Food Oils and Fats: Chemistry & Technology
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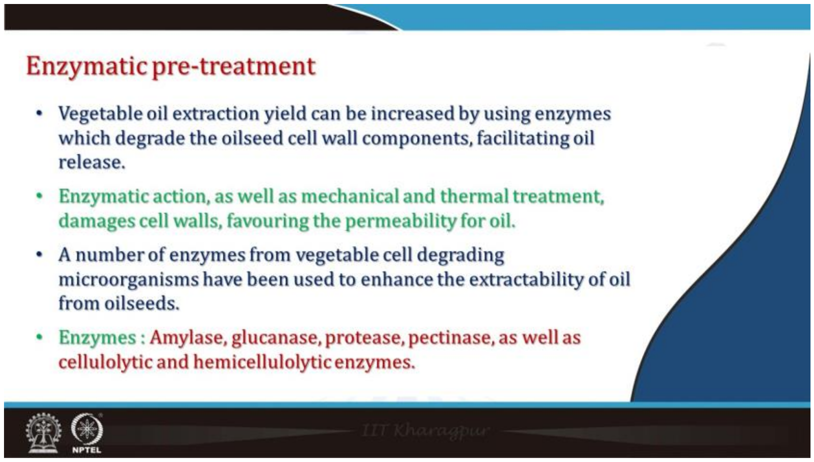
Week 4: Mechanical Expelling of Oils from Plant Sources
Lecture 20: Recent Developments in Oil Expression Technology

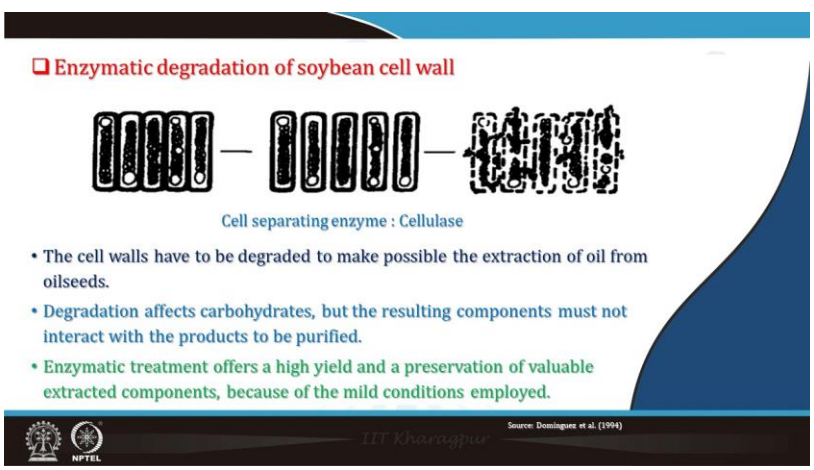
Hello everyone, Namaste. Now, we are in the last lecture of fourth week. This fourth week, we devoted on mechanical expelling of oil from plant sources basically oil seeds. Here, we saw the various pretreatments, then pressing, and expelling. We also took some examples. So, now in this lecture 20^{th}, in the next half an hour, we will discuss about recent developments and innovations or novel technologies in oil expression, novel recent developments in oil expression technology.

We will discuss about the advances in both in the advances in the pretreatment technology like enzymatic pretreatment, cold plasma pretreatment, pulse electric field pretreatment, ultrasound, or microwave pretreatment and also, we will discuss briefly about developments in pressing technology that is particularly the gas assisted pressing. Otherwise we saw the screw spelling and this hydraulic pressing which are commonly used even honey pressing that we discuss. So, how that is the gas assisted pressing helps in the getting better recovery that also we will discuss slightly. So, let us see first is the enzymatic pretreatment.

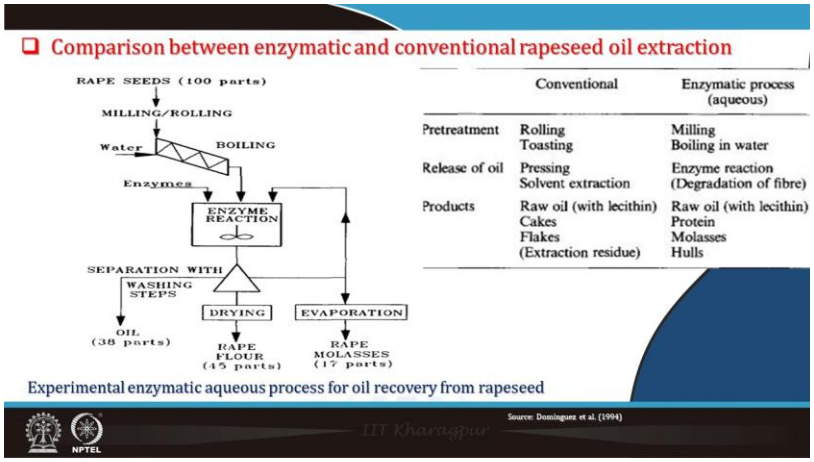


These are the what is the importance of the pretreatment, what are various pretreatments we already discussed in the earlier class, but here we will just see that is these novel methods of pretreatment, how they are beneficial, or how they improve the oil yield and the quality.

The vegetable oil extraction yield can be increased by using enzymes which degrade the oil seed cell wall components and therefore, facilitate the oil release. Enzymatic action, as well as mechanical and thermal treatment, damages the cell walls and favors the permeability of the oil. A number of enzymes from vegetable cell degrading microorganisms have been used to enhance the extractability of the oil from oilseeds, and the amylases, glucanases, proteases, pectinases, etc. are a few examples of the enzymes that have like amylases will break the starch molecule. Even cellulolytic and hemicellulolytic enzymes, they are also used which break the cellulosic and hemicellulosic materials. Here, you see that enzymatic degradation of the soya bean cell wall has been shown here.

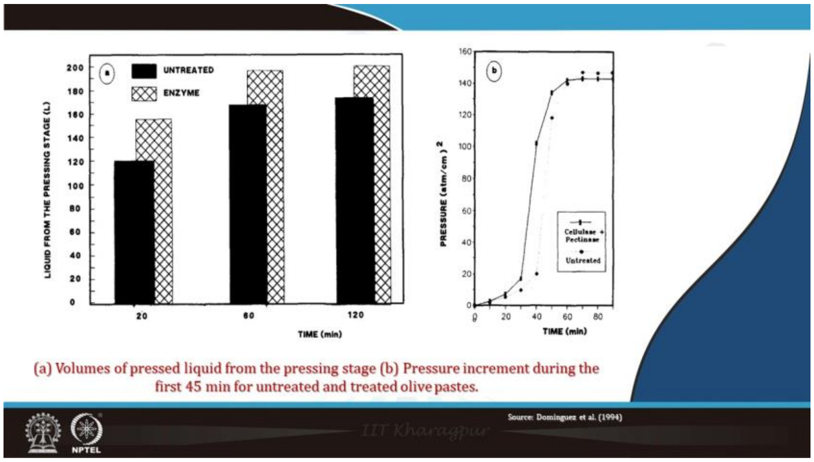


You can clearly see in the picture how when the enzyme treatment is there, the cell wall disintegrates that is cell is separated. The cellulase enzyme is used or other enzymes are used, and then it eats away or it breaks down the structure, this releases that this makes the easy release of the oil. The cell wall has to be degraded to make possible the extraction of oil from oilseeds. Degradation affects carbohydrates, but the resulting component must not interact with the products to be purified. Enzymatic treatment offers a high yield and a preservation of valuable extracted components because there, mild conditions are implied, even the heat is not applied and pressure also. If at all it is used it is it needs very less (little) pressure to be applied. So, here a comparison between enzymatic and conventional methods for wrapped seed oil extraction is shown in the experimental setup.

