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ARTICLE

Effects of Waste Organic Samples and Extraction Methods towards the Absorption Range of Carbon Nanodots and How it Affects Plants' Growth

Joshua Tanujaya
University of Surabaya | St. Kalirungkut, Kali Rungkut, Surabaya, East Java 60293
✉ joshua.tanujaya.max@gmail.com

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Abstract: Carbon-nanodots(CND) were nanotechnologies possessing low toxicity, photoluminescence, and biocompatibility qualities which were applicable to various aspects namely in assisting plant growth. Chloroplasts were essential in plant growth that is to absorb sunlight, however the UV spectrum's wavelength range which could be absorbed was limited and therefore the photosynthesis efficiency was also inadequate. Nevertheless, chloroplasts which integrated with CND would have wider range of the UV absorptivity that was the combination from the absorptivity of chloroplast and CND. Therefore, the CND needed would require a broad absorptivity range. CNDs were extractable from various waste organic samples with a plethora of extraction methods. This study reviews the organic samples and the methods which were able to produce CND with widest absorptivity range and the effects CND gave to plant growth. The data used were the outcome of evaluating literatures. It was discovered that CND synthesized from dragon fruit skin and pear fruit skin have the widest absorptivity which was 70 nm which could be affected by numerous amounts of chromophore group in the sample and the most effective extraction methods were those which utilized micro waves as it has disadvantage being only that it couldn't work on large number of samples and advantages being a fast process of extraction and small energy required. CND contributed positive effects to plants by increasing sprout length, root length, fresh root weight, dry root weight, fresh sprout weight, dry sprout weight, fresh plant weight, dry plant weight, root strength, stem length, Rubisco activity, and chlorophyll content.

Keywords: Carbon Nanodots, Absorptivity, Photosynthesis, Chlorophyll, Plant Growth.

1. Preliminary

Photosynthesis was a very important reaction or plant as it is directly associated with the plant's growth itself and the crucial organelle for this reaction is the chloroplast which is to absorb sun light's energy and then utilize it for the reaction. However, chloroplast have a very narrow UV spectrum range that was able to be absorbed which was between the range of 400-700 nm (Li et al, 2021), and hence the efficiency of the photosynthesis was very limited too which is less than 10% (Li et al, 2021). The consequence of the low chloroplast efficiency in absorbing UV light which should have the most essential role in plant's development, hence the growth would also be not maximized.

In this plant growth issue, the solutions needed would be a way to force the chloroplast to absorb more UV light and more efficiently. Then, it was found that CND could pose as an answer. When CND interacted with a chloroplast, it formed a new compound and the absorption by the chloroplast would be widened depending on the CND's being used. As the UV spectrum absorption was broaden, the amount of UV light that was able to be absorbed will be increased too. Hence, the plant's growth could be maximized.

Therefore, the purpose of this study is to review the literatures existed to find organic samples that were able to produce CND with the widest UV spectrum absorption and to found out their role in plant's growth processes as well as the most effective extraction methods. With the discovery of CND with the widest absorptivity range, when the plant was being treated by the CND, it will form a CND-chloroplast compound which has the maximum absorption range of UV spectrum.

I.1. Research Questions

a. Which organic sample that could produce CND with the broadest absorptivity range
b. Which methods of CND extraction was the most effective
c. How does CND positively affect plant growth

I.2. Research Purposes

a. To discover which organic sample that could produce CND with the broadest absorptivity range
b. To discover which CND extraction method was the most effective
c. To discover the effects CND gave towards plant growth

I.3. Research Benefits

a. To give data and add insights about CND organic samples and each with their absorptivity data
b. To give reviews and add insights about CND extraction methods and each with their advantages and disadvantages
c. To give data and add insights about the effects of CND in plant growth

Research Background

a. Carbon Nanodots and Their Roles in Plant Growth

As humans got more developed, the problems being faced by society were also becoming more modern. Hence, the solution also needs to be more futuristic to balance the issues. There were already many technologies which were innovated and were contributing greatly towards various obstacles, especially nanoscience which provide technologies that could interact in a nano scale (Nurfathiya, 2018). By taking advantage of the size and their properties, this nano-scaled technology could be further applied to plenty of fields. One of the nanotechnologies being researched a lot recently and being used of was carbon nanodots.

