Post-Harvest Operation and Processing Of Fruits, Vegetables, Spices and Plantation Crop Product

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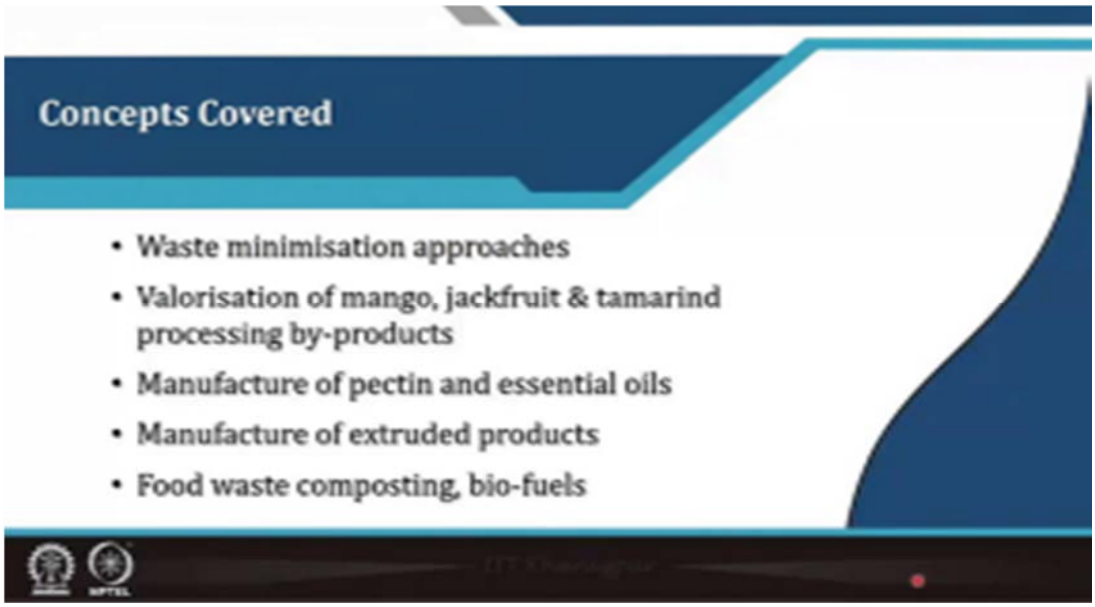
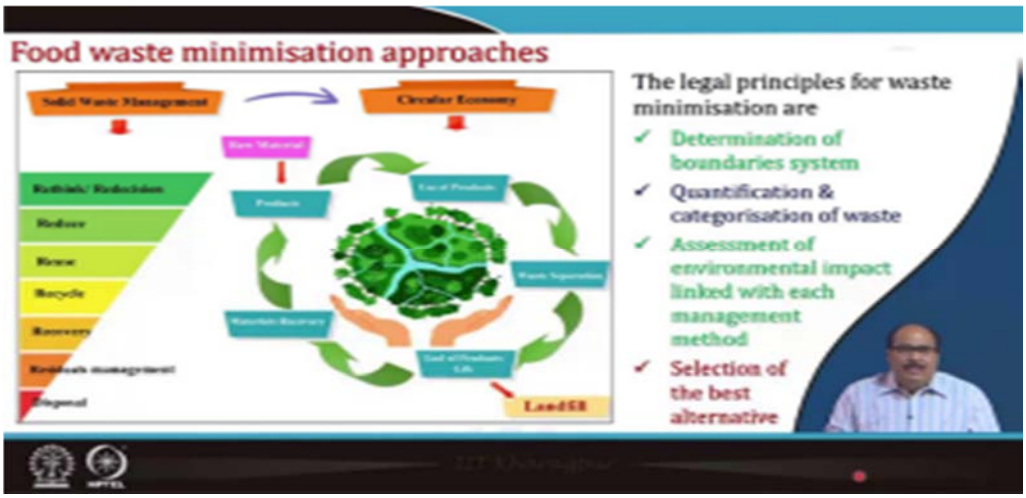
Lecture 58
Valorisation of Waste into Value-added Products



This lecture is about Valorisation of waste into value-added Products. The various approaches for waste minimization, various case studies of mango, jackfruit and tamarind processing by products and their valorisation, manufacture of pectin's and essential oils from citrus and other fruit industry waste, manufacture of ready to eat extruded products from apple pomace and food

waste composting and bio-fuel from the fruits and vegetable processing waste is discussed in this lecture.



Food waste minimisation approaches

The food waste minimization approaches include the solid waste management which consist of the following

- Rethink
- Re-decision
- Reduce
- Reuse
- Recycle
- Recover
- Residual management
- Disposal

It is very helpful in the circular economy where the raw material instead of going in the landfill and can be utilised in end products along with phases of water separation leading to end of product's life and recovery of the product.

In general different legal principles of minimization of the waste from the food industry or in particular the fruits and vegetable processing industry include

- Determination of the boundary system : determining the boundary of the ecosystem. Measures to produce minimum waste and make appropriate changes in the use of raw material, process operations, process technology and management etc.
- Quantification and categorization of the waste: different waste can be categorized into

different ways.

- Assessment of the environmental impact linked with each management method.
- Selection of the best alternative: best method which reduces produces minimum waste and whatever waste is produced can be appropriately utilized reused recycled.

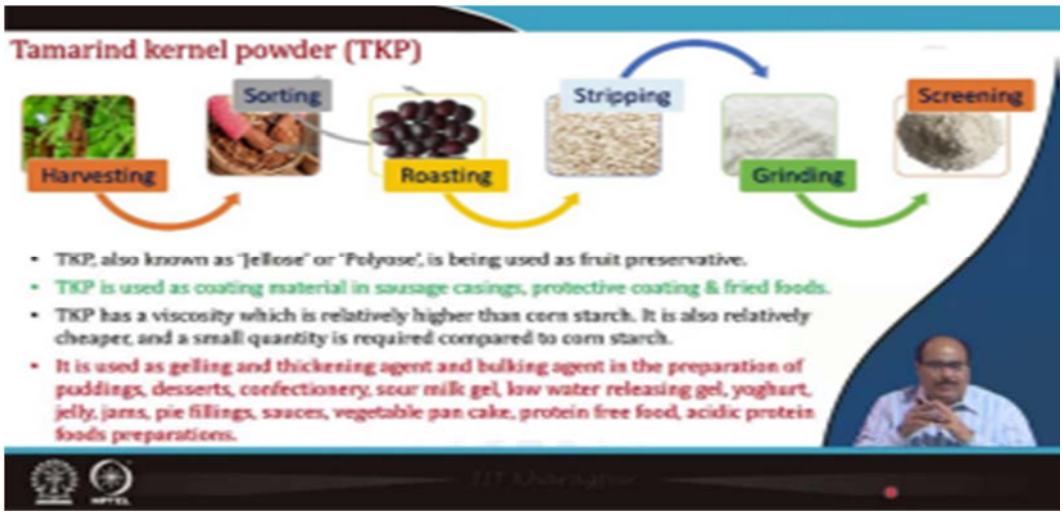
Food waste valorisation

The food waste valorisation is basically the conversion of food waste or by-products into higher value products that contribute back to the food supply chain. This contributes to the circular economy approach, where useful material in the food processing industry which was seen as waste, is recycled back into the supply chain to create new products. It is collected and reused and then it is recycled back into the supply chain to create a new product. So, it generates value, it is one of the food waste recycling pathway that can help to close the appropriate food waste loop and there are nine stage categorization of the waste include the

- Edibility: whether the waste is edible or non-edible
- State: that it is eatable or spoiled or already damaged even wastage also disintegrated and damaged
- Origin: whether it is an animal based or plant based
- Complexity: the single product waste or it is a multiple product waste
- Animal product presence: animal product, meat, by product from animal bodies and in contact or not in contact with animal waste product.
- Stage of the supply chain: where like it is a catering industry waste, or non-catering industry waste.
- Treatment: what are the treatments required for this processing or unprocessed whether it is the processing waste or peeling waste or washing waste or whatever type of

wastage

- Packaging: even what type of packaging material is used, it is packaged or unpackaged
- Packaging material: it is biodegradable packaging or non-biodegradable packaging
- Then categorize it and approach the best management mechanism and accordingly go for the proper valorization of the product.
- Preparation of the product either extraction of bioactive, pigments or other ingredient making into various products.



