Food Oils and Fats: Chemistry & Technology

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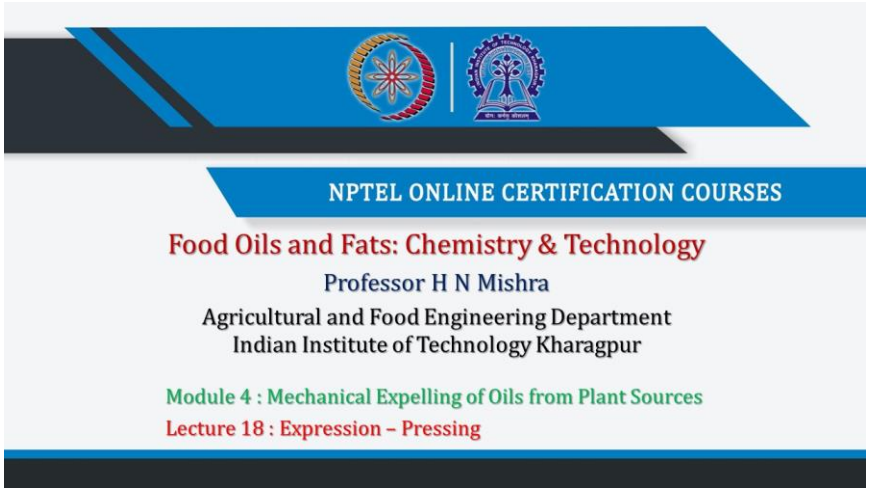
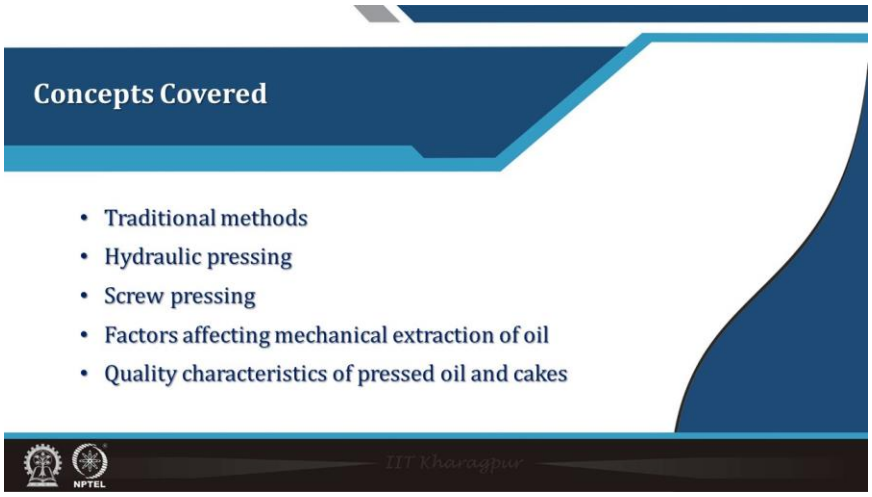
Week – 04

Lecture - 18

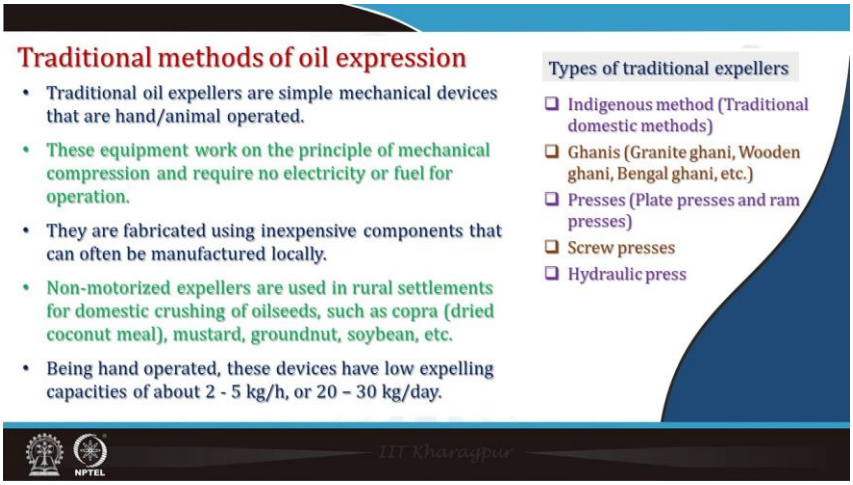


Hello everybody. Now, we are in the 18th lecture of this course and in this, and in the next half an hour, we will discuss the technology of expression, particularly pressing methods and technology which are used for the extraction of oil. In the earlier lecture, we discussed about its concept and mechanism which is when you press how the oil is expressed.



Now, in this lecture, we will concentrate on methods and technology of pressing. We will talk about traditional methods, we will talk about hydraulic pressing, screw pressing

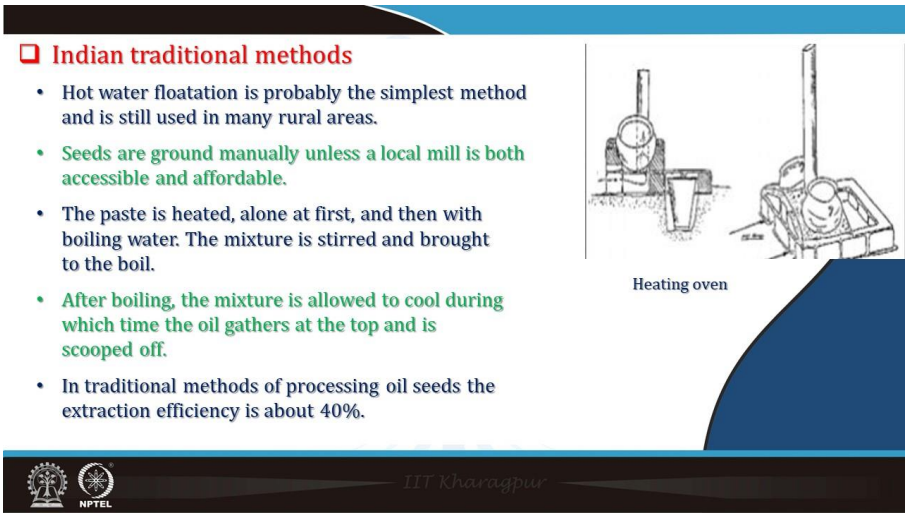
methods, and machines, then factors that affect the mechanical extraction of oil and finally, we will discuss something about the quality characteristics of both pressed oil and the meal or cake which we call. First, let us talk about traditional methods of oil expression.