Carbon nanodots were nanomaterials which consisted of carbons. After being researched for years, carbon nanodots owned incredibly advantageous qualities such as low toxicity, strong photoluminescence property, and a high biocompatibility (Nurfathiya, 2018). On the other hand, carbon nanodots were also extractable from multifarious ingredients that could be found in nature. As a consequence, carbon nanodots can be synthesized from various samples with a numerous type of methods and hence could produce a various types of carbon nanodots, each with unique properties. For this reason, one would be able to create carbon nanodots adjusted to the problems being faced or the main purpose of the creation of the carbon nanodots. One of the carbon-nanodots application that were beneficial were in assisting plant growth.

b. Plant Photosynthesis

Photosynthesis could be defined as a reaction which utilize inorganic compounds that were water and UV spectrum from the sun to create sugar as a food for the plant and also oxygen that could be explained through the reaction below

$$6H_2O(l) + 6CO_2\,(g) + UV \rightarrow C_6H_{12}O_6\ (glucose) + 6O_2\,(g)$$

The light being absorbed were from the UV spectrum from the sun which are used as energies from the photosynthesis reaction. Plants could absorb UV spectrum lights was a consequence of a pigment compound stored in plants called chlorophyll which located in an organelle called chloroplast. Photosynthesis reaction could be separated into 2 phases which were the light reaction and the dark reaction.

The light reaction was a phase where the reactions needed sunlight and occurred the reaction of the splitting water and the release of oxygen and those reactions happens in the grana/granum. In this reaction, light energies were converted into ATP and $NADPH_2$. There is 2 photosystem that operated in this reaction. Photosystem 1 or P700 was a photosystem which absorbs UV spectrum in the wavelength of 700 nm and photosystem 2 or P680. Initially, photosystem 2 will absorb UV light therefore the electrons in chlorophyll will be unstable as a result of excitation. Then, photosystem 2 will take the electrons from water molecules which were being

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split by Mn ion enzyme and caused the release H+. Electrons from the water molecules reduces the plastoquinone (PQ) which formed PQH2. Plastoquinone was a quinone molecule which exist in the thylakoid lipid bilayer membrane. Then, plastoquinone will send the electrons to cytochrome complex b6-f (plastoquinone-plastocyanin reductase) and the complex will send the electron from photosystem 2 to photosystem 1 by oxidizing PQH2, reducing the plastocyanin protein, and also pumping the H+ ion from the stroma to the thylakoid. Inside the photosystem 2, plastocyanin protein is being re-oxidized and moving the electron towards the ferredoxin proteins and the electrons is used to reduce NADP+ to NADPH. Then the H+ ion would enter the ATP-synthase which formed ATP from ADP and inorganic phosphates.

The dark reaction was also known as the Calvin reaction. It is a phase which did not need the sunlight and occurred the reaction of forming glucose from carbon dioxide (carbon fixation) and the reaction happened in the stroma. The dark reaction can be divided into 2 which were the Calvin-Benson cycle and the Hatch-Slack path. Plants which undergo the Calvin-Benson cycle were the C3 plants and the plants which undergo the Hatch-Slack path were the C4 plants. In this cycle, the ribulose-1,5-biphosphate molecule and carbon dioxide formed 2 molecules of 3-phosphoglycerate which is a molecule with 3 carbon atoms using the Rubisco enzyme, hence the plants were known as C3 plants. C4 plants were those that produce oxaloacetate acid which has 4 carbon atoms from the RuBP compound and carbon dioxide using the phosphoenol pyruvate carboxylase molecule. The forming of 3-phosphoglycerate in the Calvin-Benson cycle was the carboxylase phase. The next phase is the reducing of the carboxyl group in the phosphoglycerate and forming the 3-phosphoglyceraldehyde by utilizing the phosphate group in ATP compounds. Next was the phase of RuBP regeneration to be reused to react with the other CO^2. The phosphoglyceraldehyde compounds would be used by chloroplast to form starch. The other phosphate compounds will form sucrose in the cytosol. The whole reaction only used 3 compounds of ATP. In the Hatch-Slack path, oxaloacetate that was formed will be changed into malate which would be carboxylased into pyruvate and CO^2. Pyruvate will return into being a phosphoenol pyruvate carboxylase enzyme and the CO^2 which were formed will also undergo the Calvin-Benson cycle. For this reaction, it requires 5 molecules of ATP.