Tamarind kernel powder (TKP)

Tamarind is a very useful fruit and it is used in the pickles, chutneys or in daily cooking etc. The fermentation of tamarind kernel or seed is done after the tamarind pulp is used for various value-added product. The kernel which is obtained it has got a very valuable component. So, the tamarind kernel that is a processing waste it is sorted and then kernels are roasted and the outer cover hulls are removed and finally using appropriate grinding methodology it is ground into fine powders.

This tamarind kernel powder is basically known as jellose or polyose and it is used as a fruit preservative. It is used as a coating material in sauces, castings, in a protective coating and even fried foods etc. It has a very good viscosity which is relatively higher than corn starchit is also relatively cheaper and a small quantity is required compared to corn starch to get that desired effect. So, TKP has a various beneficial use in the food processing operations as the food additives in the food industry.

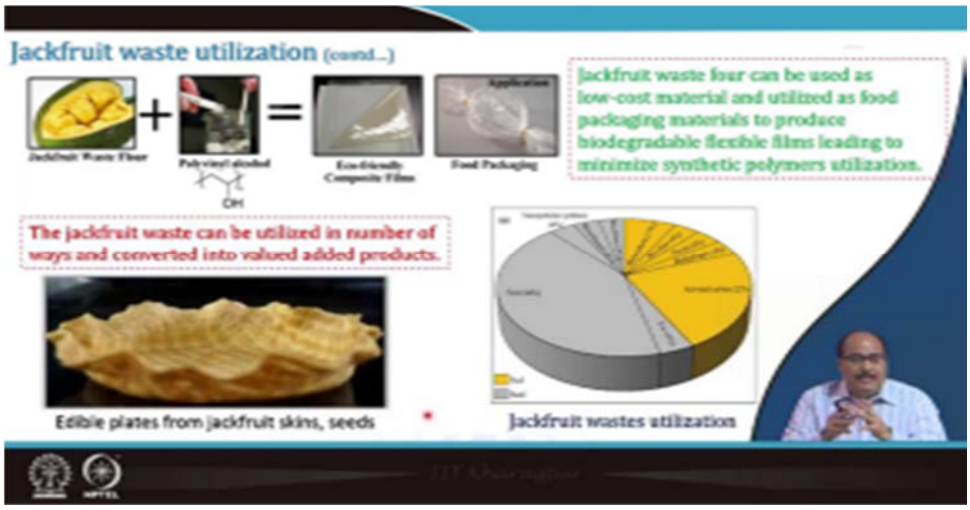
TKP can be used as a thickening agent and bulking agent in the preparation of puddings, deserts, confectionery, sour milk gel, low water releasing gel, yogurt, jelly jam. It can be used in pie fillings and sauces, vegetable pancake or in protein free food etc.

Thus, tamarind kernel can be collected and can be hygienically converted into good quality value powder. the powder characteristic particularly starch quality is at par to available thickeners. So, TKP could be a very good business line and various start-ups could work in this direction.

Jackfruit processing waste utilization

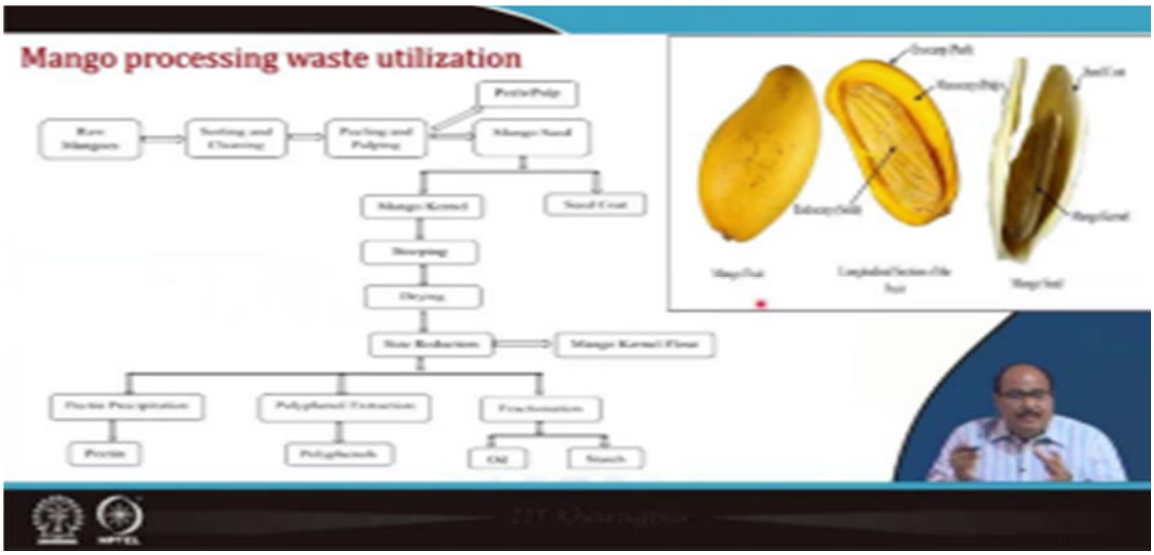
In India, almost all state produce jackfruit and the jack fruit and basically pulp is used for edible purposes and peel, seed and latex remain as waste. So, these can be for waste processing, they can be subjected to various treatment like the conversion technology. For example

1. **Peel**: Peel can be subjected to gravimetric method and the pectin can be extracted and pectin has various application in food industry. This peel can be used as activated carbon by conversion technology and this activated carbon can be used as absorbent. The peel can be subjected to anaerobic digestion process and it can be converted into bio hydrogen which is a source of bioenergy.
2. **Seeds:** seeds can be dried and milled and one can get the seed flour and fermentation leading to red pigment. This can be used as a source of good starch in various food preparations. Then granulation technique and encapsulation technique can be used in the contribution to confectionary industry. The seed powder can be used as a low GI ingredient and cellulose nano particle from seeds in the packaging it can be made use up in packaging films.
3. **Latex:** As a medicinal use latex fermented with mixed with vinegar which could heal abbesses and glandular swelling. then proximate enzymes extraction can be used for pesticide detection in food testing laboratories. Latex mixed with rubber and cement can be an excellent engineering material.



Jackfruit waste utilization

Jackfruit waste can be converted into value added products i.e. It can be used for making the low-cost material and utilized as a food packaging material to produce biodegradable film and leading to minimize the synthetic polymer utilization. So, jackfruit waste flour can be treated with polyvinyl alcohol and developed into eco-friendly composite films, it can be used for packaging chocolate and many other confectionary products. some institution in our country have worked on and they have developed edible plates from jackfruit skins and seeds etc. About 44 to 45% of the peel is used in flour and remaining that is about 4% is fat, 4% product is converted into biofilm or bio-chem, bioethanol or nanoparticle synthesis for processing. Similarly, about 22% peel is converted into activated carbon and the other into bio ethanol pectin, biofilm, bio-absorbency so, this has the potential to apply.