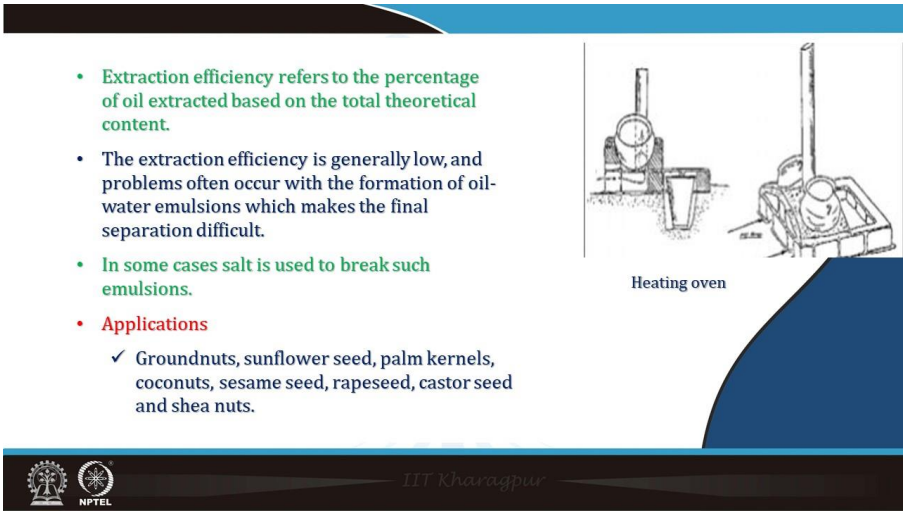
Traditional oil expressers are simple mechanical devices that are hand or animal-operated. This equipment works on the principle of mechanical expression and requires no electricity or fuel for this operation. They are fabricated using inexpensive components that can be often manufactured locally. The non-motorized expressers are used in rural settlements for domestic crushing of oil sheets such as copra, direct coconut meal, mustard, groundnut, soybean, etc.

However, nowadays that is even power-operated motorized expressors are also available and some companies like KVIC, etc. in their Kachigani oil production they use that is power operated Ghani's and all those things. What is Ghani? We will take it a little later. So, these traditional oil expressers being hand operated. These devices have low expelling capacities of about 2 to 5 kg per hour or 20 to 30 kg per day.

So, different types of traditional expressors include that is indigenous or traditional domestic equipment or methods, then Ghani which are granite ghani, wooden ghani, bengal ghani, power ghani, etc. Then presses like plate presses and ram presses, screw presses, and hydraulic presses. These are the different types of pressing machines or pressing methods or technology methods which are used in India even traditionally or even now also they are used. So, let us talk about Indian traditional methods. That is here, traditionally that is what they used to the it is a picture You can see that there is a heating oven.

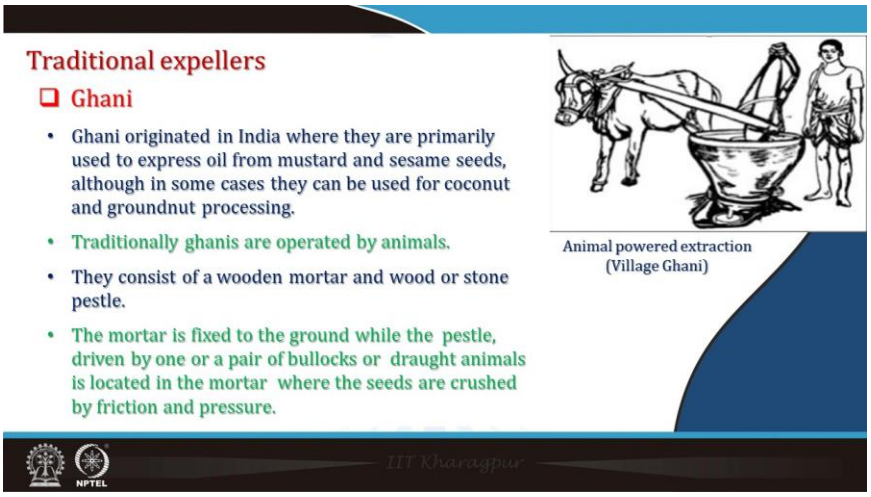


So, hot water flotation is probably the simplest method and is still used in many rural areas. So, what is done? Seats are ground that is manually unless a local mill is both accessible and affordable. So, the ground sheets that the converted to paste or the paste are heated alone at first and then with boiling water and the mixture is yeasted and brought to boil. So, after boiling the mixture is allowed to cool during his time the oil gathers at the top and is scooped off. In the traditional method the processing oil sheets the extraction efficiency is just about 40 percent not even half of the oil more than half of the oil remains in the oil cake.

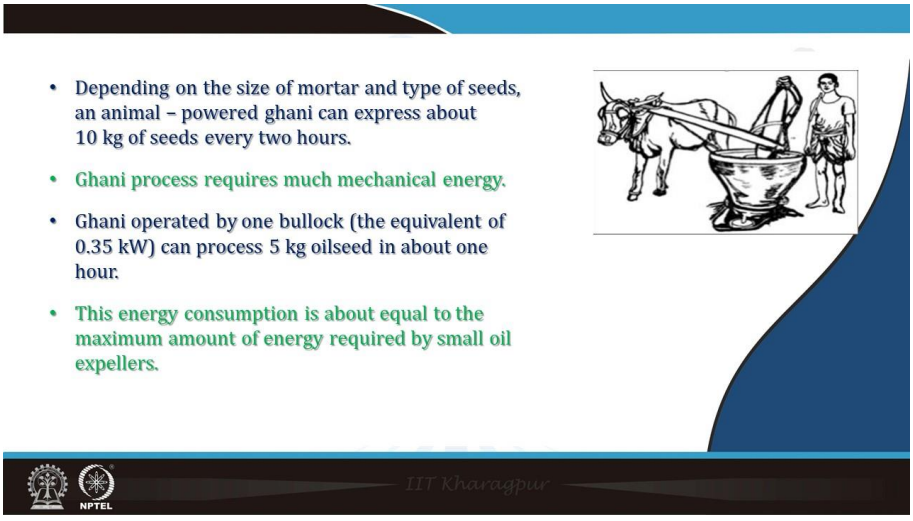


So, just by simple it is just by heating and crushing and then boiling in water. Then, extraction efficiency refers to the percentage of oil extracted based on the total theoretical content. The extraction efficiency is generally low and problems often occur with the formation of oil-water emulsion which makes the final separation very very difficult particularly the low-concentration oil finally, some emulsion is formed. In some cases, salt is used to break these emulsions. So, these methods are applicable to ground nuts,

sunflower seeds, palm kernels, coconuts, sesame seed, wrap seed, castor seed and sia nuts, etc.



Then traditional expelers there are different types of traditional expelers used in India then traditionally we have been using the village Ghani which is animal animal-powered extraction system where there is a post-pestilent motor. So, it is said that this Ghani originated in India where they are primarily used to express oil from the mustard and sesame seeds. Although in some cases, they can be used for coconut and ground nut processing. Traditionally, Ghani's are operated by animals as you can see in the figure. They consist of a wooden mortar and a wood or stone pestle that is there is a mortar and pestle and the seeds are kept inside there is an opening and these bullocks move.