c. The Correlation of Absorptivity and Carbon Nanodots in Plant Growth

The most essential thing in plant growth is the photosynthesis reaction. In this process, chloroplast in plants functioned as a UV-light absorber as an energy for the photosynthesis reaction. Also, the property of carbon nanodots which has the most important role is the absorptivity. Each carbon nanodots has a different absorptivity range. When the carbon nanodots were being given to plants, hence the carbon nanodots will bond with the chloroplast which formed a new molecule with a different absorptivity range which was the result of combining the absorptivity range of the plant's chloroplasts and the carbon nanodots' absorptivity and therefore making the absorptivity of the plant became even wider (Wang et al, 2021). Hence, the process of absorbing the UV light by plants will be more efficient and could potentially increase the rate of the plants' growth.

Carbon nanodots could be synthesized from a numerous of samples and methods hence the absorptivity of each carbon nanodots vary. From the plethora of carbon nanodots being synthesized in the literatures, this research aimed to give a comprehensive review in comparing absorptivity properties from various carbon nanodots and the extraction methods being used to find the best carbon nanodots variant which was able to maximized the UV spectrum absorptivity of plants.

2. Research Methods

This research utilizes sources which discussed carbon nanodots variants which were synthesized from organic samples with numerous of different extraction methods. Those sources include researched done by the Royal Society of Chemistry community, universities, books, and undergraduates' researches which were further explained in Figure 1.

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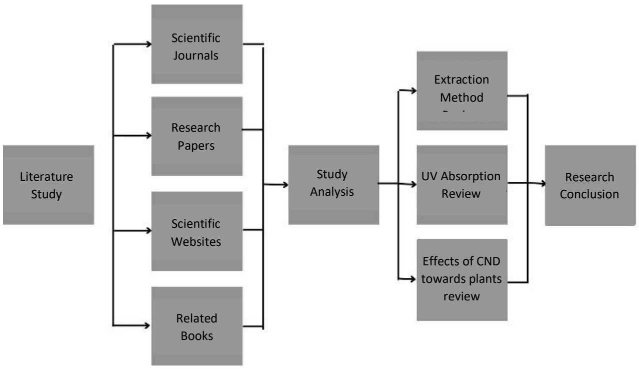

Figure 1. Research Methodology Scheme

After collecting related literature data, the review included diverse carbon nanodots extraction methods which were supported by analysis of the benefits and setbacks of each of those methods and tabulating those data concerning the data of absorptivity of carbon nanodots of each organic samples. In addition, reviews about the effects of carbon nanodots towards plants' growth.

3. Results and Discussion

3.1. Carbon Nanodots Extraction Methods from Various Organic Samples Review

To produce CND, a lot of extraction methods were available. Different methods fabricate CNDs with similar properties. However, these extraction methods possess their own advantages and also limitations. Thus, it is essential to analyze these methods to discover the ones which are the most beneficial in terms of the processing for instance energy usage, yield, heat penetration, or cost.

The first method is the hydrothermal which utilized oven. The materials and ingredients needed were oven, centrifuge machine, solvent (water/NaOH), blender, autoclave, and filter papers. This method has been used to samples such as peanut, watermelon, cucumber, and pineapple. The advantages of this method were that it has a light operational condition, small amount of time required, environmentally friendly, and has a nice dispersion in solution (Li & Liu, 2010). However, this method used autoclaves which were expensive, has safety issues, and unable to be observed during process (Asim et al, 2014). The temperature used is 150°C and the oven process is 2-4 hours.