Mango processing waste utilization

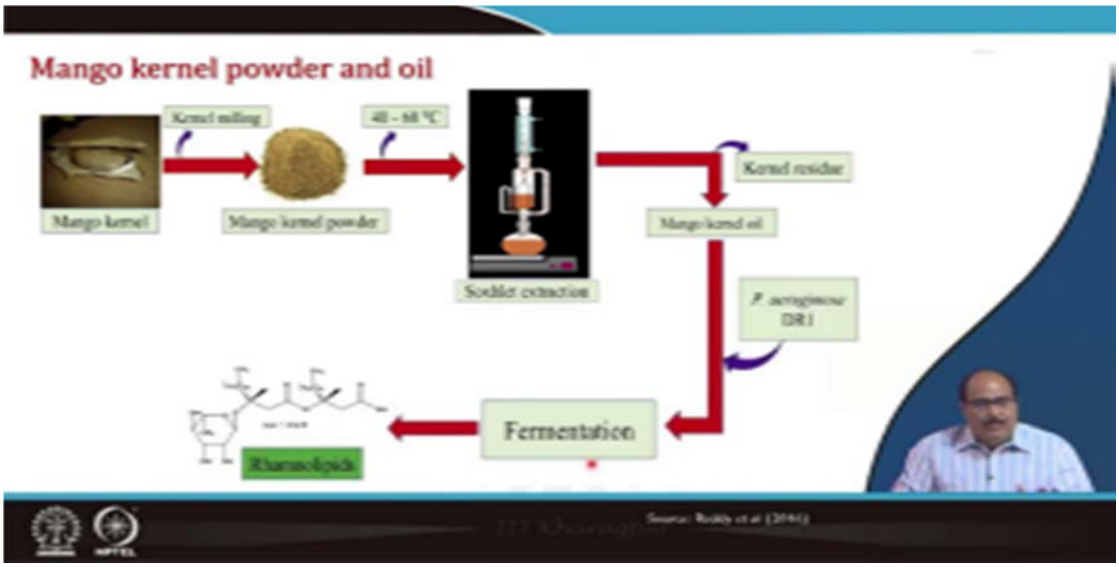
Another very important fruit crop in the country is mango and generally mango is used for its

juice and pulp. So, the major by-products of mango is its peel and mango kernel. Seed has outer seed coat and inside there is a kernel. The pulp is one useful ingredient but after the juice extracted this pulp also had some fibrous components and even the peel is a good source for quality fiber, good colours etc.

For processing mangoes, cleaning sorting after that pulp is obtained and then seed is recovered which have the coat and the kernel. The seed coat can be used as a fuel. The kernel is steeped and dried and size reduction by which mango kernel powder and mango kernel flour is obtained which has a good quality fat and carbohydrate and this can be done by fractionation. So, this flour further can be size reduced for formation of pectin by precipitation or even polyphenol extraction or fractionation of oil and starch. The of mang

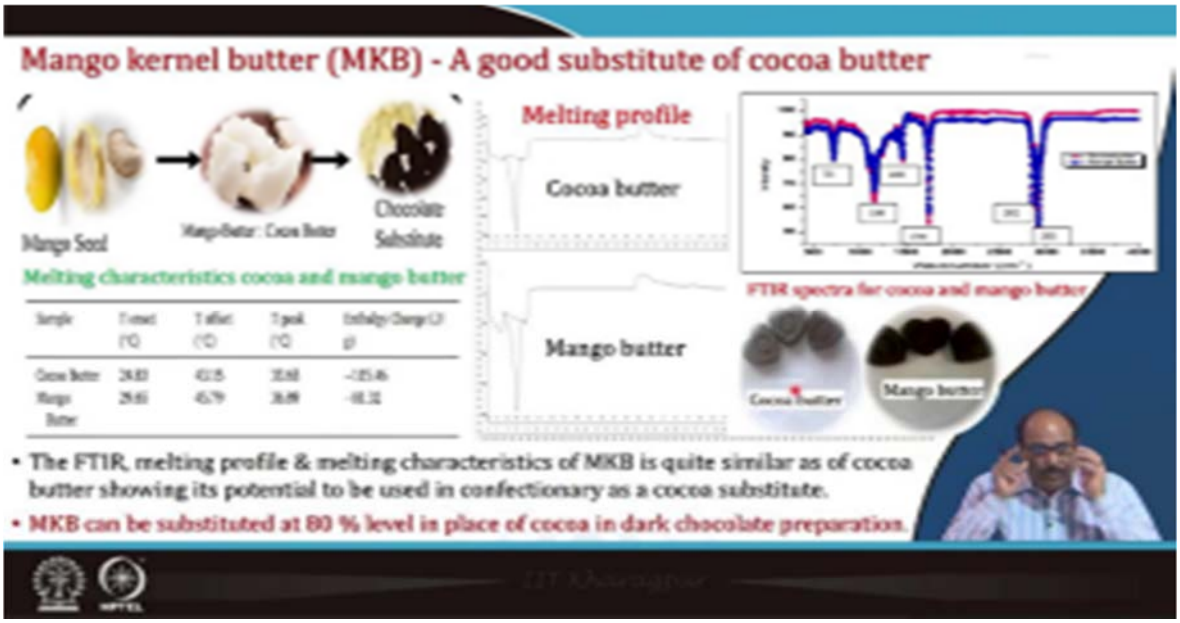
Mango waste can be utilized in many ways like jelly, packaging film, jam, etc. peel can be used for pectin purpose and also it can be used for enzyme extraction fibers and bio absorbent. The seed can be used for a fat content that is it can be used to kernel oil or powder. the dried peel can be utilised either for pectin or the colour which can be further used in jelly and jams.

The co-products lead to pectin recovery, bio-octophenols etc can be produced from mango waste. The peel can also be made into the glycerol or even other packaging material. So, waste can be utilized in many ways like in jelly and in the packaging field for many other products.



Mango kernel powder and oil

Kernel milling leads to kernel powder is obtained and this powder can be subjected to Soxhlet extraction 50 to 60 degrees Celsius from where kernel residue and kernel oil is obtained. The oil can be subjected to fermentation in presence of *Pseudomonas aeruginosa* DR1 which have glycolipids like rhamnolipids.

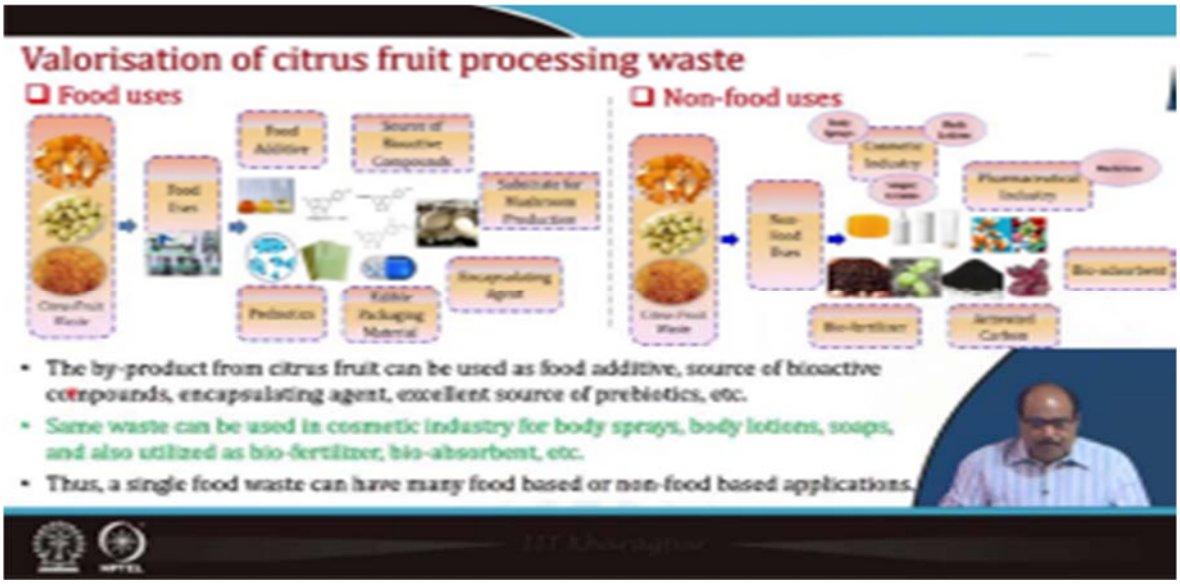


Mango kernel butter (MKB) - A good substitute of cocoa butter

This mango kernel butter i.e. The oil has very characteristics similar to the cocoa butter. So, the mango seed oil can be converted into the mango butter and which is a very good substitute of cocoa butter. When the melting profile is considered it was seen that cocoa butter is very popular in confectionery ice cream and because it has a very good melting characteristics; it

melts in the mouth and is soft in the hand. In the given FTIR spectra graph as, shown the mango butter has almost melting characteristics similar to that cocoa butter.