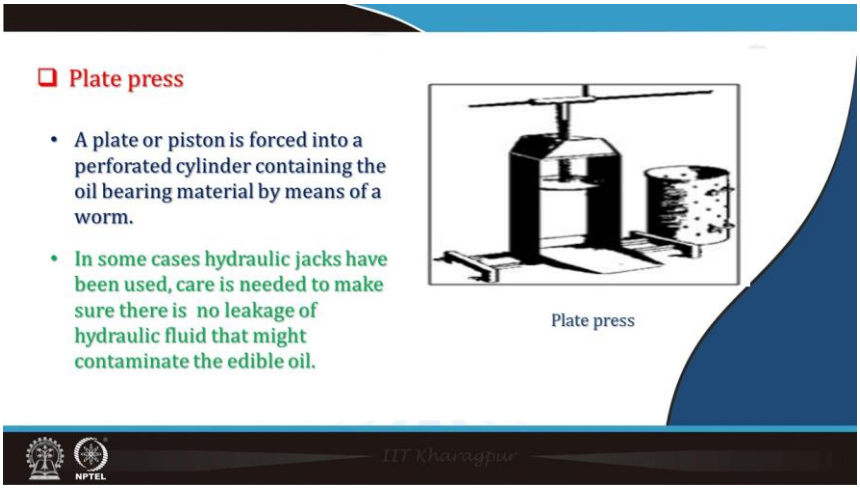


So, there is basically the friction is generated between the through which oil is separated that is oil is expelled and it is collected in that there is an opening. The mortar is fixed to the ground while the pestle driven by one or more pairs of bullocks or draught animals is located in the mortar where the seeds are crushed by friction and pressure to leave. So, depending on the size of the mortar and type of seeds. An animal-powered Ghani can

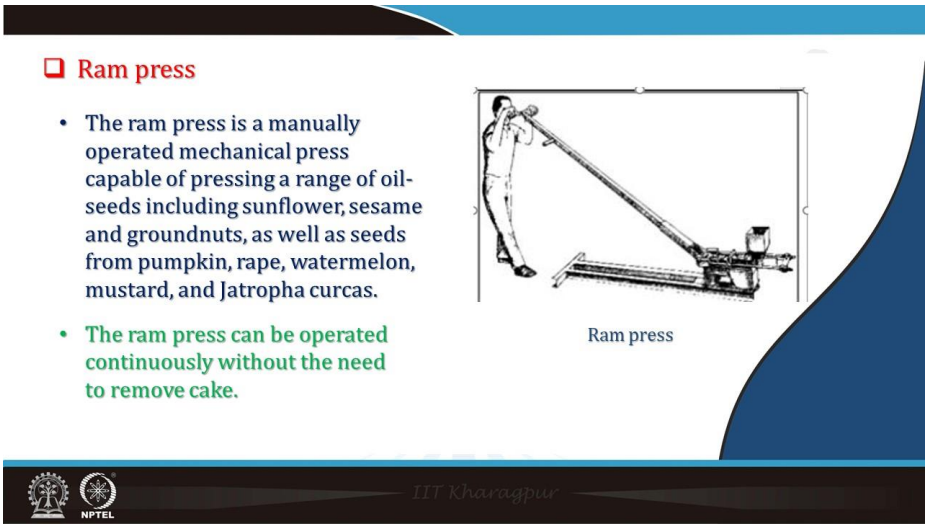
express around 10 kg of seeds every 2 hours. Ghani process requires much mechanical energy.

Ghani operated by one bullock, the equivalent of 0.35 kilowatt can process 5 kg oil seeds in about 1 hour. This energy consumption is about equal to the maximum amount of energy required by a small oil expellers. Then as I told you there are also power-operated Ghani in our country that is the this bullock or animal power is replaced with electrical power. And there are various several manufacturers available they are now making in our country and accordingly, that is the whole pestle and mortar all these are this at their mild steel or steel or iron, etc. is made so that you can see that is particularly the, but this contact surface point of the oil and oil seed cake is normally preferred that it should be of stainless steel. So, this is just simple, otherwise, the technology is the same. There is a 15 kg KOLU power Ghani machine with a gear-box or even other as 0.5 or 7.5 hp electric motor power Ghani machine and its capacity is available up to 20 kg to 750 kg or even more.

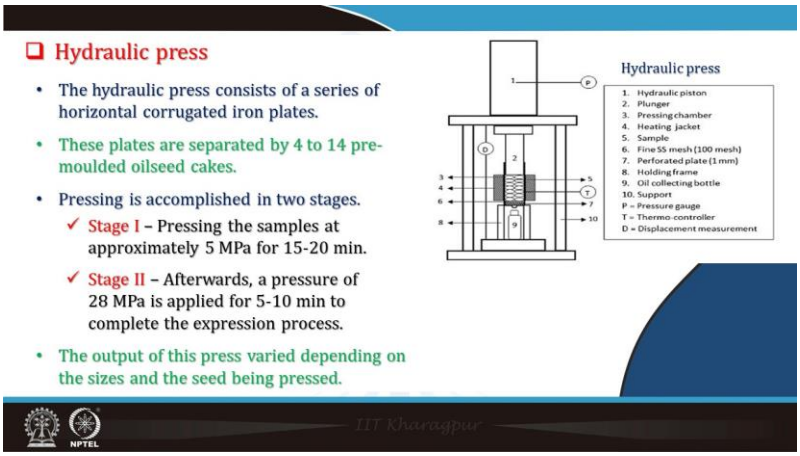
So, different types of you can see the figure here this is the wooden Ghani and where is the replaced by metal Ghani. So, both types of Ghani's are available, and this very popular particularly in rural India and now some industries in fact, as I told you KVIC, etc. produce Kachigani oil and where they mainly use motorized power Ghani.



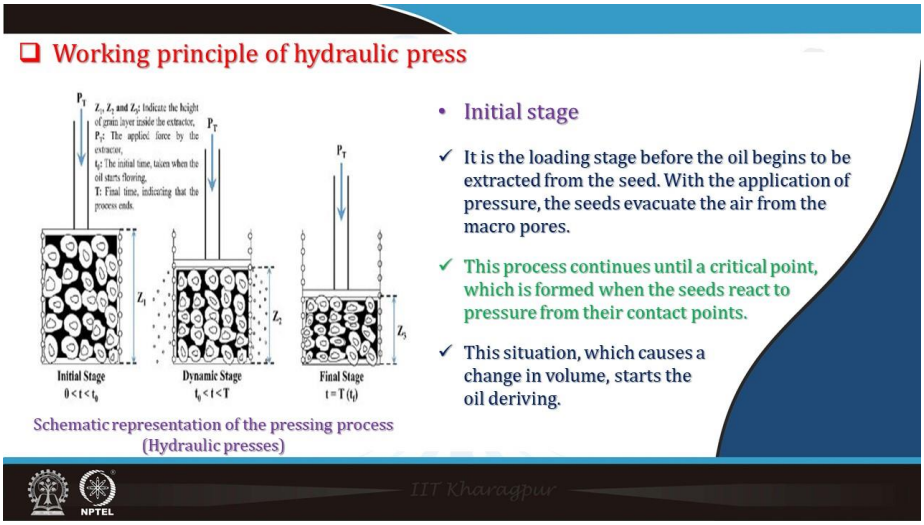
Then about the presses, there are different types of presses as we told there is a plate press. So, in the plate press, you can see that it is a plate or a piston is forced into a perforated cylinder containing the oil-bearing material by means of a worm that is worm. So, this is the plate and here the oil-bearing material is placed. So, once it is pressed and this is a perforated. So, with this perforation, oil passes oozes out and inside the cake remains there. So, in some cases hydraulic jacks have been used, care is needed to make sure that there is no leakage of hydraulic fluid that might contaminate the edible oil. Another type of press is the ram press as you can see here, the figure of the ram press is shown.