The next method was the micro wave irradiation method. This method required microwave, blender, filter paper, centrifuge machine, and water. This method has been used to extract CND from organic samples such as peanuts and watermelons. The fast rate of heating process, accelerated reactions, and able to produce high yields made this method advantageous (Hoz, Ortiz, Prieto, 2016). However, this method was not effective in processing samples with large volumes as a consequence of poor heat penetration (Hoz et al, 2011). The power of microwave needed was 450 Watt and the process is done 20-80 minutes.

Then, the frying method is the following method which has been done to spinach samples. For this method, one needed oven, mortar grinder, cooking oil, filter paper, and a solvent (n-hexane). This method was simple, safe, and did not require high cost. It was just that this method needed higher temperature than the hydrothermal method, the product has small yields, low accuracy, and it was not environmentally friendly. The temperature of this operation was 88°C with the time of process being 5 minutes.

The next method is the roasting method which also has been done on spinach samples. The ingredients necessary would be oven, mortar grinder, and filter paper. This method has a short procedure, safe, and did not require high cost and the weakness being needing temperature higher than the hydrothermal method, low purity and accuracy, as well as not environmentally friendly. The roasting method is done in 5 minutes.

On the following, this method is similar to the oven hydrothermal method however this did not require any solvent during the oven process. The ingredients would be oven, mortar grinder, water, and filter paper. This method is successfully being used to orange peel, and wet tofu waste samples. This method is included as a simple, safe, and an inexpensive, and short-timed process. However, this method required higher temperature than the hydrothermal method, low accuracy and purity, also not environmentally friendly. The oven temperature for the process is 250°C and the process is done in 1 hour.

Next is the hydrothermal method, however this one utilized microwave and not oven. The tools needed were blender, filter paper, water as the solvent, and microwave. This method has been applied to mangosteen fruit and peel and cassava peel. The procedures of this method were faster than the oven hydrothermal, and since less time is needed, the energy needed would also decrease. However, microwave hydrothermal would not work efficiently towards samples in large volumes as a result of low heat penetration. The power of the microwave that was being used was 450 Watt in 40-60 minutes.

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The next method is similar to the microwave method; however, this was helped with sonication process. Materials required were mortar grinder, solvents (UPW [ultra-pure water], chitosan, and diethylene glycol), sonicator, microwave, filter paper, and centrifuge machine. The samples that were being used in this method is the shell of oil palm. This method has a faster extraction procedure, low solvent volume needed, and low energy. However, this method was a bit complicated hence the process must be done with great thoroughness to create an accurate result. The sonication process is done in 30 minutes and the power of the microwave is 385 Watt in 1-5 minutes.

The next method was also similar to microwave method, however this method also utilized oven to dry the samples. Materials needed were oven, mortar grinder, water, microwave, and filter paper. This method has been applied to cow waste. The oven drying process has a high precision, has rapid heating, and it is effective towards samples with large volumes. Even so, in this drying process, different spots in the samples would have different temperatures and also would cause important volatile substance to be lost in the process. For the microwave process, it was a very environmentally friendly procedure, quick, and low cost. However, the CND produced would vary in size. The temperature of the oven drying was 105°C for 3-5 hours, and the power of microwave being used is 180 Watt for 20 minutes.

The last method was the ultrasonication method. This method required H_2O_2 as a solvent, a microprocessor based sonicator, ammonium solution, filter paper, and a dialysis machine. This method has been used on sugarcane bagasse, taro peel, and garlic peel. The procedure has a low cost, low pollution, as well as high accuracy and purity (Kurian & Paul, 2021). However, the procedure required high energy to operate (Biswal & Bhatia, 2021).