The fatty acid profiles and other characteristics of MKB is very also similar. The offset temperature, onset temperature, peak temperature and enthalpy change of MKB and cocoa butter is comparable. So, this shows that this is a very good product from the mango kernel or mango by-product and mango processing industry and it can be exploited in the contractionary product as a coco's substitute. So, MKB can be substituted up to 80 percent level in some report says are the preparation of cocoa in the dark chocolate preparation.



Valorisation of citrus fruit processing waste

The valorisation of citrus food processing waste from citrus foods can be used for both food usages as well and non-food usage. The by-product from citrus fruit can be used as food additive, source of bioactive compounds, encapsulating agent and it is an excellent source of prebiotic i.e. The fiber, oligosaccharides and polysaccharide which are present in the citrus food waste is a very good prebiotic. Same waste can be used in cosmetic industry for body sprays, body lotions, soaps, and also utilized as bio-fertilizer, bio-absorbent, etc.. So, a single good waste can have many foods waste or non-food waste applications.

Manufacture of essential oils from citrus fruits peel

citrus peels are very good source of essential oil. So, these citrus peels can be used for extractions of oil. For extraction one of the major processes with high extraction rates are ultrasound assisted or super critical fluid extraction. The accelerator clevenger operators is used for the extractions of essential oil from these materials because these essential oils are highly volatile. So, the temperature has to be properly adjusted.

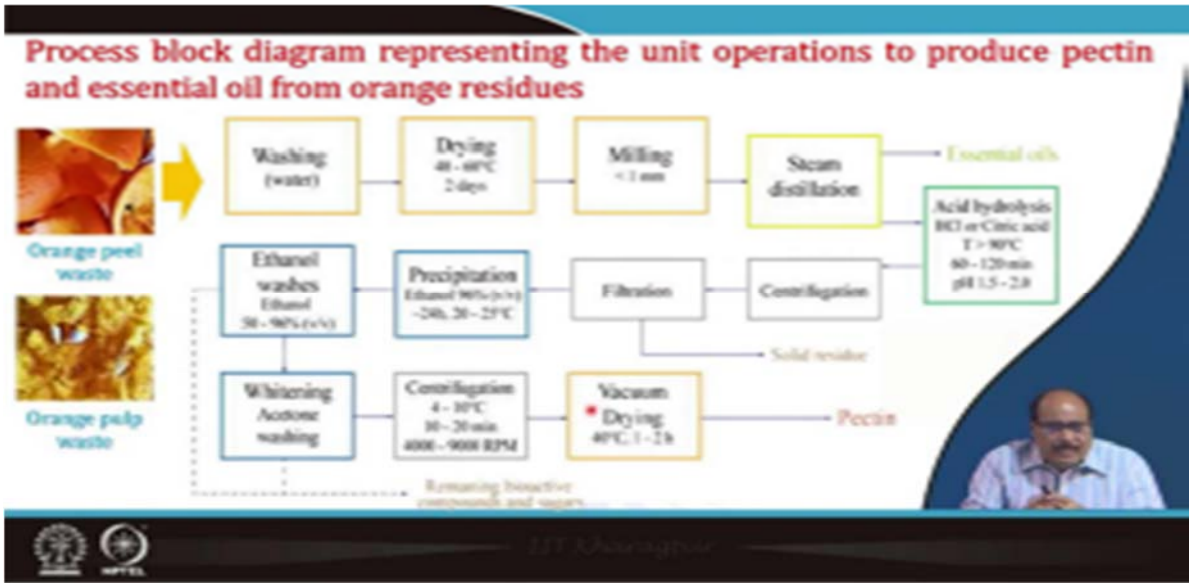
Manufacture of pectin from citrus fruit wastes

One of the potential applications of the citrus peel that is essential oil and another important utilization of the citrus fruit waste is the pectin. Both pomace and peel can be the source. The orange peels is the heated with the mother liquor and citric acid in water bath. Then it is subjected to filtration and filter cake is obtained. The ethanol subject to precipitation up of the

pectin and it is centrifuge. This is characterized may be in jelly grade characterization. The pectin is dried in dryer and the dry pectin is obtained.

The actual process parameters need to be standardized and optimized and a well develop standard technology.

- Pectin 1: Microwave hydro-distillation followed by freeze drying
- Pectin 2: Microwave hydro-diffusion and gravity followed by freeze drying

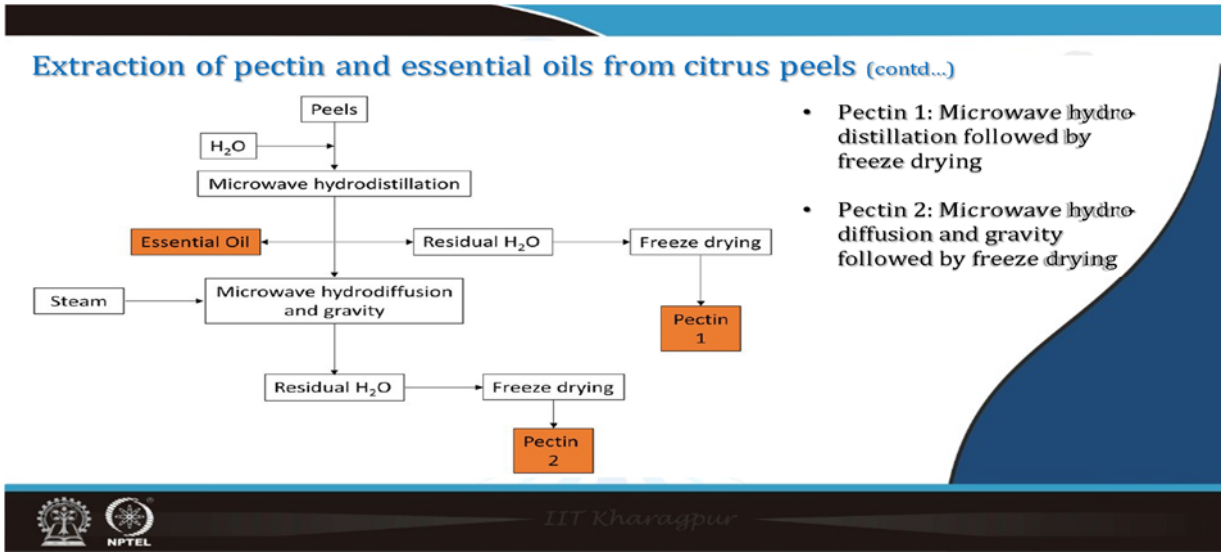


Process block diagram representing the unit operations to produce pectin and essential oil from orange residues

This fig. Shows the process block diagram representing the unit appraisals to produce pectin and essential oil from the orange residues and this can be used for any citrus fruit etc like orange peel waste or orange pulp waste i.e after the extraction of pulp and juice; the peel and pumace both are treated as waste. The process involves washing, drying at around 40 to 60°C for 2 days and then it is milled less than 1 mm. So, it is now converted into fine powder which is subjected to steam distillation. After the steam distillation the essential oil is obtained.