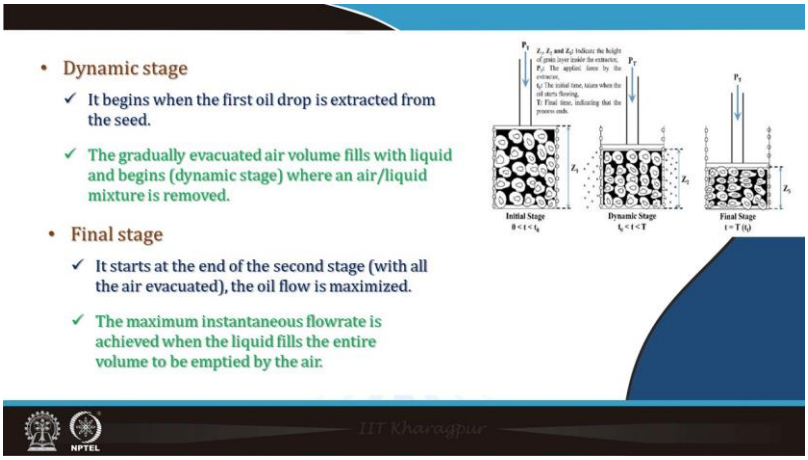
The ram press is a manually operated mechanical press it is capable of pressing a range of oil seeds including salt flower, sesame, and ground nuts as well as seeds from pumpkin, rapeseed, watermelon, mustard, and jatropha carcass. The ram press can be operated continuously without the need to remove the cake. So, that is here that is you put the seeds and the ram pressure that is just by pressing it, the pressure is applied and it gives the oozes.



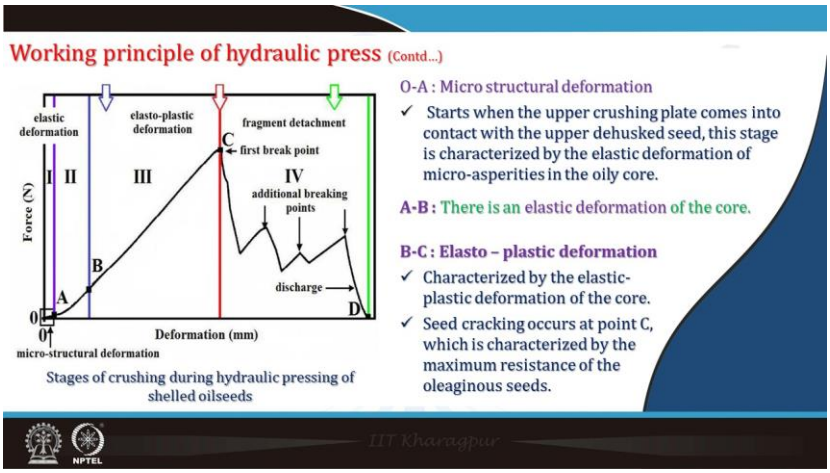
Then hydraulic press, the hydraulic press consists of a series of horizontal corrugated iron plates as you can see inside the picture here. These plates are separated by 4 to 14 press molded oil seed cakes, etc. The pressing is accomplished in two stages, in stage 1, pressing the sample at approximately 5 megapascal pressure for about 15 to 20 minutes, and which obviously, releases the maximum amount of oil, but for the remaining oil that is when the oil quantity is reduced then pressure has to be increased. So, afterwards, a pressure of 28 megapascals is applied for 5 to 10 minutes to complete the expression process. The output of this press varies depending on the size and the seed being pressed. So, you can see here the different components in the hydraulic press or a hydraulic piston, plunger, pressing chamber where the seeds are kept and it is pressed, heating jacket, their samples there are fine, SS mesh, perforated plate, holding frame, oil collecting tube and there is support, etc. And you can see here that is the P, T, and D that is P is the pressure gauge, T is for the temperature controller and then D is the displacement measurement is all these accessories and controls, etc. are provided, but simple is that just by hydraulic that is it is pressed pressing and there is a from the bottom it presses that is the oil is oozes out.



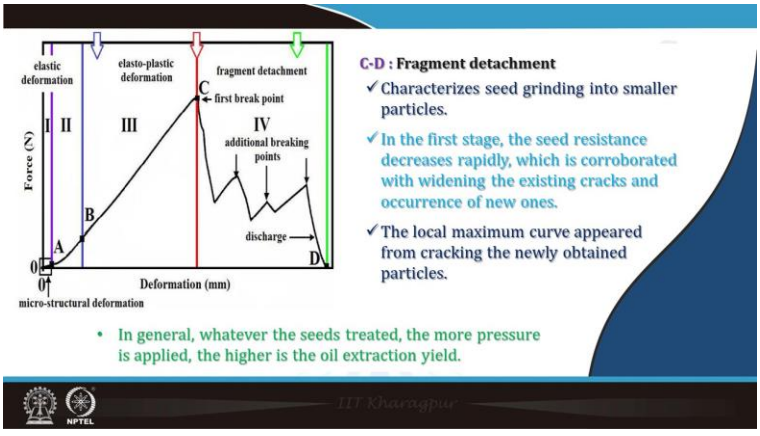
So, the working principle of the hydraulic press you can see here there is the schematic representation of the pressing process, in the hydraulic press is shown that is in the initial stage that is first in the initial stage, it is the loading stage, before the oil begins to be extracted from the seed with the application of pressure, the seeds evacuate the air from the macropores. So, that is in the initial stage that is oil does not exist, but when you press there is the air, what is there present in the micropores, etc. in that the seed is removed and this process continues until a critical point which is formed when the seeds react to pressure from their contact points and this situation which causes changes in the volume starts the oil driving. So, this is the initial stage.



Then comes the dynamic stage, in the dynamic stage you can see that the second stage is the dynamic where T is more than T0 but less than T, and a pressure P is applied here in this case. It begins when the first oil drop is extracted from the seed at this stage now at the gradually evacuated air volume fills with the liquid and begins where that is the dynamic stage begins where an air-liquid mixture is removed and then finally, it comes the final stage where T becomes capital T is a Tf that is it starts at the end of the secondary stage that is after when all the air has been evacuated and the oil flow is now maximized. The maximum instantaneous flow rate is achieved when the liquid fills the entire volume to be imputed by the air.