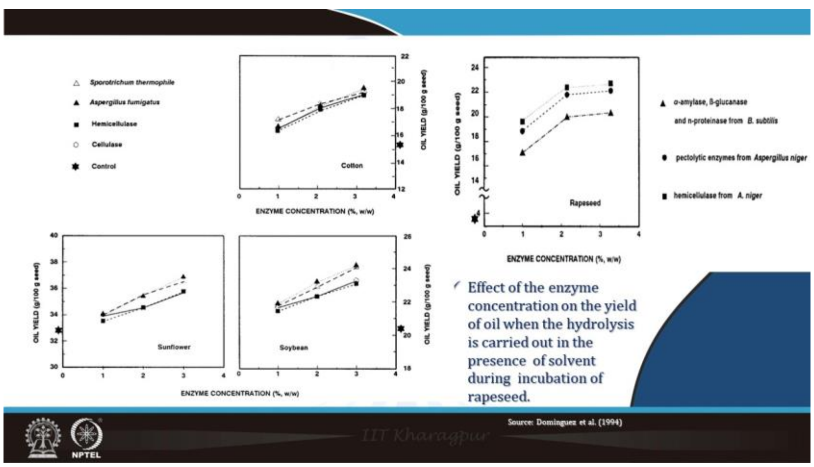


Here, that rape seed that is, let us see 100 parts or 100 kg is milling or rolling. It is pressed to the water treatment then boiling, and then here in that chamber experimental setup container that is these pressed seeds are given that is milled and rolled and boiled seeds and then enzymes are added here and it is given for the proper reaction time. After that, it is separated. With separation, it is washed, and you get oil 38 points that is from 100 kg. If it is there, about 38 kg of oil is obtained. Separation is subjected to further evaporation it can be further recycled to this enzyme treatment chamber. And then finally, it gives molasses of about 17 parts, and the drying right you get a rape seed flour of about 45 parts or 45 kg.

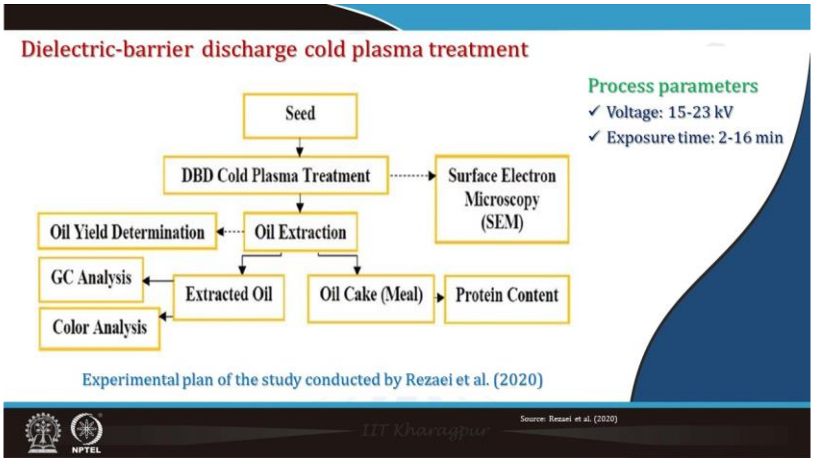
So, in both conventional and enzymatic processes that is an aqueous process. Pre-treatment in the conventional process is rolling and toasting whereas in the enzymatic process milling and boiling in water as you could see here these are the pretreatment. Then release of oil, in the conventional method; after the pretreatment, they are subjected to pressing or solvent extraction whereas, in the enzymatic process, it is basically the enzyme reaction which causes the degradation of the fiber causes the degradation of the cell wall cell structure and releases the oil. So, in the product, in the conventional oil, you get the raw oil with lecithin, cakes, flakes, or extraction residue whereas, in the enzymatic treatment, you get raw oil with lecithin, protein, molasses and hulls, these are the product.



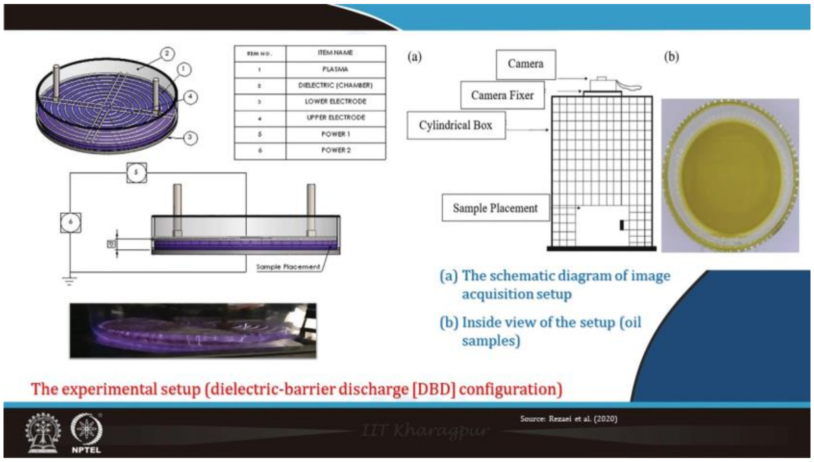
Then here, in this you see that it is an effect of liquid from the pressing stage that is more recovery that is how much you are getting. The time is 20 minutes, 60 minutes, and 120 minutes. This is the volume of pressed liquid from the pressing stage. So, you can see in both the cases, that enzyme-treated in all cases with 20-minute pressing, 60-minute pressing, or 120-minute pressing, enzyme-treated material is giving more oil yield or more liquid yield. In the second graph you see here that is the time versus the pressure. That is the pressure increment during the first 45 minutes for untreated and treated olive pastes. You see that first 45 minutes in the cooked material, cellulase or pectinase enzymes which are used, there the pressing rate is more rather than the untreated one.



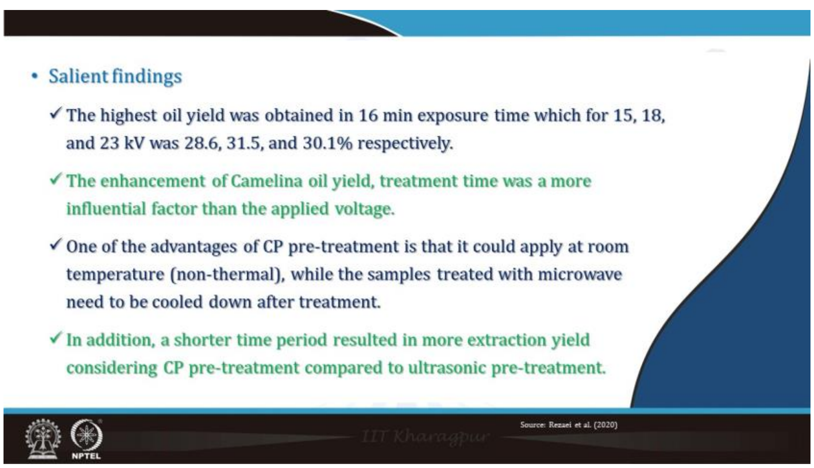
Here in this, you see again that is the effect of the enzyme concentration on the oil yield. In the case of cotton seed, sunflower seed as well as soybean seed and various enzymes you have taken as cellulase, hemicellulase enzyme or A*spergillus fumigus* enzymes that are contained in those seeds etc. In all the three cases, you can see that is the treatment that is the enzyme concentration the increase in the enzyme concentration caused an increase in the oil yield in all the three cases. This figure here, you see that effect of enzyme concentration on the yield of oil when the hydrolysis is carried out in the presence of solvent during incubation of rapeseed it is case of rapeseed. And here, also again alpha-amylase and beta-glucanase, and n-proteinase from the *Bacillus subtilis* and the proteolytic enzyme from the *Aspergillus niger* was used and hemicellulase from *Aspergillus niger* was used. And all the three cases, you can see that of course, there is up to 2 percent weight by weight enzyme concentration, there is a steep rise in the oil yield and after which of course, there is an increase is there, but the rate of the oil recovery it decreases, but the increase in the oil content is there. So, that depends, but obviously, this will all depend upon the what are the other conditions like pH, temperature, and this moisture content in that because these are the parameters which influence the enzyme activity even effectiveness of your enzyme, enzyme activity all these things.