The residue which is obtain it can be subjected to acid hydrolysis treatment. In the presence of either HCL or citric acid temperature may be more than 90 degree and pH is around 1.5 to 2 and time duration maybe around 60 to 120 minutes. then it is centrifuged and filtered after filtration and that filtrate is precipitated in the ethanol at 96% v/v for 24 hours at 20 25°C, then ethanol washing 50 to 60% (v/v). Then so it is followed by whitening by the acetone washing. The precipitation by acetone washing and then finally centrifuge at 4 to 10°Celsius for 10 to 20 minutes at 4000 to 9000 RPM. Then vacuum drying at 40°C for 1 to 2 hours and finally pectin

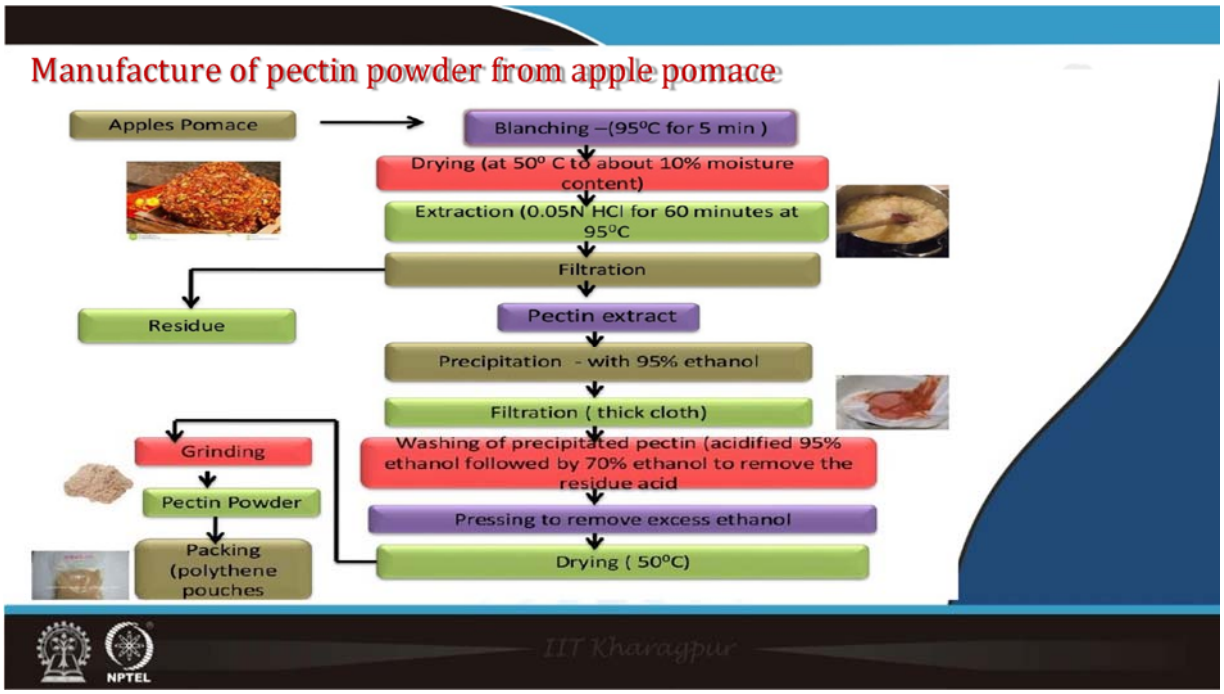
is obtained. After ethanol washing whatever residue is remaining, the bioactive compounds and the sugar etc can be extracted from this.



Pectin 1 is obtained by microwave hydro-distillation followed by freeze drying and Pectin 2 is pectin obtained due to Microwave hydro-diffusion and gravity followed by freeze drying.

Manufacture of pectin powder from orange waste

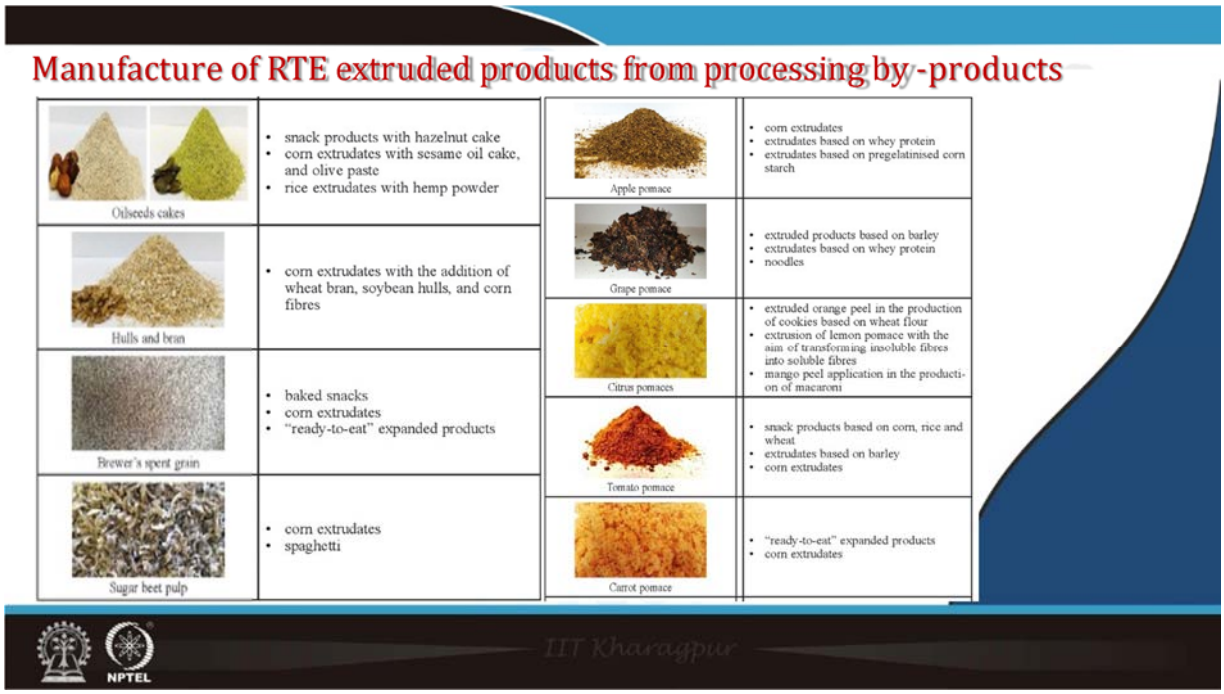
The manufacture of pectin powder is from sweet orange. The peel is first washed and then dried at 60°C, then grinding followed by acid treatment and final extraction in water bath. Vacuum filtration and centrifugation results in residue formation and precipitation. The ethanol precipitation and filtration helps to obtain wet pectin and then this wet pectin is dried and converted into pectin powder which can be further analyzed and characterized.



Manufacturer of pectin powder from the apple pomace

Himachal and such a Jammu Kashmir are those region in our country which produces significant quantity of apple and as apple is being used for making juice and other products . But after the preparation of the juice, huge amount of waste to go remain as the apple pomace and this apple pomace is a good quality fiber.

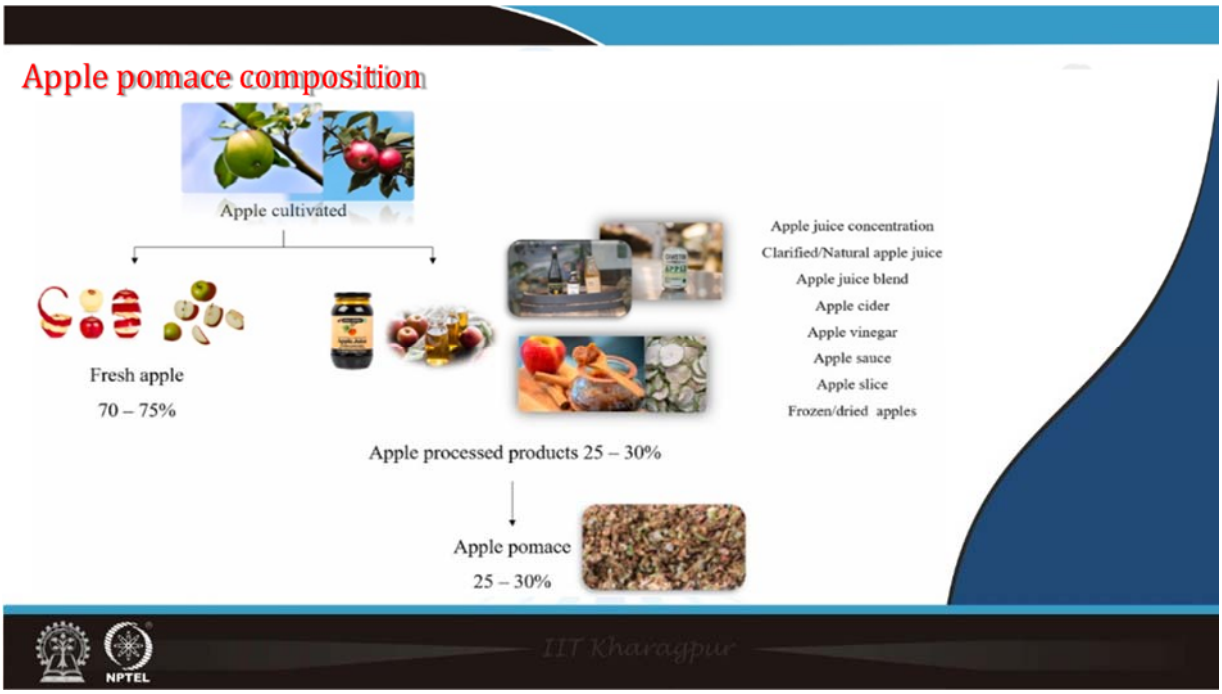
So, this pomace is collected, it is branched that around 95°C for 5 minute and then dry it at 50°C to about 10 percent final moisture content then it is subjected to HCL extraction by .05N HCL for 60 minute at 95°C which is then filtered to get the residue and pectin extract. Extract is then precipitated with 95% ethanol then again filtered by a thick cloth. Then again washed with 95% ethanol followed by 70% ethanol to remove the residue acid. Then it is pressing to remove excess ethanol followed by drying at around 50°C. The dried mass is grounded into pectin powder and then it is packaged in polyethene films.