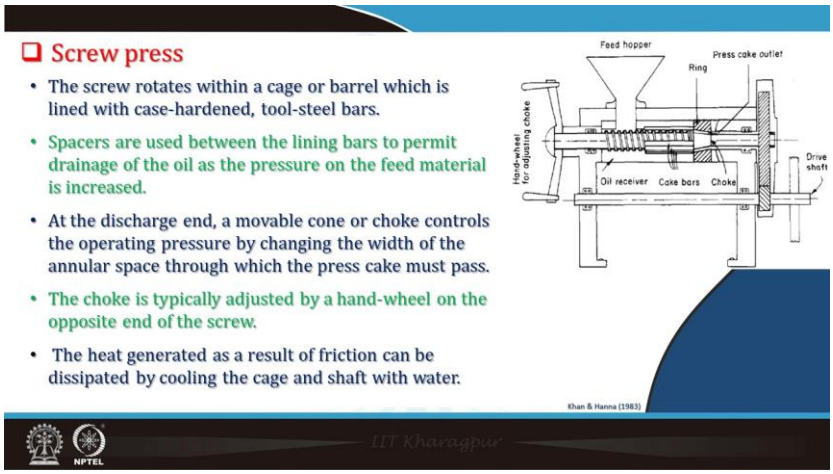


So, this is the same the working principle whatever you told that pictorially you can see that the first second that is first is the elastic deformation that is O to A. O to A is the there is a microstructural or microstructural deformation then you apply the pressure that is this is the deformation size and there is the force when you give the force that different deformation will take place. So, first is the microstructural deformation, it starts when the upper crushing plate comes into the contact with the upper dehusked seed. This stage is characterized by the elastic deformation of the micro asperities in the oily core and then from A to B, this is the there is a second stage, it is the elastic deformation stage that is here this elastic deformation of the core takes place and then comes from stage from B to C that is you can see further the force is increasing then this results into the elasto plastic deformation that is characterized by the elastic plastic deformation of the core that is seed cracking occurs at point C at this way and which is characterized by the maximum resistance of the oleaginous seeds.

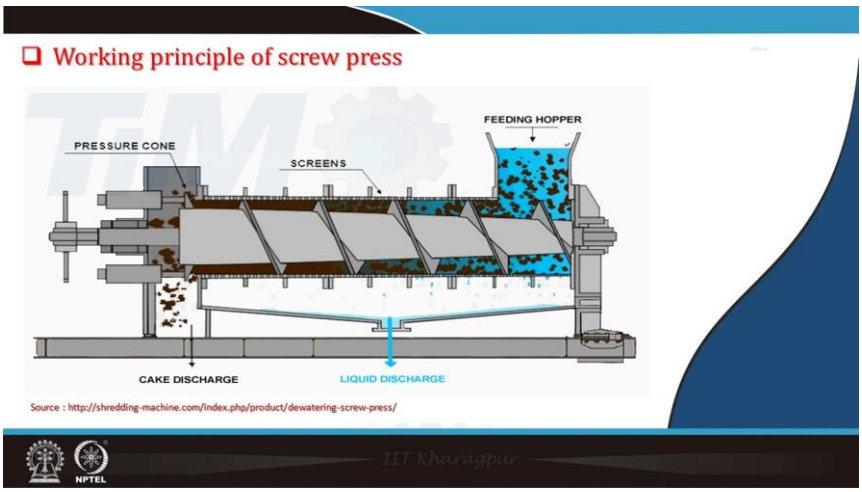


Then this after, from C to D finally, see this is a characterizes seed grinding into a smaller particle size and the in the first stage the seed resistance decreases rapidly which is corroborated with widening the existing cracks and occurrence of new ones and the local maximum curve appeared from cracking the newly obtained particles that is you see the additional breaking points and then finally, it releases that cause the oil to flow and oil is

released. So, in general, whatever the seed treated the more the pressure is applied, the higher is the oil extraction yield.

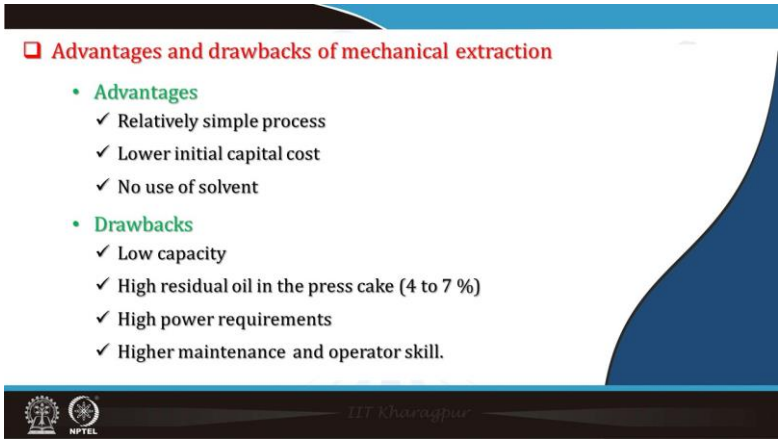


Now, talk about a screw press you can see in the figure that is the screw presses they had some hopper there is a there is a screw design here where the which becomes when it comes to the end it becomes selectively closer pitch. So, now, this screw rotates within a cage or a barrel which is lined with case hardened tool steel bars and there are spacers. The spacers are used between the lining bars to permeate the drainage of the oil as the pressure on the seed material is increased that is when this is the hopper and this operated either manually, but mostly power operated and it goes towards it. So, when it goes it is progressively closer pitch and this pressure increases as the discharge in a movable cone or choke controls the operating pressure by changing the width of the earlier space through which the press cake must pass. The choke is typically adjusted by a hand wheel and at the opposite end of the screw. The heat generated as a result of the friction can be dissipated by cooling the cage with shaft and the shaft with the water.

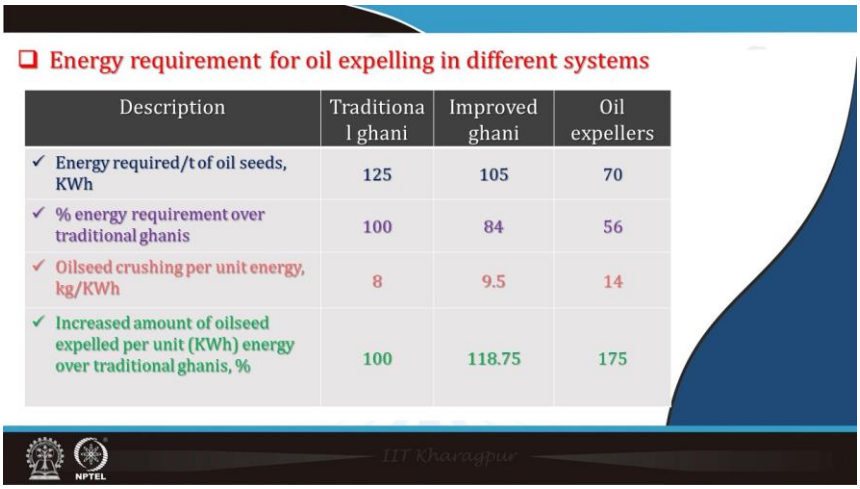


So, it is provided with the water cooling arrangement, etc. that can be done. So, this is about the screw press you can see here in this operation that is the for it is hopper the

material is coming and it is good at it moves here. That is the oil gets squeezed that is pressed and oil-liquid discharge cake and finally, the cake is getting here, it is a pressure cone. So, this is the simple screw expelling and this cake till it is again recycled till we get the maximum amount of oil released and this is a filter press and then you can get the oil discharge.