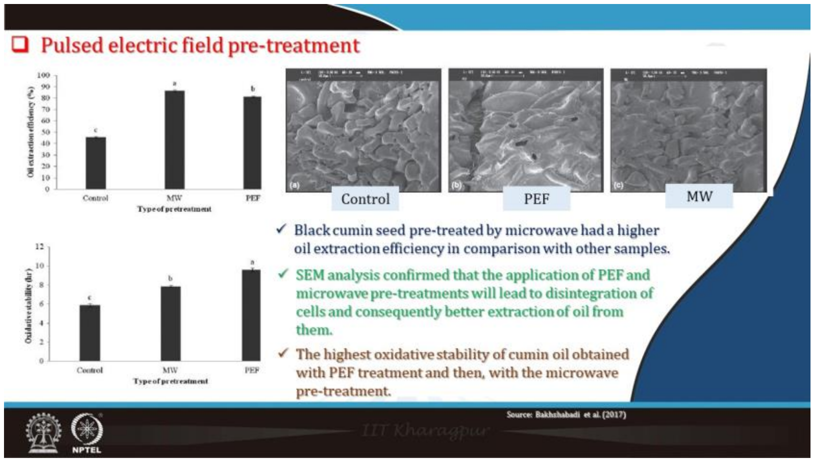
Then, next novel method of pretreatment is dielectric-barrier discharge cold plasma treatment. Here, you see that the seeds were subjected to dielectric barrier discharge cold plasma treatment and then after that this was treated the seeds were subjected to surface electron microscopy (SEM) studies to see their effects that is the plasma treatment effect. And this treated material was taken where the oil yield determination and whatever the oil was obtained, it was analyzed by GC analysis or color analysis to see its quality and the meal was analyzed for the protein content. So, this is the experimental plan was study conducted by Regel et al. in 2020. The process parameters, they considered where voltage up to in the range of 15 to 23 kV, and exposure time was varied from 2 to 16 minutes.



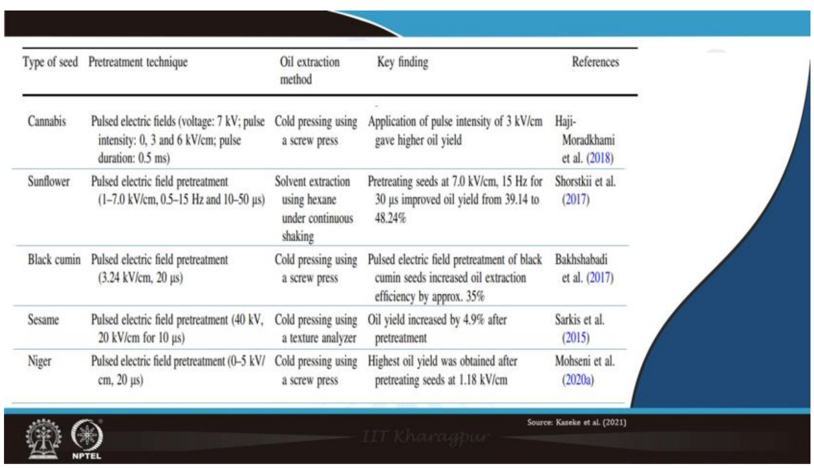
Here, it is the experimental setup for the dielectric barrier discharge configuration. In this, you can see here there is a plasma treatment and then 2 and 3, 2 is the dielectric chamber is this one, and then there are 3 and 4 lower electrode and upper electrodes and there is a power source 5 and 6 power source 1 and power source 2. So, sample placement is done here, you can see here. Inside also in this sample, there is a camera, a fixer, cylindrical box to see the sample, that is the inside view of the setup of oil and schematic diagram of the oil acquisition setup this you can say that is where is the how they are getting the oil there is the photographs are taken that is the photograph of the system.



From this experiment, they reported that the highest oil yield was obtained in 16-minute exposure time for which for 15, 18, and 23 kV were 28.6, 31.5, and 30.1 percent, respectively. The enhancement of camellia oil yield treatment time was a more influential factor than the applied voltage. One of the advantages of CP pretreatment is that it could rapidly be done or it could be done applied at room temperature, it is a non-thermal process and while the sample treated with microwaves and need to be cooled down after the pretreatment because during microwave heating that of heat is generated. In addition, a shorter time period resulted in more extraction yield considering the CPP treatment compared to the ultrasonic pretreatment. So, this CPP treatment gives some better effect, this advantageous from the microwave and ultrasound treatment.



Then pulse electric field treatment, PF treatment it is a black cumin seed was pretreated by microwave and pulse electric field both and a comparison were done in the control. As you can see that the in the both a comparison between here the in the microwave treated pretreated the oil extraction yield was more and almost in the PF and microwave they were comparable, but much higher than the that was the control ok. But if the oxidative stability accordingly, but oxidative stability was found to be more in the PF treated oil than that of the microwave treated oil. So, this CM analysis confirmed that the application of PF and microwave pretreatments will lead to the disintegration of the cell and consequently better extraction of oil from them. The highest oxidative stability of cumin seed oil obtained was with the PF pretreatment and then with the microwave pretreatment.