Manufacture of RTE extruded products from processing by-products

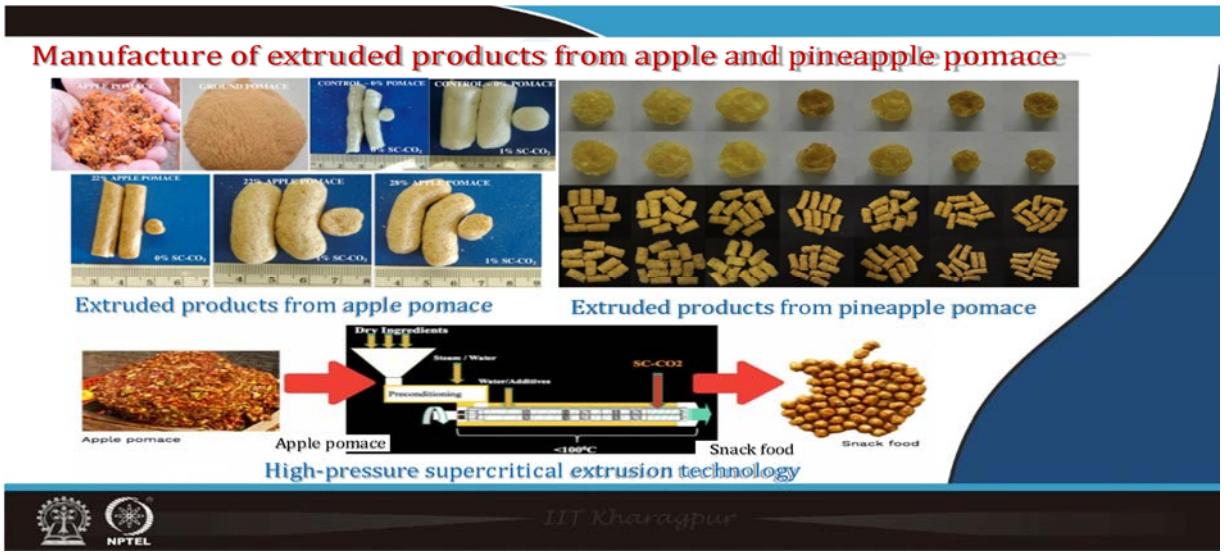
These fruits and vegetable industry waste and other food industry waste can also be used for manufacture ready to eat extruded products, like earlier said that apple pomace, or grape pomace, citrus pomace, tomato pomace, carrot pomace all these are obtained after extracting the juice and they can be appropriately mixed with various oil seed cakes or hulks and brand powders even brewers is printed grain and sugar beet pulp and all these things.

So, this what is the level up mixing this can be optimized and they can be put to the extrusion technology added and fiber rich antioxidant like say that apple pomace have very good health very good fiber prebiotic and fiber and also there are many antioxidant etcetera. So, this can be used for depression of antioxidant rich fiber rich or healthy snack products ready to eat product all this process parameter has impact in our laboratory also we have worked and ready to eat snacks using pea protein and combination of pea protein and apple pomace.



Apple pomace composition

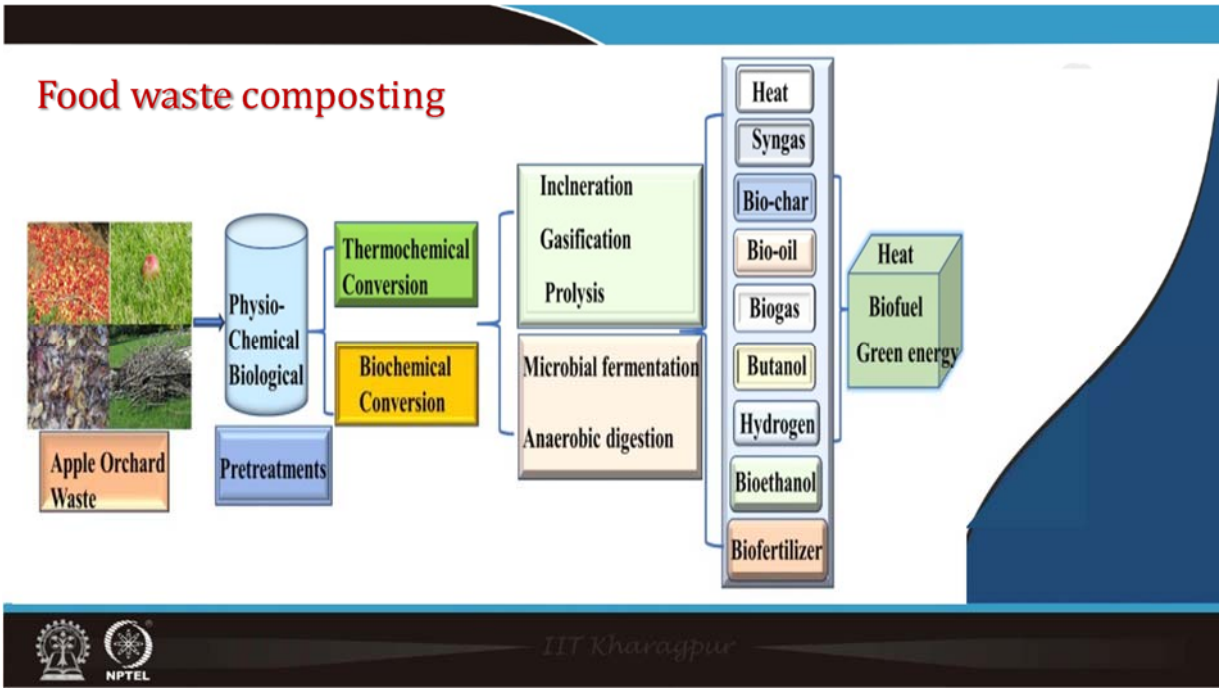
In our country about 70-75% apple is consumed fresh from the farm and the remaining 25 to 30% the processed and up to 25 to 305 which is processed it gives around 25 to 30% pomace. So, the huge amount of pomace we are getting and it has a various valuable component.



Manufacture of extruded products from apple and pineapple pomace

The manufacturer of various extruded products from the apple and pineapple pomace, where various researchers have worked on ready to eat snack etc using extrusion technology. Apple pomace can be taken and other dry ingredients are fed into the extruder where extruder conditions are appropriately maintained i.e system parameter material parameters etc are

maintained and results into a good snack food. Thus, by varying the combination of various ingredients extrusion process parameter and even the die design; a variety of snacks can be obtained. One can get ready to eat food extruded products either from both pineapple pomace or apple pomace in various shape, various sizes having various values and they all can be used snack food as a healthy alternative for the snack food industry.