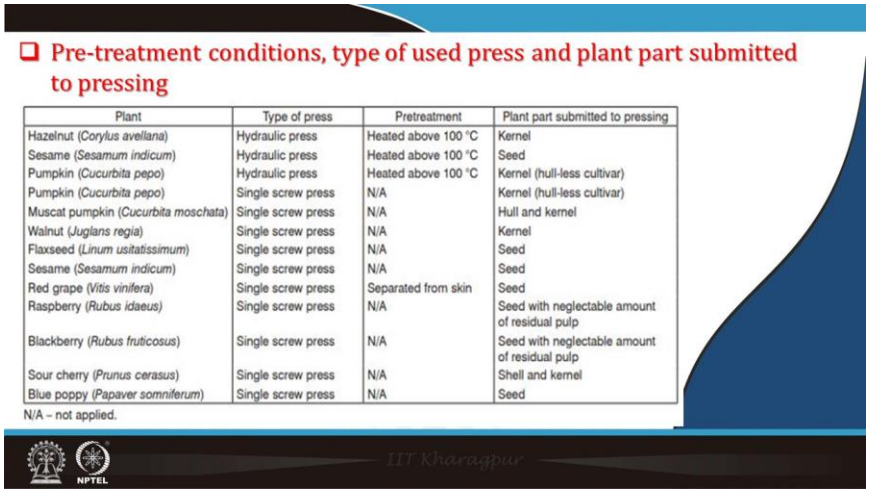


So, this is about schematic representation of the principle of working of a screw press. So, the advantages and drawbacks of mechanical extraction that is the advantages of part relatively simple process, they are lower initial capital cost and there is no use obviously, of solvent any. So, but drawbacks are they are low capacity, high residual oil there in the cake, mostly of the 4 to 7 percent as sometimes as high as 8 to 9 percent. Then high-power requirements and high maintenance and cost and operational skills etc. is needed.

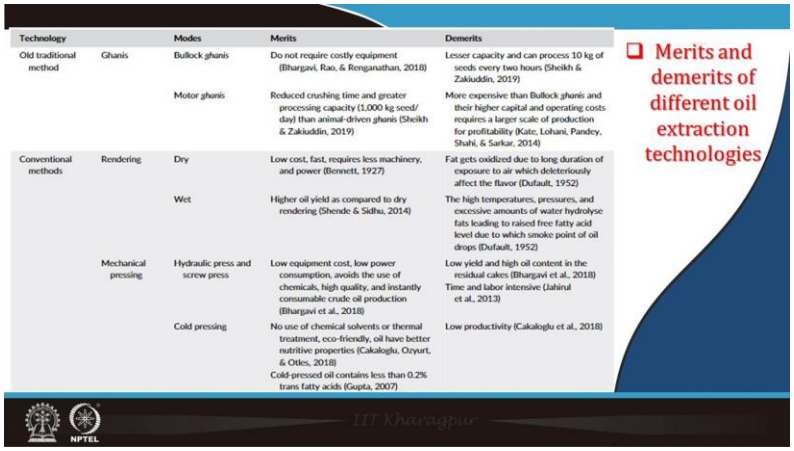


So, in this table, I have just given you some of the energy requirements for oil expelling in different systems like traditional Ghani, improved Ghani, and oil expellers. So, the energy required per ton of oil seed in kilowatt hour in the traditional Ghani is 125 kilowatt hour. Whereas, in the improved Ghani – 105 and oil expeller resistance is just so much. Less energy is required in the oil expellers. Then percentage energy requirement over traditional Ghani that is if you take this 100 percent. So, the improved Ghani it

needs only 84 percent of that and this is oil expellers almost half of that that is 56 percent. Oil seed crushing per unit energy that is kg per kilowatt hour in the traditional Ghani is 8, improved Ghani 9.5 and oil expeller is 14. So, the increased amount of oil seed expelled per unit energy over traditional Ghani that is if you take is 118 percent in the improved Ghani and even in the oil expellers, it is 175 percent. So, here they are these are the various pretreatment conditions, types of used presses and plant part which are submitted to pressing normally.

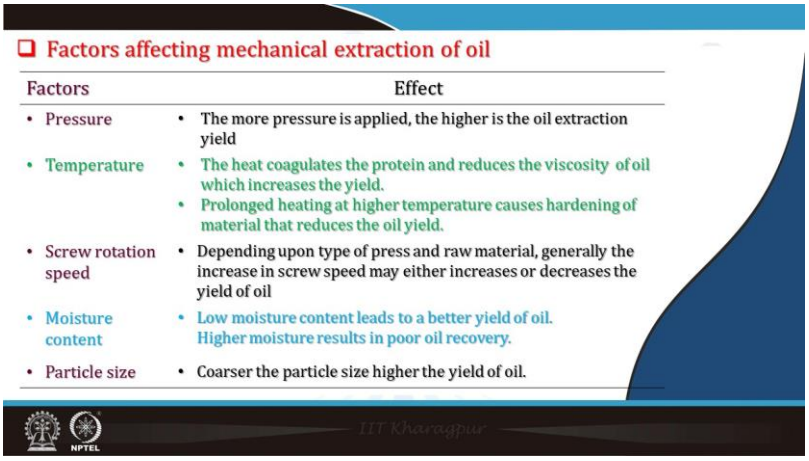


So, you can see here for hazelnut, sesame, and pumpkins. Normally hydraulic presses are used and these are the pretreatments, all these three they are heated above 100 degree Celsius and normally in the hazelnut it is the kernel, in the sesame it is the seed and also in the pumpkin it is the kernel that is a hull less cultivar. So, these are normally the parts of the plants which are used for the extraction. Then there is also the in the pumpkins that muscat pumpkin, walnut, flax seed, sesame, red grape, and raspberry, in all these generally they go for the single screw is press and pretreatment generally not used except for the red grapes where there is the skin is separated. And then in the case of pumpkin hull seed kernel, this is in case of muscat pumpkin hull and kernel, this walnut it is kernel whereas, in the flax seeds, sesame, red grape, etc. it is the seeds are used for oil extraction. In raspberry, it is a single screw press with no treatment seed with a neglectable amount of residual pulp. Similarly, blackberry, sour cherry, and blue poppy, normally that is a single screw press is used and no treatment pretreatment is given. In the blue blackberry, it is the seed and sour cherry it is a shell and kernel, and blue poppy is the seed that is the part of the plant which is used for oil extraction.



So, here that is the merits and demerits of different oil extraction technology we have already discussed earlier also we have talked this is a some of the review collected from various researchers which they have then like if you see the traditional ghani maybe bullock ghani its merit it does not require costly equipment, but it is as a lesser capacity and can process 10 kg of seeds every 2 hours. Motor ghani is there, merit is that, it has reduced crushing time and has a greater crushing capacity, than in comparison to the bullock ghani, but here again more expensive than the bullock ghani and their high capital cost is required.