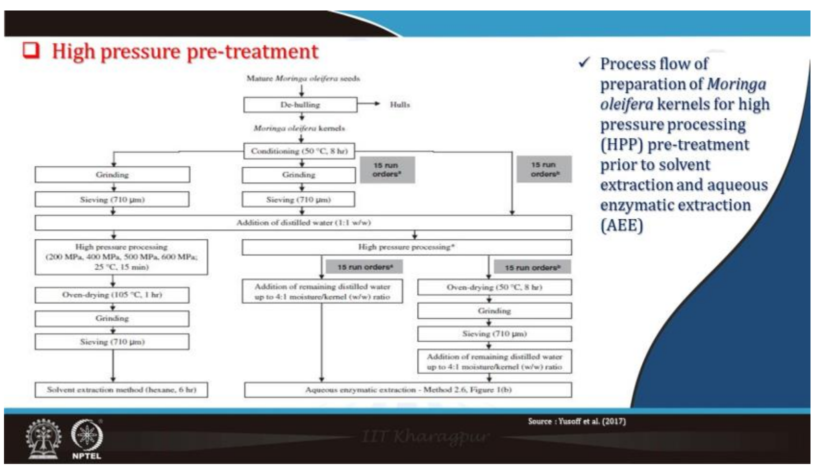
Type of seed	Pretreatment technique	Oil extraction method	Key finding	References
Cannabis	Pulsed electric fields (voltage: 7 kV; pulse intensity: 0, 3 and 6 kV/cm; pulse duration: 0.5 ms)	Cold pressing using a screw press	Application of pulse intensity of 3 kV/cm gave higher oil yield	Haji-Moradkhami et al. (2018)
Sunflower	Pulsed electric field pretreatment (1–7.0 kV/cm, 0.5–15 Hz and 10–50 µs)	Solvent extraction using hexane under continuous shaking	Pretreating seeds at 7.0 kV/cm, 15 Hz for 30 µs improved oil yield from 39.14 to 48.24%	Shorstkii et al. (2017)
Black cumin	Pulsed electric field pretreatment (3.24 kV/cm, 20 µs)	Cold pressing using a screw press	Pulsed electric field pretreatment of black cumin seeds increased oil extraction efficiency by approx. 35%	Bakhshabadi et al. (2017)
Sesame	Pulsed electric field pretreatment (40 kV, 20 kV/cm for 10 µs)	Cold pressing using a texture analyzer	Oil yield increased by 4.9% after pretreatment	Sarkis et al. (2015)
Niger	Pulsed electric field pretreatment (0–5 kV/cm, 20 µs)	Cold pressing using a screw press	Highest oil yield was obtained after pretreating seeds at 1.18 kV/cm	Mohseni et al. (2020a)

Here that is the it gives that is the various reviews from the literature. That is what are the different pulse electric PF treatment and the varying conditions and the cannabis, sunflower, black cumin, sesame and niacin seeds were there and the oil extraction methods were this cannabis they were treated at a voltage of 7 kV pulse intensity and 0, 3 and 6 kV per centimeter and pulse duration was 0.5 milli second. And after the pretreatment that is the oil extraction method was cold pressing using a screw press. And the salient findings were that as application of pulse intensity of 3 kV per centimeter gave a higher yield. This was reported by Haji Moradkhami in 2018. Shorstkii et al. in 2007 reported that, in the case of sunflower oil in the PF treatment was given in varying condition and then followed by solvent extraction using hexane under continuous shaking and they reported that the pretreating seeds at 7 kilowatt per centimeter, 15 megahertz for 30 microseconds improved oil yield from 39.14 to 48.24 %.

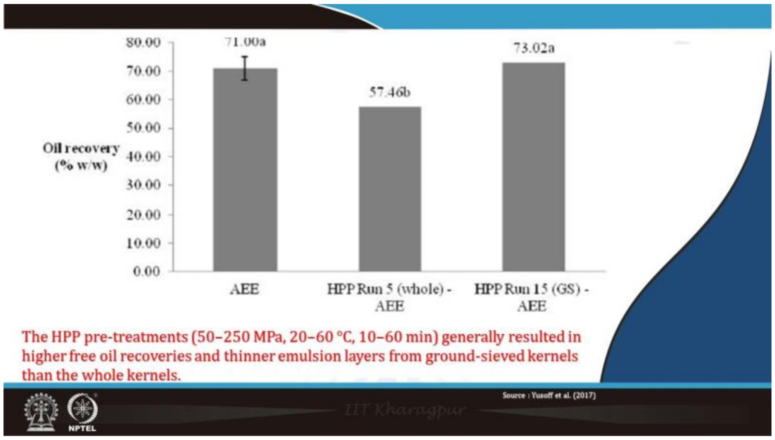
In another study on black cumin seed where after the pretreatment, the seeds were subjected to cold pressing using a screw press it was reported that pulse electric field pretreatment of black cumin seeds increased oil extraction efficiency by approximately 35 percent. In sesame seed, that PF treatment followed by cold pressing using a texture analyzer, it was reported that oil yield increased by 4.9 % after the PF treatment. In niger seed, that is highest oil yield was obtained after pretreating seeds at 1.18 kilowatt per centimeter.

So, all these reports, literature reports confirm that, PF is a promising pretreatment for getting not only the more oil yield, but also better quality of the oil. In the earlier class, when we were discussing various pretreatment then I told you how what is the mechanism because when you are giving pretreatment it creates new pores or enlarges the pore electroporation takes place and which increases the fluid ability of the oil by just simple pressing the oil is increased.

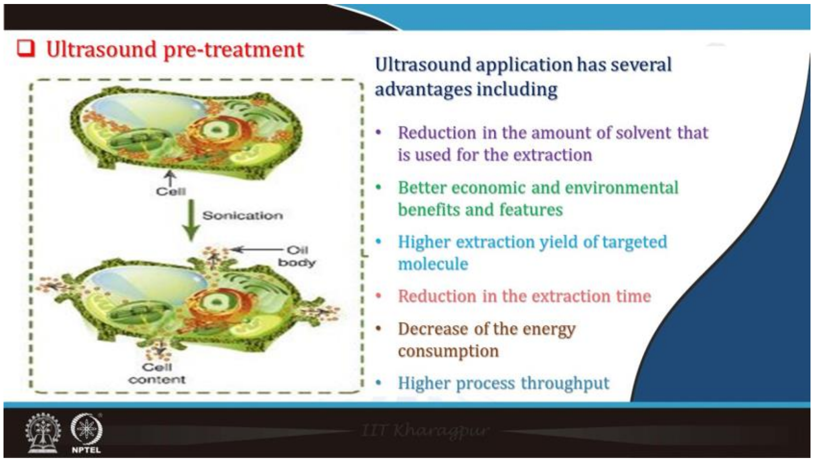
Then the high-pressure pretreatment, now another novel technology and the process flow chart for the preparation of *Moringa oleifera* kernels for high pressure processing pretreatment prior to solvent extraction and aqueous enzymatic extraction is shown here.



So, there is the mature *Moringa oleifera* seeds are taken, they are dehulled hulls are blown off and then these kernels they are conditioned at around 50 degree Celsius for 8 hours and then these conditioned seed they are subjected to grinding, sieving or they are directly these conditioned seed they are used as such and here the additional and grinding, sieving conditions are also varied. Then addition of distilled water in 1 to 1 ratio is done, they added and then a portion of it which is given to high pressure treatment and high-pressure treatment 200 megapascal, 400 megapascal, 500 megapascal, and 600 megapascal for 15 minutes and at 25 degree Celsius and then they were oven dried at 205 degree Celsius for 1 hour then grinding and sieving and then passed through the solvent extraction process. Or this high-pressure processing in the treatment is given. Then addition of remaining distilled water into 4 is to 1 micro moisture kernel ratio and then aqueous enzymatic extraction method was used. In oven drying, grinding, sieving, addition of remaining distilled water in 4:1. So, these conditions were varied and then it was subjected to aqueous enzymatic extraction.



So, a comparison was made between solvent extraction and aqueous enzymatic extraction after giving the high-pressure pretreatment and you can see here, this high-pressure pretreatment is 50 to 250 megapascal, 20 to 60 degree Celsius, 10 to 60 minutes generally resulted in higher free oil recoveries and thinner emulsion layers from the ground sieved kernel than the whole kernel, that is shown here. That is oil recovery percent it is AEE aqueous enzyme extraction, HPPRun5 and HPPRun15, here you get better oil recovery in HPPRun15.