Food waste composting

The food waste can be used for extractions of bioactive, coloring agents, additives etc are composed of many significant bio active agents and biochemicals; or they can be converted into manure. The residue undergoes physical chemical and biological pre-treatment and then thermochemical conversion or biochemical conversion.

It may include incineration, gasification, pyrolysis, microbial fermentation or anaerobic digestion and it can be used in various product like biogas, butanol, hydrogen, bio ethanol, bio fertilizer, bioconversion, biofuel which generates green energy. So, this will have a good impact on reducing the carbon footprint as well as at the same time we can get very valuable product.

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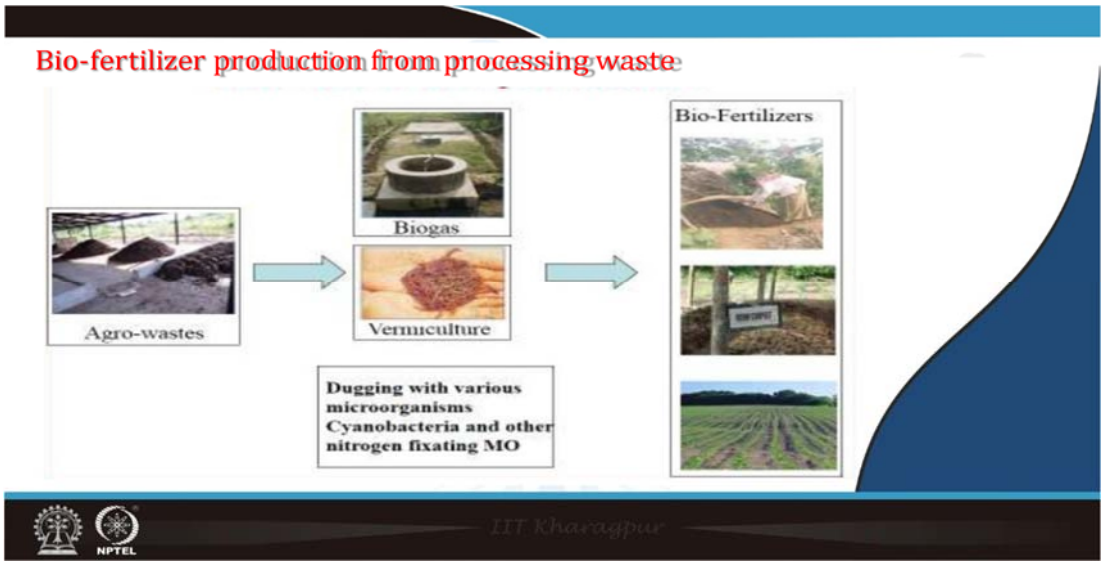
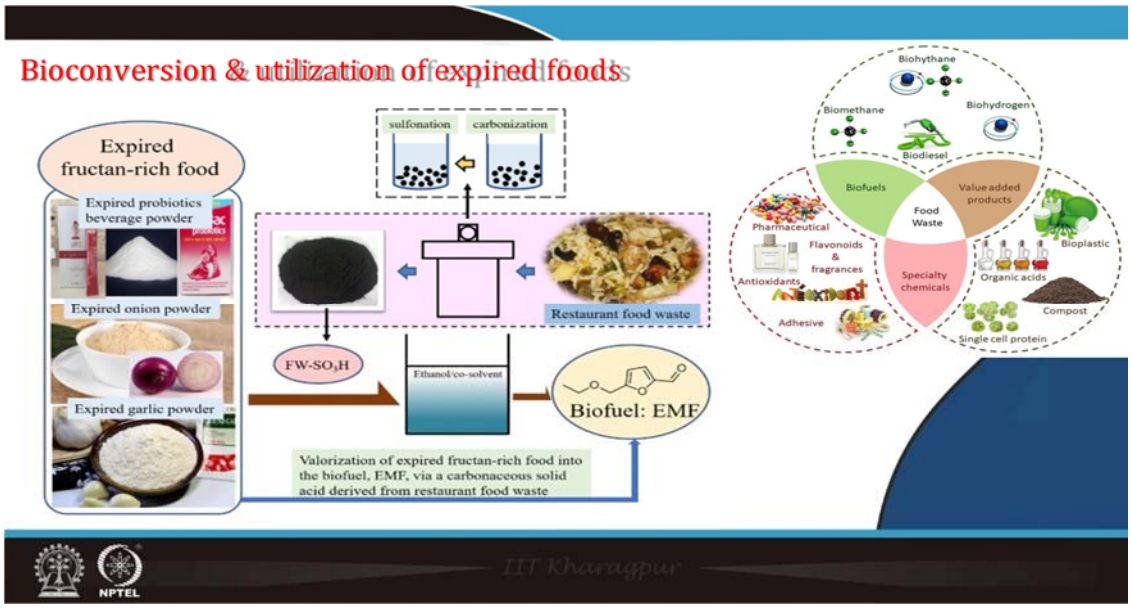


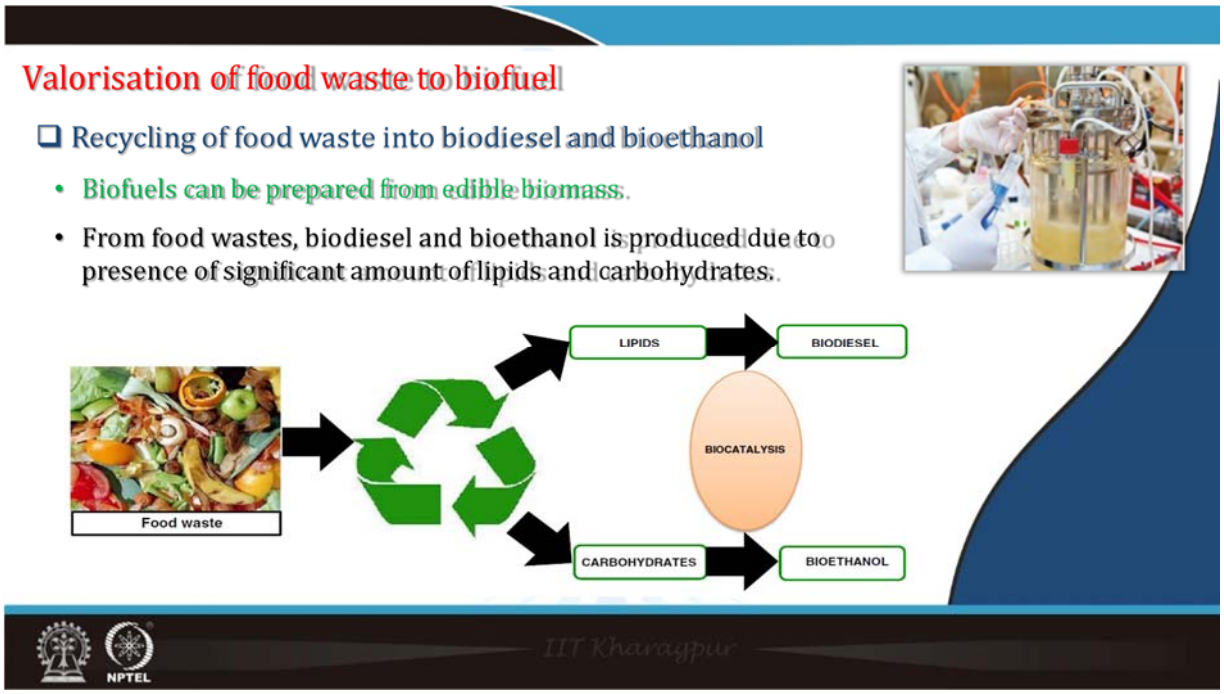
Bio-fertilizer production from processing waste

The bio fertilizer products and from the processing waste like agro based biogas by burying waste with the various microorganisms, cyanobacteria etc and nitrogen fixing microorganisms and fertilizer is used. So, even kitchen waste and other food processing waste etcetera can be can be used for bio fertilizer products.