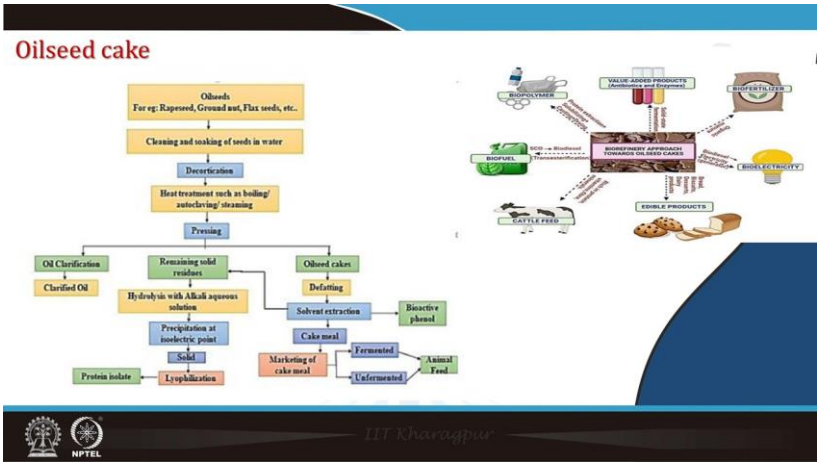
Then the conventional method if you see that mechanical pressing hydraulic press and screw press, their merit is low equipment cost, low power consumption, avoid the use of chemical high quality and instantly consumable crude oil production whereas, its demerits are low acid and low yield and high oil content in the residual cake and they are time and labour intensive. Cold pressing, there is no use of chemical solvent or thermal treatment. These are ecofriendly, the oils have better quality, and better nutritive value. Cold press oil contains less than 0.2 percent transferred acid etc. very less or negligible transferred acid, but these are low productivity and their demerits is a low productivity.



So, these are some of the factors which affect the mechanical extraction of oil different factors like pressure are important factors earlier also. I elaborated on this that is, the heat

calculates the protein and reduces the viscosity of the oil which increases the yield. Prolonged heating at a high temperature causes hardening of the material that reduces the oil yield. So, this is the effect of the temperature. If you of course, the heat causes the coagulates the protein and it reduces the viscosity of the oil which increases the yield, but it should not be excessive heating if you do go for excessive heating that is high temperature will cause hardening of the material. The pressure earlier also told the more the pressure applied higher yield the oil yield and extraction yield.

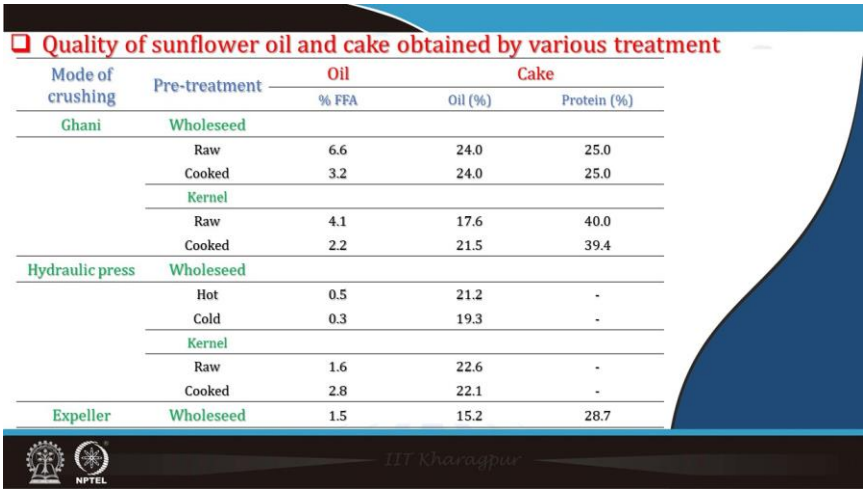
Then screw rotation speed, in a screw expeller depending upon the type of the press and raw material generally, the increase in the screw speed may either increase or decrease the oil yield. Moisture content, low moisture content lead to a better yield of oil. Higher moisture results in poor oil recovery. Particle size, coarser the particle size higher will be the yield, but at the same time that if they very fine particle size, etc. are there, they may choke that they may act as a that some sort of they may create barrier when you are applying the pressure particularly. So, it may become a hard cake and it may reduce the oil yield, but also the other drawback is that this particle size particles if they are very fine particle they may go with along with the oil and there may be more refining losses refining cost cleaning cost etc.



So, here it is about oil seed cake another very important. After the extraction the cake valuable material which we are getting that is particularly depending upon except for the mustard seeds which have certain undesirable components in the hull and the dehulled mustard seed when it is used particularly there is the thioglucosinoylates, etc. which are there which are not good for health. So, it is not suitable for human consumption otherwise all other most of the oil seeds are used. So, there is after the extraction of the like sesame, pumpkin seeds, or even peanut oil or soybean all this there is the after the extraction of the oil the residue that remains that is a very good quality material which can be used for various food purposes Of course, these cakes might require certain further reprocessing, etc. to make it edible and use in the food formulation. So, this is the oil seed cake which is obtained by de-fatted solvent extraction that is solvent extraction

cake the bioactive phenols and then the cake is ground into meal. Marketing of the cake meal or it can be fermented or un-fermented can be used as an animal feed etc. So, this cake feed depends upon the process from which particularly if you are taking the cake which is obtained from the mechanical extraction.

So, this cake has a high quantity of oil. So, normally what they do this is further flaked and then it is sent to the solvent extraction. So, that the maximum oil or alternatively this cake with little more amount 4, 5 amount percent of the oil can be used i.e. it can be further dried, grounded into fine particles, and then it can be used in various food preparations food formulations, etc. So, this biorefinery approach towards the oil seed cakes, etc. if you can say it can be used for edible products, cattle feed, it can be biofuel or biopolymers value-added products in bioelectricity, biofertilizer. So, various applications can be there of course, as of course, towards the end of this course we will discuss some of the potential common technology for utilization of these byproducts of the oil which is a valuable byproduct kale cake or oil seed meats, etc. We will discuss about that more detail.