Then ultrasound pretreatment. Already ultrasound application has several advantages earlier it was reported there is a reduction in the amount of solvent that is used for the extraction, there is a better economic and environmental benefits and features, higher extraction yield of targeted molecules, there is a reduction in the extraction time when the ultrasound application pretreatment is used, it results in decrease in the energy consumption as well as higher process parameters. You can see, ultrasound again it breaks this is the cell and when you are sonicating at high speed it results into the rupture of the cell membrane and because of this that is oil body that this causes the rupture and oil flowability is moves that is you get better recovery and even the temperature etc. is not much. So, the oil quality also is better.

Type of seed	Pretreatment technique	Oil extraction method	Key finding	References
Watermelon	Ultrasonic pretreatment (100–700 W, 10–50 °C, 5–25 s)	Aqueous enzyme extraction	Ultrasonic pretreatment at 700 W, 40 °C for 25 s showed higher extraction rate of 98%	Liu et al. (2011)
Apricot and almond	Ultrasonic pretreatment (42 kHz, 2.5, 10 and 15 min)	Aqueous enzyme extraction	Oil yield for both apricot and almond increased within the range of 19–22%	Sharma and Gupta (2006)
Hemp	Ultrasound pretreatment (20 MHz, 200 W, 10, 20 and 40 min)	Supercritical carbon dioxide extraction	Highest oil yield was exhibited by seeds pretreated for 10 min	Da Porto et al. (2015)

Source: Kaseke et al. (2021)

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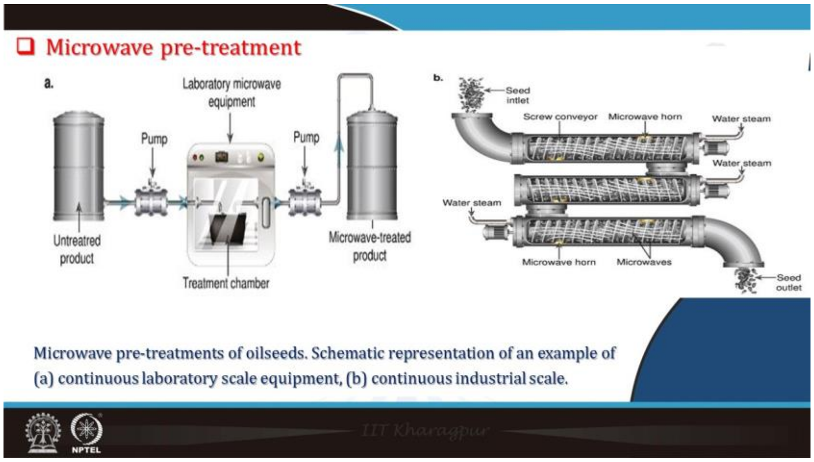
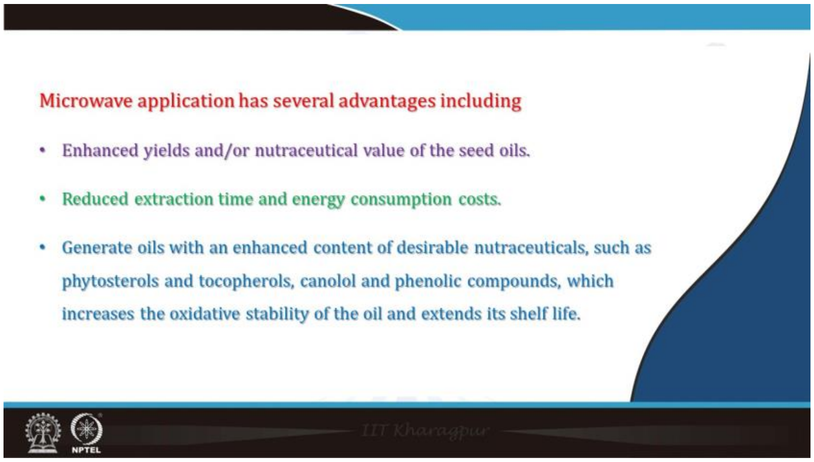
So, here in this an ultrasonic treatment in the watermelon, apricot, almond, and hemp. This ultrasonic treatment in watermelon was used from 100 to 700 watt, 10 to 50 degree Celsius for 5 to 25 seconds. In apricot, it was for 42 kilohertz, 2.5, 10, and 15 minutes, and in hemp ultrasound treatment was given 20 megahertz, 200 watt, for 10, 20 and 40 minutes. In all these cases, that is in the watermelon and apricot after the ultrasound treatment they were subjected to aqueous enzyme extraction whereas, the hemp after the ultrasound treatment was subjected to supercritical carbon dioxide extraction. These are the literature references given. So, in all these cases it was reported that in the case of watermelon ultrasonic retreatment at 700-watt, 40 degree Celsius for 25 seconds showed higher extraction rate of 98 percent. In the apricot and almond, oil yield for both was increased with the range of around 19 to 20 percent. High yield was exhibited by hemp seeds which are pretreated by ultrasound for 10 minutes. So, all these literature reports say that, yes ultrasound has a promising method for pretreating seeds for getting better oil, both quantity and quality.

This is the microwave pretreatment if you see that is the experimental setup. So, the therapeutic treatment of oil seed schematic representation of a continuous laboratory setup where this is a microwave chamber. With the help of a suitable pump, the untreated product is sent to the microwave chamber where it is treated for suitable time. In the chamber, it is exposed with the microwaves and then after the proper treatment it is taken into the microwave treated product in the container.

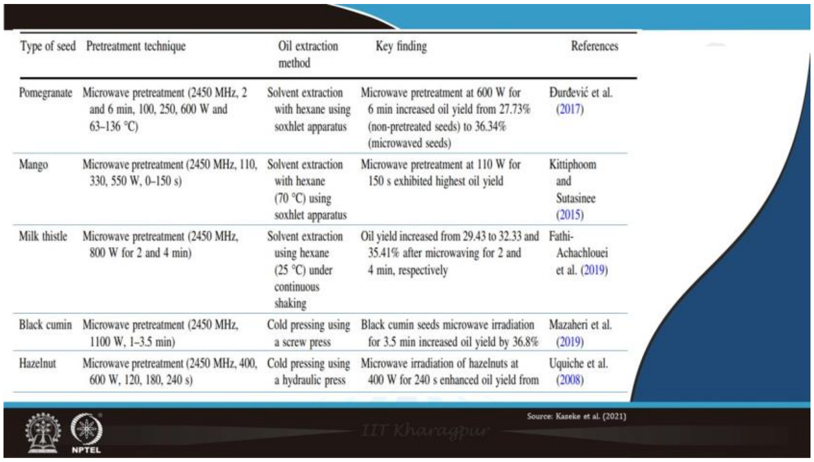


Whereas, in this is a continuous setup it is also almost same there, is the seed inlet there are a screw conveyor and it is subjected to microwave horn and there is also the it is conditioning is done with the water steam. Then it comes to the second chamber, then it moves to the third chamber, the individual chamber the water steam is added to make it to condition it and then it is treated with the microwave horn and microwave finally, the seeds are taken out. So, this is a large-scale continuous setup and this is the laboratory scale continuous laboratory scale setup.



