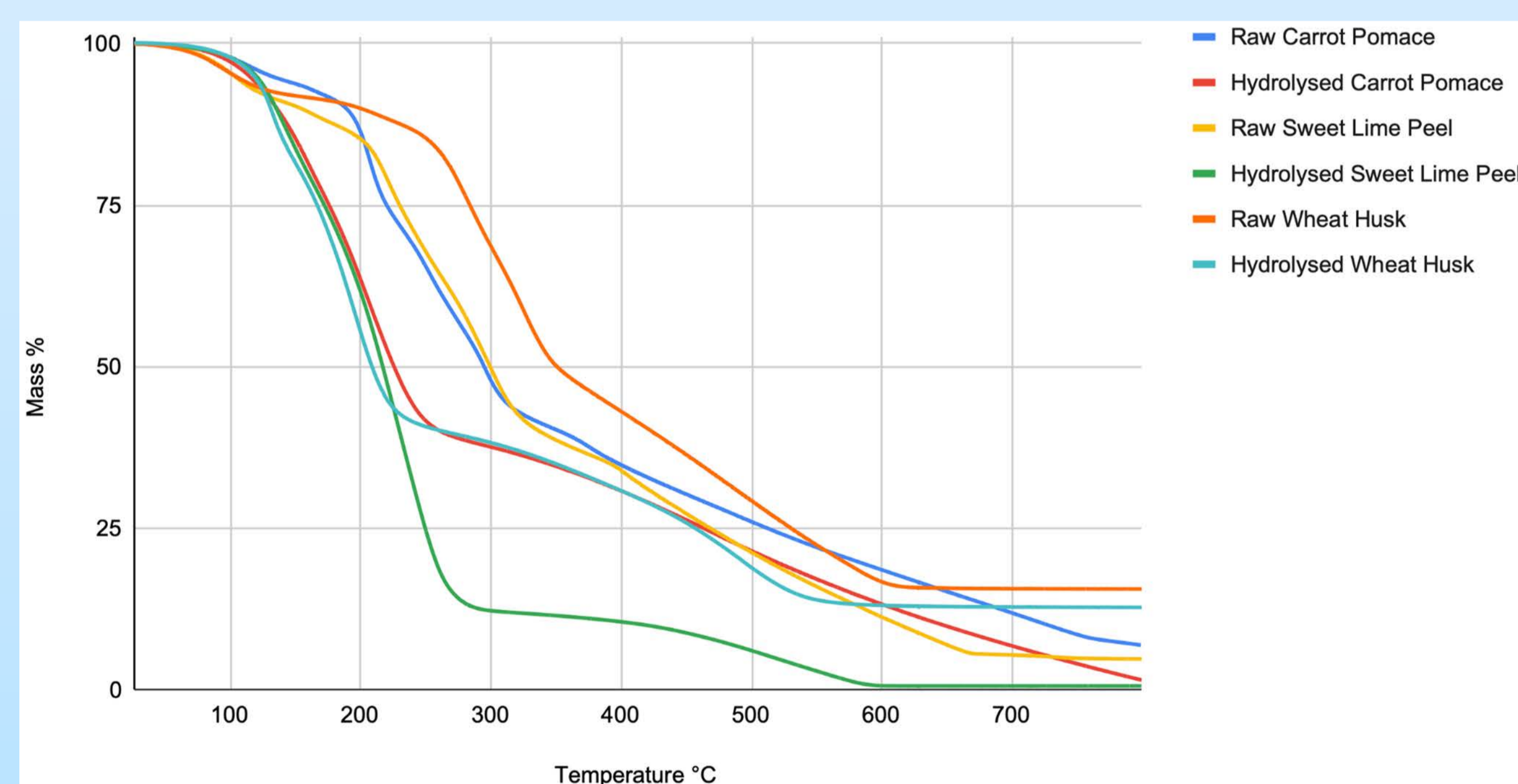


The diffractogram of raw wheat husk exhibits peaks around 2θ of 15°, 20°, and 34°, which are associated with the presence of cellulose I and II. After acid hydrolysis, the wheat husk diffractogram shows peaks at 2θ of 18° and 30°, indicating modifications in the cellulose structure. When comparing the peaks of acid-hydrolyzed wheat husk with those of raw wheat husk, diminished peaks at 2θ of 15° and 34° for hydrolyzed wheat husk indicate the breakdown of crystalline structures. So, it is evident that the structural disintegration of cellulose into simpler sugars like glucose occurs as a result of acid hydrolysis.

The diffractogram of the raw sweet lime peel exhibits peaks at around 2θ of 20° and 35°, alongside a bump visible around 15°-18° and an elevation near 25°. Just before the major peak, there is a minor elevation, and several smaller peaks appear between 35-50° degrees and beyond throughout the range. Post acid hydrolysis, the diffractogram of treated sweet lime peel still shows major peaks around 20°, 30° and 45° with reduced intensity, indicating a decrease in crystallinity. This is likely due to the acid hydrolysis treatment breaking down the hydrogen bonds in cellulose and hemicellulose, leading to a more amorphous structure.

The diffractogram of raw carrot pomace exhibits peaks around 2θ of 15.7°, 21.7° and 34.6° which are related to the existence of cellulose I. The diffractogram of carrot pomace after acid hydrolysis treatment exhibits peaks around 2θ of 13°, 23°, and 29.5° related to the existence of cellulose. For hydrolysed carrot pomace, peaks around 2θ 17.3°, 35° relates to electrospun lignin and glucose I, respectively. All peaks of raw carrot pomace show greater intensity compared to the peaks of acid hydrolysed carrot pomace. Therefore, it is further supported that glucose is extracted from biowastes as a result of acid hydrolysis.

### TGA Before & After Hydrolysis



The TGA of raw wheat husk reveals three main weight loss stages: the initial loss at 50-100°C due to moisture evaporation, at 250-400°C attributed to polysaccharide degradation, and at 400-600°C associated with CO and CO<sub>2</sub> release from lignin decomposition. For acid-hydrolyzed wheat husk, the weight loss curves appear at 100-200°C due to moisture loss and at 200-500°C due to accelerated degradation of polysaccharides into simpler sugars such as glucose. Compared to raw wheat husk, the acid-hydrolyzed sample exhibits less thermal stability, indicating a faster degradation process.

The TGA of raw carrot pomace shows three weight loss curves from around 50°C, mainly due to moisture loss, with substantial degradation occurring between 250-350°C. The acid-hydrolyzed sweet lime peel shows a significant mass loss at around 100°C, suggesting alterations in the material's thermal stability and decomposition dynamics. The primary degradation phase for the hydrolyzed peel is shifted to a higher temperature range, around 300-400°C. The steeper decline in mass during this phase suggests a more uniform degradation of the material components, likely a result of the acid hydrolysis process breaking down complex molecules.

The TGA of raw carrot pomace shows three weight loss curves at 100-190°C related to moisture evaporation, at 200-310°C related to polysaccharide degradation and at 360-800°C related to CO and CO<sub>2</sub> release. For acid hydrolysed carrot pomace, the weight loss curves are at 100-250°C related to moisture evaporation and at 320-800°C related to polysaccharide degradation into glucose. The raw carrot pomace showed better thermal stability compared to acid hydrolysed carrot pomace as the latter degrades faster.