From the review of the varieties of CND extraction methods, with considering the advantages and disadvantages of each procedure, the best method would be the methods which used micro waves which were microwave irradiation and microwave hydrothermal. The reason behind this was that it was effective and efficient than other methods.

Table 1. CND extraction method comparison table

	Methods	Tools & Materials	Organic Samples	Advantages	Disadvantages	References
1	Hydrothermal (Oven)	Oven, Centrifuge Machine, NaOH/Water, Blender, Autoclave, Filter Paper	Peanut, Watermelon, Cucumber, Pineapple	Light operation condition, Short timed synthesis procedure, Nice dispersions in solutions	Expensive autoclaves, Safety issues, Unable to observe	(Nurfathiya, 2018), (Himaja dkk, 2014)
2	Microwaves Irradiation	Microwave, Blender, Filter Paper, Centrifuge Machine, Water	Peanut, Watermelon	Fast heating process, Acceleration in reaction, High yield	Limited heat penetration (not effective in large volume samples)	(Nurfathiya, 2018)
3	Fried	Oven, Mortar Grinder, Cooking Oil, Filter Paper, n-Hexane	Water Spinach	Simple process, Safe, Low cost	Temperature higher than hydrothermal process, Low purity, Low accuracy, Environment issue	(Sari, 2019)
4	Roast	Oven, Mortar Grinder, Filter Paper	Water Spinach	Simple process, Safe, Low cost	Temperature higher than hydrothermal process, Low purity, Low accuracy, Environment issue	(Sari, 2019)
5	Oven	Oven, Mortar Grinder, Water, Filter	Tofu waste	Simple process, Safe, Small cost, Less time in oven	Higher temperature than hydrothermal, Less purity, Small accuracy, Environmental issues	(Nurohman dkk, 2021)
6	Hydrothermal (Microwave)	Blender, Microwave, Filter Paper	Mangosteen peel, Mangosteen Fruit, Dragon Fruit Peel, Pear Peel	Faster extraction, Less energy needed	Limited heat penetration (Ineffective towards large volume of samples)	(Tarigan, 2018) (Selvy & Isnaeni, 2018)
7	Microwave & Sonication	Grinder, UPW/Chitosan/DEG, Sonicator, Microwave, Filter	Oil palm shell	Fast extraction process, Low cost, Small solvent	Complex procedure and hence needed high accuracy	(LunAng dkk,2020)

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	Methods	Tools & Materials	Organic Samples	Advantages	Disadvantages	References
		Centrifuge Machine		volume, Small energy required		
8	Microwave & Oven Drying	Oven Grinder Water Microwave Filter	Cow waste	[Oven Drying] Relative speed, Precision, Effective towards large samples, Fast heating [Microwave] Environmentally friendly, Fast, Low cost	[Oven Drying] Variation of temperature in different spots, The loss of useful volatile substance [Microwave] Unable to control the size of CND produced	(Haryadi, 2018)
9	Ultrasonication	H2O2 Microprocessor or Sonicator Ammonium Filter Dialysis	Sugarcane waste, Taro peel, Garlic peel	Simple process, Low cost, No pollution produced, High purity, High accuracy	Require much energy, Long extraction process	(Boruah dkk, 2020)