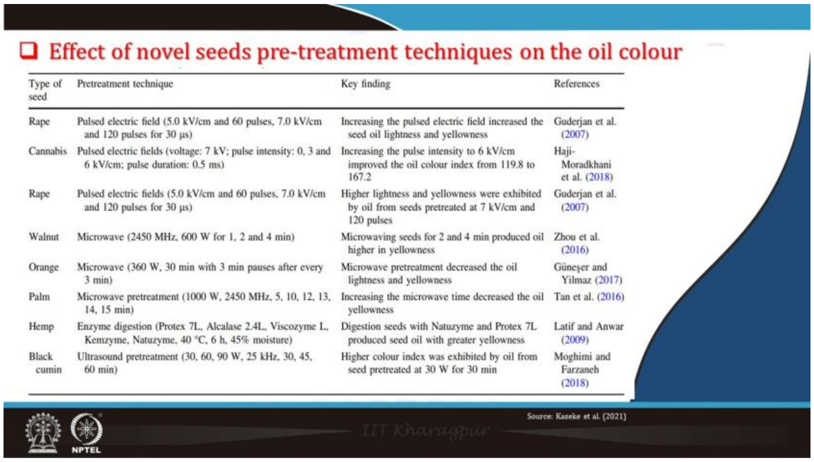
So, the findings of these reports were there. Enhanced yield and or nutritional value of the seed as well as seed oils as well as meal both was obtained. Reduced extraction time and energy consumption cost were there with the use of microwave application. These microwave applications generate oil with an enhanced content of desirable nutraceuticals such as phytosterols, tocopherols, canolols and phenolic compounds etc. which increase the oxidative stability of the oil and also extended shelf life. They also increase the thermal stability of the oil.

So, here there is again literature reports, various researchers they have reported on the various they have studied the pomegranate seeds, mango, milk thistle, black cumin, hazelnut, etc. to varying conditions of microwave, microwave power, then time that is the wattage etc. and after the treating with microwaves they were treated with normally solvent extraction with hexane using soxhlet apparatus and or solvent extraction using hexane and there are continuous shaking or this black cumin was cold pressing using a screw press or hazelnut cold pressing using a hydraulic press.



Type of seed	Pretreatment technique	Oil extraction method	Key finding	References
Pomegranate	Microwave pretreatment (2450 MHz, 2 and 6 min, 100, 250, 600 W and 63–136 °C)	Solvent extraction with hexane using soxhlet apparatus	Microwave pretreatment at 600 W for 6 min increased oil yield from 27.73% (non-pretreated seeds) to 36.34% (microwaved seeds)	Đurđević et al. (2017)
Mango	Microwave pretreatment (2450 MHz, 110, 330, 550 W, 0–150 s)	Solvent extraction with hexane (70 °C) using soxhlet apparatus	Microwave pretreatment at 110 W for 150 s exhibited highest oil yield	Kittiphoom and Sutasinee (2015)
Milk thistle	Microwave pretreatment (2450 MHz, 800 W for 2 and 4 min)	Solvent extraction using hexane (25 °C) under continuous shaking	Oil yield increased from 29.43 to 32.33 and 35.41% after microwaving for 2 and 4 min, respectively	Fathi-Achachlouei et al. (2019)
Black cumin	Microwave pretreatment (2450 MHz, 1100 W, 1–3.5 min)	Cold pressing using a screw press	Black cumin seeds microwave irradiation for 3.5 min increased oil yield by 36.8%	Mazaheri et al. (2019)
Hazelnut	Microwave pretreatment (2450 MHz, 400, 600 W, 120, 180, 240 s)	Cold pressing using a hydraulic press	Microwave irradiation of hazelnuts at 400 W for 240 s enhanced oil yield from	Uquiche et al. (2008)

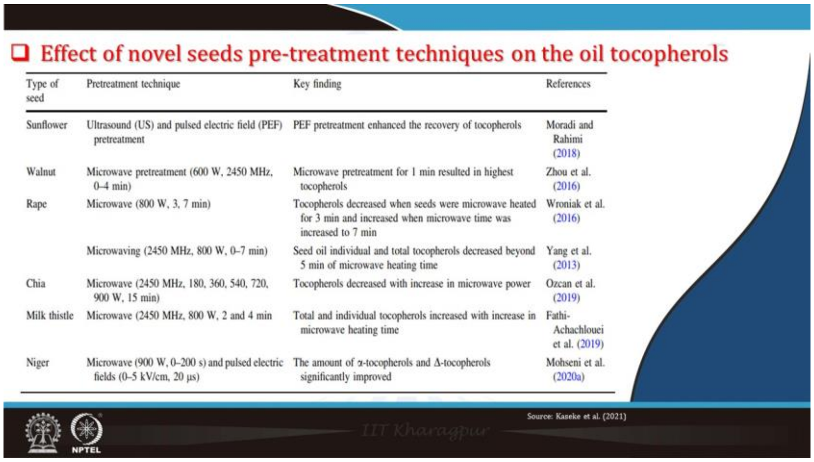
And in all the cases, that is whatever the microwave treatment you are giving and after the treatment whether you go for solvent extraction or you go for a screw expelling or hydraulic pressing etc. In almost all the cases, it has been found that, microwave treatment gives a better yield of the oil. Microwave treatment in the case of pomegranate, it was reported that at microwave pretreatment at 600 watts for 6-minute increased oil yield from 27.73 percent to 36.34 percent. In the mango, the pretreatment at 110 watts for 150 second exhibited highest oil yield. Oil yield increased in milk thistle from 29.43 to 32.33 and 35.41 after microwaving for 2 and 4 minutes, respectively. Similarly, in the black cumin, microwave pretreatment at 2450 megahertz, 1100 watt and 123.5 minutes followed by a cold pressing using a screw press, that is it resulted into the increased oil yield that is oil yield was increased by around 36.8 percent. In the case of hazelnut, also microwave irradiation at 400 watts for 240 seconds enhance the oil yield.



❑ Effect of novel seeds pre-treatment techniques on the oil colour

Type of seed	Pretreatment technique	Key finding	References
Rape	Pulsed electric field (5.0 kV/cm and 60 pulses, 7.0 kV/cm and 120 pulses for 30 μs)	Increasing the pulsed electric field increased the seed oil lightness and yellowness	Guderjan et al. (2007)
Cannabis	Pulsed electric fields (voltage: 7 kV; pulse intensity: 0, 3 and 6 kV/cm; pulse duration: 0.5 ms)	Increasing the pulse intensity to 6 kV/cm improved the oil colour index from 119.8 to 167.2	Haji-Moradkhani et al. (2018)
Rape	Pulsed electric fields (5.0 kV/cm and 60 pulses, 7.0 kV/cm and 120 pulses for 30 μs)	Higher lightness and yellowness were exhibited by oil from seeds pretreated at 7 kV/cm and 120 pulses	Guderjan et al. (2007)
Walnut	Microwave (2450 MHz, 600 W for 1, 2 and 4 min)	Microwaving seeds for 2 and 4 min produced oil higher in yellowness	Zhou et al. (2016)
Orange	Microwave (360 W, 30 min with 3 min pauses after every 3 min)	Microwave pretreatment decreased the oil lightness and yellowness	Güneşer and Yilmaz (2017)
Palm	Microwave pretreatment (1000 W, 2450 MHz, 5, 10, 12, 13, 14, 15 min)	Increasing the microwave time decreased the oil yellowness	Tan et al. (2016)
Hemp	Enzyme digestion (Protex 7L, Alcalase 2.4L, Viscozyme L, Kemzyme, Natuzyme, 40 °C, 6 h, 45% moisture)	Digestion seeds with Natuzyme and Protex 7L produced seed oil with greater yellowness	Latif and Anwar (2009)
Black cumin	Ultrasound pretreatment (30, 60, 90 W, 25 kHz, 30, 45, 60 min)	Higher colour index was exhibited by oil from seed pretreated at 30 W for 30 min	Moghimi and Farzaneh (2018)