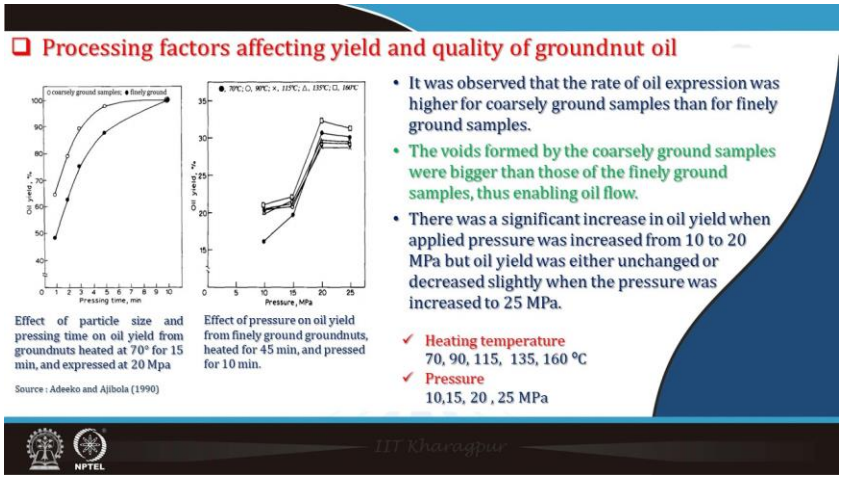


Mode of crushing	Pre-treatment	Oil	Cake	
		% FFA	Oil (%)	Protein (%)
Ghani	Wholeseed			
	Raw	6.6	24.0	25.0
	Cooked	3.2	24.0	25.0
	Kernel			
	Raw	4.1	17.6	40.0
	Cooked	2.2	21.5	39.4
Hydraulic press	Wholeseed			
	Hot	0.5	21.2	-
	Cold	0.3	19.3	-
	Kernel			
	Raw	1.6	22.6	-
	Cooked	2.8	22.1	-
Expeller	Wholeseed	1.5	15.2	28.7

So, the quality of the oil seed and cake this particularly you have taken example of sunflower oil and it is obtained by various treatments we are taking Ghani, hydraulic press, and expeller press. So, the pretreatment for Ghani that is if you see the whole seed, the whole seed raw, and cooked. So, it has a free fatty acid percent around raw 6.6 percent cooked less free fatty is 3.3 percent in the oil recovery in both it is about oil in the cake is around 24 percent. As high as 24 percent oil remains in the cake and the protein is 25 percent.

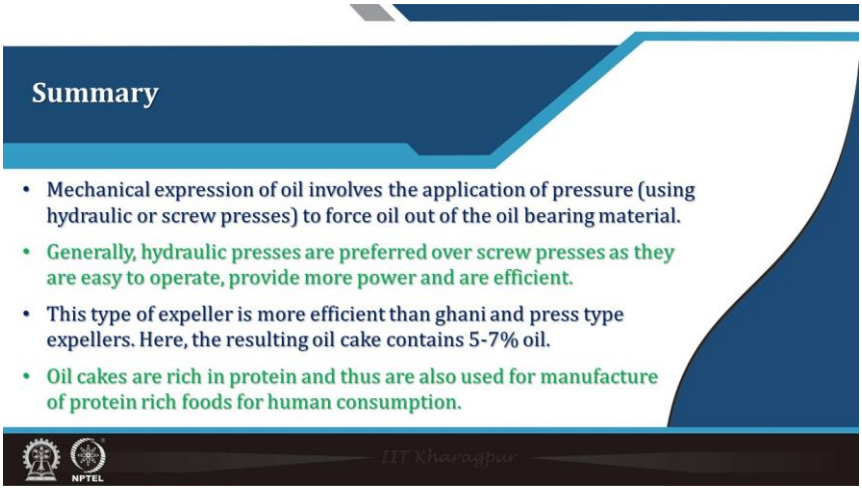
So, you see these have a very good sunflower meal, that is in the cake and it has a very good quality oil as well as protein both. Similarly, kernel if you see there is a sunflower kernel, there is a raw kernel percent, it has 4.1 percent free fatty acids cooked kernel has 2.2 percent fatty acids. Oils in the cake, there is about 17.6 percent oil in the cake and 21.5 percent in the cooked one, and the protein has most in both the 40 and almost 39.4.

Then when it is used as a Ghani, but when hydraulic press is used then in the whole seed that is a hot sunflower seed whole seed it is oil in oil free fatty acid is very less, but in the cake oil content is around high that is about 21 percent and in cold press 19.3 percent. Similarly, in the kernel raw and cooked, free fatty acid content may be 1.6 to 2.8 percent respectively, and oil content in both the cake is around 22 percent. Then the same thing is done by expeller expelling then free fatty acid is around 1.5 percent, oil in the cake is 15 percent like here, that oil in the cake is reduced by expeller expelling and the protein in the cake is around 28.7 percent.

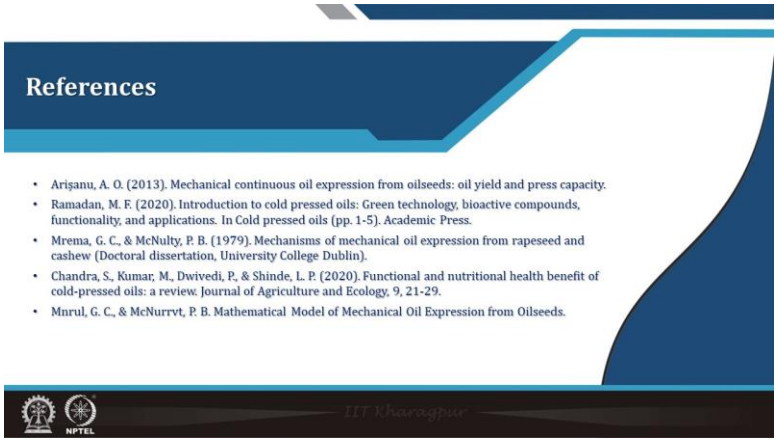


So, the various factors which influence the yield and quality of the grounded oil you can see that is where some experiments were conducted that is the heating at it were applied at temperature 70, 90, 115, 135, and 160 degree Celsius and the pressure were 10, 15, 20, and 25 megapascals. So, the various particle sizes, that is ground nut oil of varying particle size, they were subjected to different temperature and pressure conditions and its effect on the oil yield was taken the pressing time and oil this is given here at a vertical. The effect of particle size and pressing time on oil yield in ground nut heated at 70 degree Celsius for 15 minutes and expressed at 20 MPa. This see as the pressing time is increasing the oil yield is increasing in both cases.

Similarly, the other graph here the pressure versus oil yield effect of pressure on oil yield. So, you can see from here in the figure that the rate of oil expression is higher for coarsely ground samples than for finely ground samples. The void formed by the coarsely ground samples was bigger than those of the finely ground samples and thus it enabled the oil flow. There was a significant increase in oil yield when applied pressure was increased from 10 to 20 megapascals, but oil yield was either unchanged or decreased slightly when the pressure was increased to 25 megapascals.



So, finally, I will summarize this lecture by saying that the mechanical expression of oil involve the application of pressure that is either it uses hydraulic pressing or a screw pressing and these presses are used to force the oil out of the oil-bearing material. Generally hydraulic presses are preferred over a screw press as they are easy to operate, provide more power, and are more efficient. This type of expeller is more efficient than Ghani and press-type that is screw expellers that they are more efficient than Ghani and press type expeller. Hence the resulting oil cake contains around 5 to 7 percent oil. Oil cakes are rich in protein and thus are also used for the manufacture of protein-rich food for human consumption. They can be there is great potential of course, that is that these oil seed cakes should be properly utilized and of course, before that they need to be properly that is some processing they need to be refined and made into edible products for fine powder, etc. and the food can be formulated using these or they can be used as a protein source.



These are the references that we have used in this lecture. Thank you very much for your patience here.