3.2. UV Spectrum Absorptivity from Various Organic Samples Review

The CND samples being used were of organic wastes. The first sample was the peanut using the hydrothermal oven method, and this sample could produce CND with the absorption range of 298-307 nm and hence the length of the range would be 9 nm. The second sample was the watermelon sample using the hydrothermal oven method too, this sample has the absorption range of 298-307 nm which was 9 nm in length. Next is the spinach sample with the frying and roasting method. The frying method could produce CND with the absorption range of 260-290 nm or 30 nm in length, and the roasting method could produce CND with absorption range of 260-270 nm or 10 nm in length. The next sample is the cucumber peel with the hydrothermal oven method which has the absorptivity range of 267-328 nm which was 61 nm in length. Next is the pineapple peel with the oven hydrothermal method which could yield CND that could absorb UV in the range of 269-317 nm or 48 nm in length. The CND from the dragon fruit peel sample was extracted by the method of......Then the mangosteen peel with the microwave hydrothermal method produces CND that were capable of absorbing in the range of 272-297 nm or 25 nm in length. Other than the mangosteen peel, the fruit itself was also used to extract CND with the method of microwave hydrothermal that absorbed UV in the range of 274-291 nm or 17 nm in length. Then the pear fruit peel sample using the microwave hydrothermal method produce CND that absorbed in the range of 280-350 nm or 70 nm in length. Next is the shell of oil palm with the microwave method and sonication which yielded CND with the absorption range of 265-300 nm or 35 nm in length. Then, the CND from the wet tofu waste using the oven method has the absorption range of 243-276 nm or 33 nm in length. Lastly, CND were also extracted from the samples of sugarcane bagasse, taro peel, and garlic peel with the method of ultrasonication and the result were similar which were CND with the absorption range of 260-280 nm which were 20 nm in length.

From the review above, one could take 5 samples of CND which has the widest absorptivity range which were the dragon fruit peel, pear fruit peel which were 70 nm, then the cucumber peel with 61 nm, pineapple peel with 48 nm, and the shell of oil palm with 35 nm.

From the review, one could also take 5 samples of CND which has the narrowest absorptivity range. The first two is the peanut and the watermelon which has the absorption range of 9 nm, then the spinach with 10 nm, mangosteen fruit with 17 nm, and the sugarcane bagasse, taro fruit, and garlic peel with 20 nm only.

In organic compounds, some were able to absorb UV lights as some has chromophore groups. Chromophores were groups with conjugated bonds which contain pi electrons and this electron is capable of absorbing light spectrum between the wavelength of 200-800 nm and then this electron would be excited becoming the anti-bonding pi electrons (Shukla et al, 2017). This factor could be the reason behind the wide absorptivity range of dragon fruit peel and pear fruit peel which was that these samples contain large numbers chromophore groups. In the dragon fruit sample, it contained coloring compound which was anthocyanin in a large amount and this anthocyanin compound was included as a chromophore group (Dewi et al, 2020). Then in the pear fruit peel sample, it contained flavonoid compounds in a large amount and flavonoid compound was also classified as a chromophore group (Reiland & Slavin, 2015). One could conclude that samples with a high number of chromophores could potentially produce CNDs with a wide absorptivity range.

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Table 2. CND from waste organic samples UV absorption comparison table

	Organic Samples	UV Absorption Range	Range	Methods	Reference
1	Peanut	298-307	9	Hydrothermal Oven	(Nurfathiyah, 2018)
2	Watermelon	298-307	9	Hydrothermal Oven	(Nurfathiyah, 2018)
3	Spinach	Fry : 260-290 Roast : 260-270	Fry : 30 Roast : 10	-	(Sari, 2019)
4	Cucumber Peel	267-328	61	Hydrothermal Oven	(Himaja dkk, 2014)
5	Pineapple Peel	269-317	48	Hydrothermal Oven	(Himaja dkk, 2014)
6	Dragon Fruit Peel	280-350	70	Hydrothermal Microwave	(Selvy dan Isnaeni, 2018)
7	Mangosteen Peel	272-297	25	Hydrothermal Microwave	(Tarigan, 2018)
8	Mangosteen Fruit	274-291	17	Hydrothermal Microwave	(Tarigan, 2018)
9	Pear Peel	280-350	70	Hydrothermal Microwave	(Selvy dan Isnaeni, 2018)
10	Oil Palm Shell	265-300	35	Microwave & Sonication	(LunAng dkk, 2020)
11	Wet Tofu Waste	243-276	33	-	(Nurohman dkk, 2021)
12	Sugarcane Bagasse	260-280	20	Ultrasonication	(Boruah dkk, 2020)
13	Taro Peel	260-280	20	Ultrasonication	(Boruah dkk, 2020)
14	Garlic Peel	260-280	20	Ultrasonication	(Boruah dkk, 2020)