So, in this I have just given a again from the literature report a summary of the novel seed pretreatment techniques on the oil colour. There is increasing the pulse electric field increase the seed oil lightness and aloneness in the rape seed and this was reported by Guderjan et al. in 2007. Similarly, in the cannabis, it was reported that increasing the pulse intensity to 6 kilowatt per centimeter improve the oil colour index from 119.8 to 167.2. In the case of rape seed again, higher lightness and aloneness were exhibited by oil from the seeds pretreated at 7 kilowatt per centimeter and 120 pulses. Zhao et al. in 2016 reported that microwaving walnut seeds for 2- and 4-minute produced oil higher in yellowness. Their yellowness was high. Similarly, in another experiment with the orange, it was shown that the microwave pretreatment decreased the oil lightness and yellowness increasing the microwave time decreased the oil yellowness in case of palm oil. Digestion seeds with Natuzyme and Protex 7 L produced seed oil with greater yellowness in the case of hump. This is was reported by Latif and Anwar in 2009. Moghimi and Farzaneh in 2018, they reported that in the case of black cumin higher colour index was exhibited by oil from seed pretreated at 30 watts for 30 minutes. Similarly, that is the novel seed pretreatment techniques they influence the oil quality particularly the antioxidant presents in the oil the oil tocopherols content.


Effect of novel seeds pre-treatment techniques on the oil tocopherols

Type of seed	Pretreatment technique	Key finding	References
Sunflower	Ultrasound (US) and pulsed electric field (PEF) pretreatment	PEF pretreatment enhanced the recovery of tocopherols	Moradi and Rahimi (2018)
Walnut	Microwave pretreatment (600 W, 2450 MHz, 0–4 min)	Microwave pretreatment for 1 min resulted in highest tocopherols	Zhou et al. (2016)
Rape	Microwave (800 W, 3, 7 min)	Tocopherols decreased when seeds were microwave heated for 3 min and increased when microwave time was increased to 7 min	Wroniak et al. (2016)
	Microwaving (2450 MHz, 800 W, 0–7 min)	Seed oil individual and total tocopherols decreased beyond 5 min of microwave heating time	Yang et al. (2013)
Chia	Microwave (2450 MHz, 180, 360, 540, 720, 900 W, 15 min)	Tocopherols decreased with increase in microwave power	Ozcan et al. (2019)
Milk thistle	Microwave (2450 MHz, 800 W, 2 and 4 min	Total and individual tocopherols increased with increase in microwave heating time	Fathi-Achachlouei et al. (2019)
Niger	Microwave (900 W, 0–200 s) and pulsed electric fields (0–5 kV/cm, 20 μs)	The amount of α-tocopherols and Δ-tocopherols significantly improved	Mohseni et al. (2020a)

In the sunflower oil, it was suggested by Moradi and Rahimi in 2018, they reported that PEF pretreatment enhance the recovery of tocopherol. They experimented both PEF as well as ultrasound and PEF they found that better in the recovery of the tocopherol. In the case of walnut, microwave pretreatment for 1 minute resulted in higher tocopherol content. In the rapeseed, tocopherol decreased in the seeds where microwave heated for 3 minute and increased when the microwave time was increased to 7 minutes. Also seed oil individual and total tocopherol decreased beyond 5 minutes of microwave heating time. Fathi et al. conducted experiment on milk thistle and reported that total and individual tocopherol increased with increase in microwave heating time. Similarly, Mohsemi et al., they conducted experiment on niger seeds. They exposed niger seeds to microwave treatment and pulse electric pretreatments and they reported that the amount of alpha tocopherol and delta tocopherols significantly improved by these treatments.

Type of seed	Pretreatment technique	Key finding	References
Rape	Microwave (2450 MHz, 540 W, 0, 100, 200 s) and pulsed electric fields (0–5 kV/cm, 0.5 ms)	The δ-tocopherols increased from 0.00 to 30.07 ppm after seeds pretreatment	Mohseni et al. (2020b)
Hemp	Enzyme digestion (Protex 7 L, Alcalase 2.4 L, Viscozyme L, Kemzyme, Natuzyme, 40 °C, 6 h, 45% moisture)	Higher total tocopherols were manifested in oil from seed digested with Natuzyme	Latif and Anwar (2009)
Borage	Enzyme pretreatment (Olivex and Celluclast at 0.3% enzyme to substrate ratio, 45 °C for 9 h)	The α-tocopherols varied from 1480 (untreated seeds) to 1494 mg/kg (enzyme treated)	Soto et al. (2008)
Goldenberry	Enzyme pretreatment (Cellulase EC, Pektinase L 40 (1:1), 50 °C , pH: 4.3, enzyme concentration: 2% (w/w), 2 h)	The β-tocopherols and γ-tocopherols varied from 2.10–2.11 g/kg and 1.08–1.10 g/kg respectively after seeds enzyme pretreatment	Ramadan et al. (2008)
Tiger nut	Enzyme pretreatment (Alcalse, α-amylase and Viscozyme enzymes at pH 8 and 40 °C for 6 h)	The level of α-tocopherols improved from 145.7 to 159.5 µg/g	Ezeh et al. (2016)
Rape	Pulsed electric field (5.0 kV/cm and 60 pulses, 7.0 kV/cm and 120 pulses for 30 µs)	Higher α-tocopherols was exhibited by oil from seed pretreated at 7 kV/cm and 120 pulses Higher α-tocopherols was exhibited by oil from seed pretreated at 7 kV/cm and 120 pulses	Guderjan et al. (2007)

Source: Kaseke et al. (2021)