3.3. Effects of Carbon Nanodots in Plant Growth

From the research done, it was proven that CNDs has a large contribution towards the increasing of the rate in plants' growth. A study by (Li et al, 2021) compared rice plants that were treated by CNDs with the rice plants without CNDs. Initially, they synthesized CND using a pyrolysis method on citric acid sample and ethanolamine and react the CNDs with chloroplast that were isolated from a rice plant. From the comparison, one could see the difference in the growth of CND treated rice plant and those without CND. The first variable being observed was the length of the shoot and root of the plant. CND treated rice plants has 24,8% longer shoot and 18,9% longer roots compared to the normal rice plants. Then they also observed the fresh weight and the dry weight of the root and shoot and it was found that CND plants have 50,9% more weight in fresh root weight and 61,8% more weight in dry root weight. For the shoot weight, CND plants have 77,9% heavier fresh shoot weight and 64,3% heavier dry shoot weight. Next variable was the chlorophyll content and it was found that CND plants contain 64,5% more chlorophyll contents. Then, the last observation was done on the Rubisco activity in those plants. Rubisco activity was the reaction of fixating carbon from carbon dioxide that were absorbed by plants. CND plants has a higher Rubisco activity than normal plants by 23,4%.

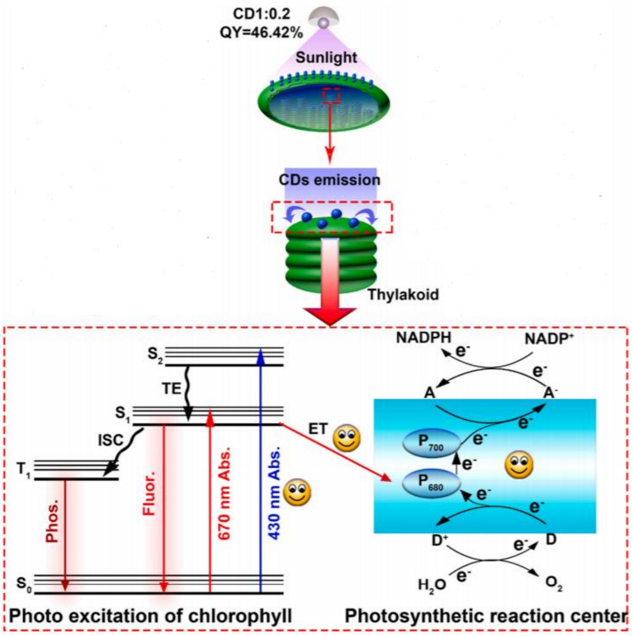

Figure 2. Effects of CND towards photosynthesis

The next study by (Li et al, 2020) was done on green bean samples. The CND was extracted using the hydrothermal method form the sample of citric acid and cysteine. It was found that CND helped plants in increasing root length by 29,9%; stem length by 18,3%; root strength by 36,1%; and fresh plant weight by 14,9%. It was a result of CND being a good electron donor and acceptor. With this, when CND formed a compound with chloroplasts, the process of charge exchange reactions could be done in a faster rate. Then when CND entered the plant's system, those CND was degraded by the H2O2 enzyme in plants to form plant hormones and CO2. Then, one could see form figure 3 which shows the effects of CND in the rate of Romaine lettuces' growth.

Figure 3. Effects of CND towards Romaine lettuce

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The next research was done by (Chen et al, 2021) which aimed to test the quality of CND which contain nitrogen group. As it was well known, that nitrogen was one of the most essential elements in affecting plants' growth. The reason was that nitrogen element could function as a plant's nutrition in increasing the process of germination, growth, as well as becoming the molecule which affected the gene expression that controlled the dormant phase of the seedlings, leaf growth, and the lateral root growth. However, excessive usage of nitrogen fertilizers would cost fortunes and would pose a threat to the environment, therefore nitrogen doped CND would present as a solution. The plants being studied was Arabidopsis thaliana. From the experiment done, they conclude that plants that were treated with nitrogen doped CND have 64% more dry plant weight and 55% more chlorophyll content than the others. The next plants being experimented were bok choi plants. Turns out, bok choi plants that were treated with nitrogen CND would have higher yield than the normal plants by 2.1 times in the 18th day and 1.4 times in the 30th day. From figure 3.3 and 3.4, one could observe the effects nitrogen CND has towards the growth of Arabidopsis thaliana compared to plants that were not treated with CND.