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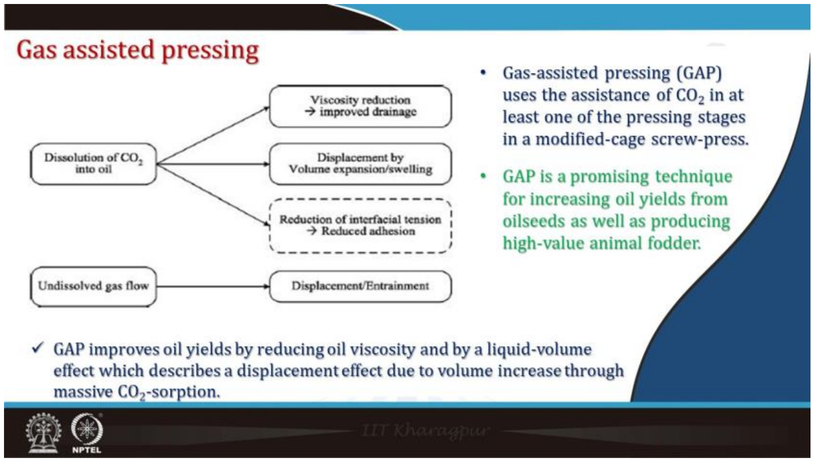
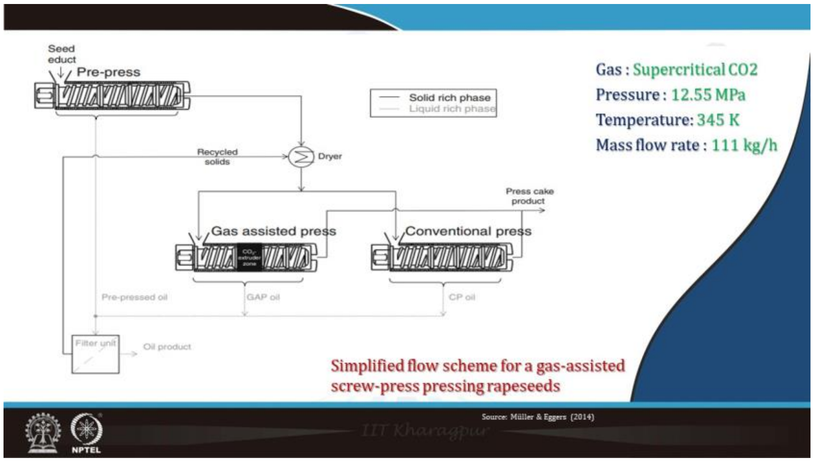
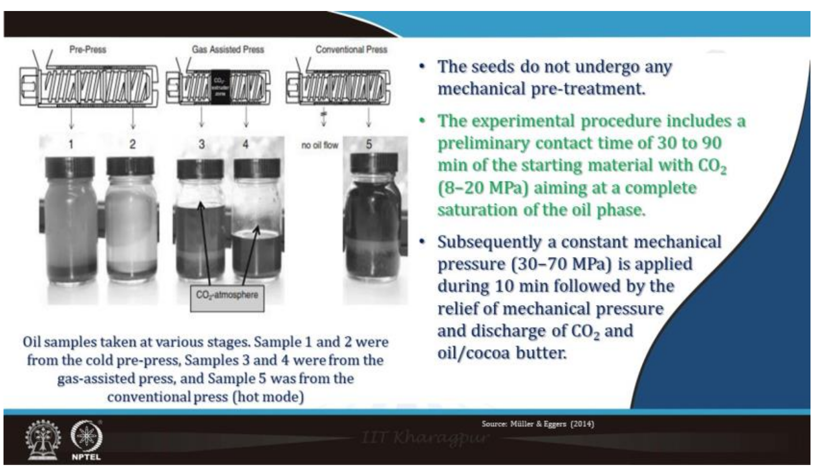
Similarly, in the case of rape seed, that is the delta tocopherol increased from up to 30.07 from 00 ppm after the seed pretreatment with the microwave as well as pulse electric field. In the hemp seed, higher amount of total tocopherols were manifested in oil from the seed digested with natuzyme. Another study said that in the goldenberry, it was subjected to enzymatic pretreatment with Cellulase EC, Pectinase L, in 1 to 1 ratio at 50 degree Celsius, pH was 4.3, enzyme concentration was 2 percent, and treatment time was 2 hours. And in this case, that is these are reporting of Ramadan et al., that the beta tocopherol and gamma tocopherol varied from about 2.1 to 2.11 gram per kg and 1.08 to 1.1 gram per kg respectively after seed enzyme pretreatment. In the case of rapeseed, that is Guderjan et al., they subjected it rapeseed to pulse electric field as of 5 kV per centimeter and 60 pulses, 7 kV per centimeter and 120 pulses for 30 µs. And they found that higher alpha tocopherols were exhibited by oil from seed pretreated at 7 kV per centimeter and 120 pulses.



Then finally, let us see the gas assisted pressing. The gas assisted pressing uses the assistance of carbon dioxide in at least one of the pressing stages in a modified cage screw press. The gas assisted pressing is a promising technique for increasing oil yield from the oilseeds as well as producing the high value animal fodder that is the cake quality is also improved. So, what is done dissolution of carbon dioxide into the oil, it improves the drainage because it results into the reduction in the viscosity. It is displaced there is displacement by volume expansion or swelling or there is a reduced adhesion the reduction in the interfacial tension. So, dissolution of CO_2 that is the when you CO_2 assisted pressing it has advantages like this. The undissolved gas flow, it causes the displacement or entrainment. So, GAP improves oil yield by reducing oil viscosity and by a solid volume effect which describes a displacement effect due to volume increase through massive CO_2 sorption.



This is the experiment that is the set up experimental setup that is a prepress seed educt and it is a passed through a dryer that is the conditioned and then it recycles solids comes filters in it is oil product. So, this is a gas assisted press and conventional press. So, in this they after drying it is can be set the CO_2 gas will come and then it is pressed or in the conventional press. The gas is supercritical carbon dioxide, pressure is around 12.55 megapascal, temperature 345 Kelvin, and mass flow rate is 111 kg per hour. This was reported by Muller and Eggers in 2014 and their experimental setup and on the basis of their study conducted in this. These shows that, their finding suggested that gas assisted pressing has an advantage in both the increasing the oil yield and in improving the oil quality getting better quality oil as well as having a better effect it gives the improved quality of meal as well.

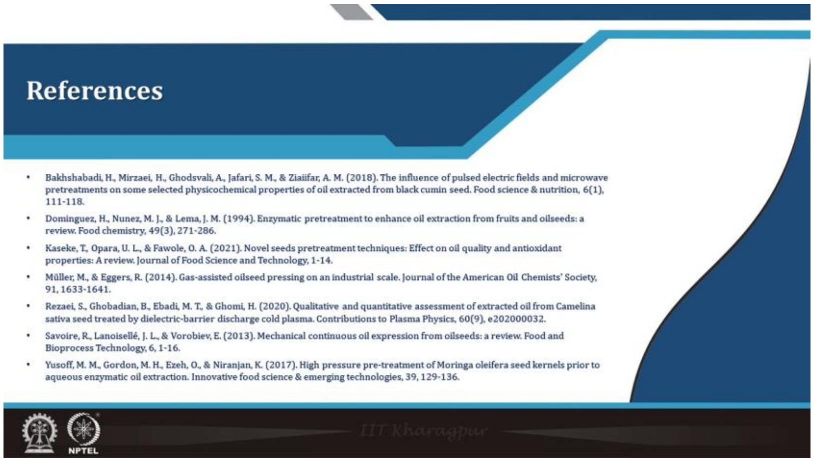


So, these are the oil samples taken as various stages from the experiment sample 1 and 2 where from the cold press seeds, sample 3 and 4 you can see here, they are from the gas assisted press and sample 5 was from the conventional press. The seeds do not undergo any mechanical pretreatment in this case. These are the prepress, then gas assisted press, CO_2 atmosphere and conventional press these are the three setups.

So, the experimental procedure includes a preliminary contact time of 30 to 90 minute of starting material with CO_2 8 to 20 megapascal aiming at a complete saturation of the oil. Subsequently the constant mechanical pressure of 30 to 70 MPa is applied during 10 minutes followed by the relief of mechanical pressure and discharge of CO_2 the oil and cocoa butter and it gives that is this experiment when they were analyzed for both oil and quality yield as well as quality and it was found the both were of superior were higher. The order that is yield was also better by the in the gas assisted press and the quality of the oil and meal was also better.

So, finally, I will summarize this lecture saying that the microwave, ultrasound, pulse electric field, and enzyme pretreatment of oil seeds they are vital for improving the oil quality that is these are they can be considered as a novel technique for the pretreatment of oil seeds before their pressing or solvent extraction. However, the quality of the oil is dependent on the technical parameters such as microwave power, ultrasound power, pulse intensity, exposure time, enzyme concentration parameter that influence the enzyme activity and so on. The type of the enzyme, pH temperature, enzyme concentration, and pretreatment time etcetera reduces the oil yield and quality.

Improvement of the oil, antioxidant properties of the seed are pretreated with a desirable development given in the oil application in functional foods and nutraceutical formulation because this oil seed meal also gets better quality and it has a better application both as a food as well as feed.



These are the references which are used in this lecture this.

Thank you very much for your patience here. Thank you.