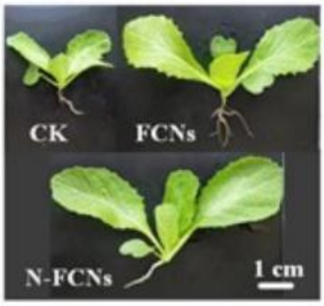

Figure 4. Effects of CND towards bok choi sprouts

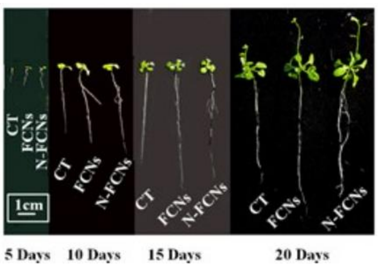

Figure 5. Effects of CND towards Arabidopsis thaliana sprouts

(Li et al, 2020) also explained regarding the mechanism of how CND could help increase plants' growth. CND were compounds that have excellent electron donor and acceptor properties. That was caused the variety of functional groups in the surface of CND such as carboxyl, hydroxyl, and amines helped in the process of charge exchange or the process of donating and accepting electrons (Srivastava et al, 2019). When CND compound captured the energies of UV spectrum, the electrons in the functional groups would be excited and these excited electrons would be the ones having the essential roles in the charge exchange reactions. Photosynthesis reaction was a reaction which included a lot of charge exchange reactions such as the forming of ATP hence with the presence of CND that were integrated to chlorophylls in plants would help the process of charge exchange and therefore the photosynthesis reaction would also be helped. Photosynthesis reaction produced carbohydrates that would be the nutrition supply for plants and hence when the effectivity of photosynthesis reaction is increased, then the food supply for the growth of plants would also increase.

4. Conclusion

The purpose of this study is to review the organic samples that could be potentially used to extract CNDs, the extraction methods, as well as the effects of treating plants with CNDs towards their growth. After evaluating existing literatures, it was discovered that extraction methods which utilized micro waves such as microwave irradiation and hydrothermal microwave was advantageous by most as it's weakness only being ineffective in processing large samples, then the strength being a fast process with high yields of CND. Apart from comparing extraction samples, researcher also compared the varieties of organic samples and their UV-absorptivity variable and it was found that CND that were extracted from dragon fruit peel and pear fruit peel have the widest absorptivity in the UV spectrum which the length of the range was 70 nm which possibly caused by the numerous amounts of chromophore groups in the sample. Then the effects of treating plants with CNDs by comparing it with those that did not receive any CND were also reviewed. It was found that CND treated plants experienced escalation in shoot length by 24,8%; root length by 18,9% and 29,9%; fresh root weight by 50,9%; dry root weight by 61,8%; fresh shoot weight by 77,9%; dry shoot weight by 64,3%; fresh plant weight by 14,9%; dry plant weight by 64%; root strength by 36,1%; stem length by

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18,3%; Rubisco activity by 23,4%; and the chlorophyll content by 64,59% and 55% compared to normal plants. This was caused by the varieties of functional groups in the surface of CNDs which helped in the process of charge exchange or electrons therefore the photosynthesis reaction's effectivity was also increased.

To develop this research further, one could deepen it through experimental method which was in extracting CND using the microwave hydrothermal and the microwave irradiation. Then, one could also find the correlation between the number of chromophore groups in a sample with the absorptivity of CND derived from it, therefore one could also find more potential in other organic samples that could produce CND with a better absorptivity than the dragon fruit peel and the pear fruit peel.

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