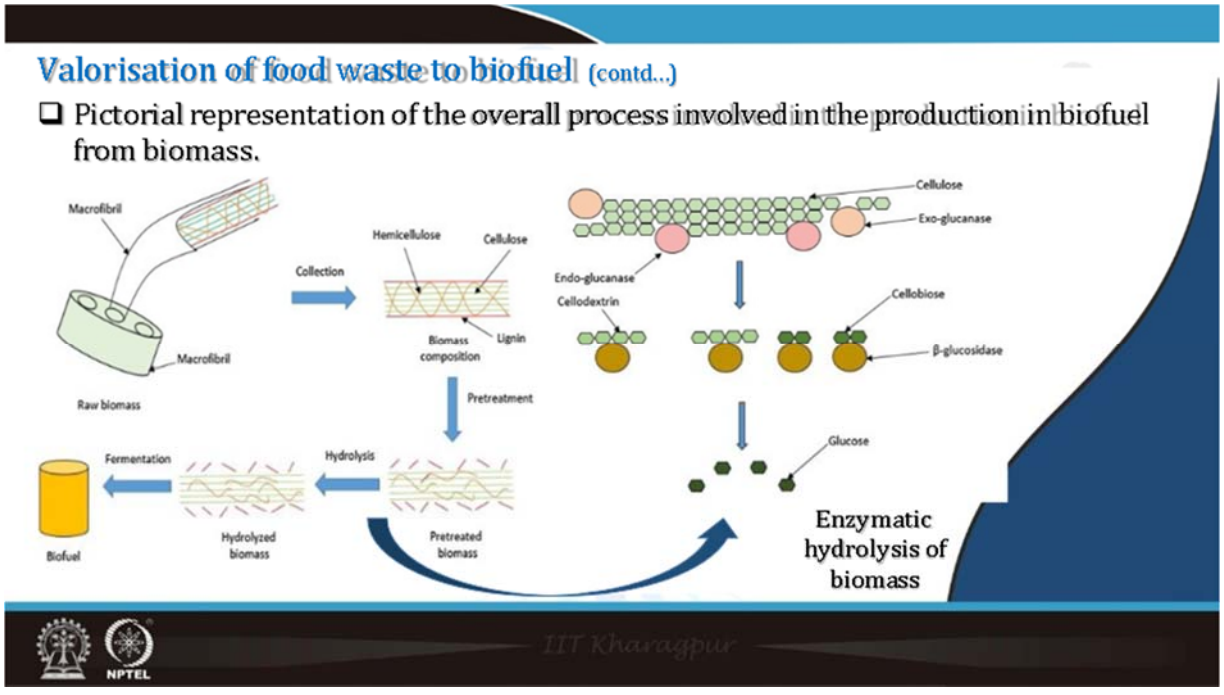
Bioconversion & utilization of expired foods

The bioconversion or utilization of the expire food can also be done, for example probiotic beverage powder, onion and garlic powder have low self-life. If it is not consumed before expiry and products can be recalled. However, they can be converted into biofuel. Similarly, appropriate carbonaceous solid which will be derived from restaurant food waste etc can also be used. Then carbonation process and sulfonation process suitable treatment can be given to them and then they can be converted into biofuel.



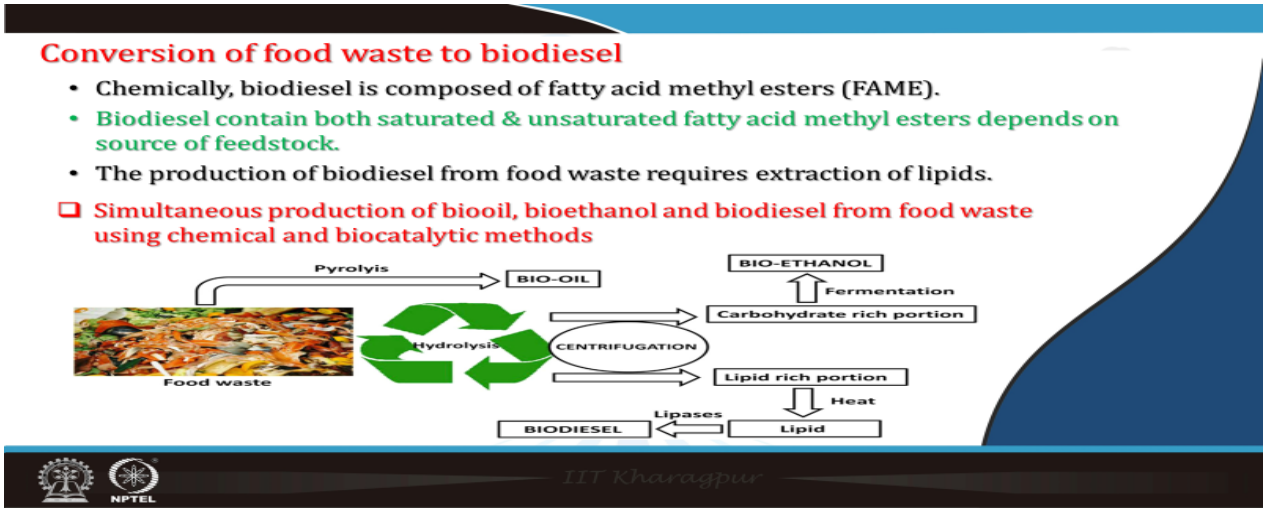
Valorisation of food waste to biofuel

Then valorization of food waste into biofuel is a novel approach in recycling of food waste. Biofuel and bio ethanol can be prepared from edible biomass from food waste. Biodiesel is produced due to presence of significant amount of lipids and carbohydrates. And this in fact can be more if only the lipid and the carbohydrate can be used for bio ethanol.



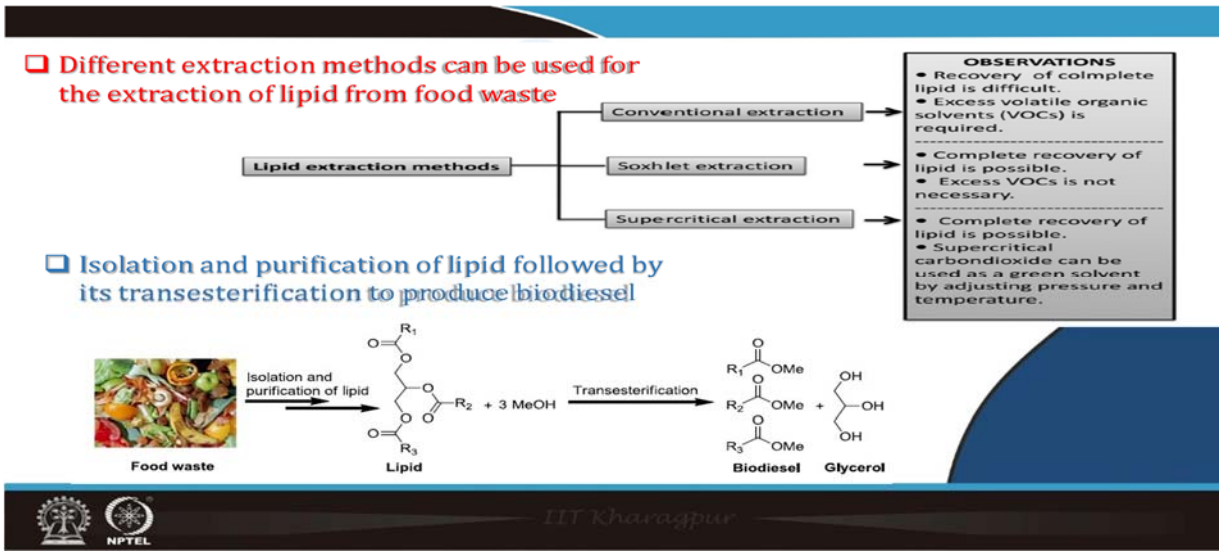
There is a pictorial representation of overall process involved in the production in biofuel from the biomass can see that you can collect a biomass that collection hemicellouse, cellouse material, then it can be given pre-treatment and hydrolysis. After that it can be fermented into

bio fuel, and also hydrogen product, one can again get various product like glucose i.e by enzymatic hydrolysis, or biomass, one can also get β-glucosideas and cellular various products.



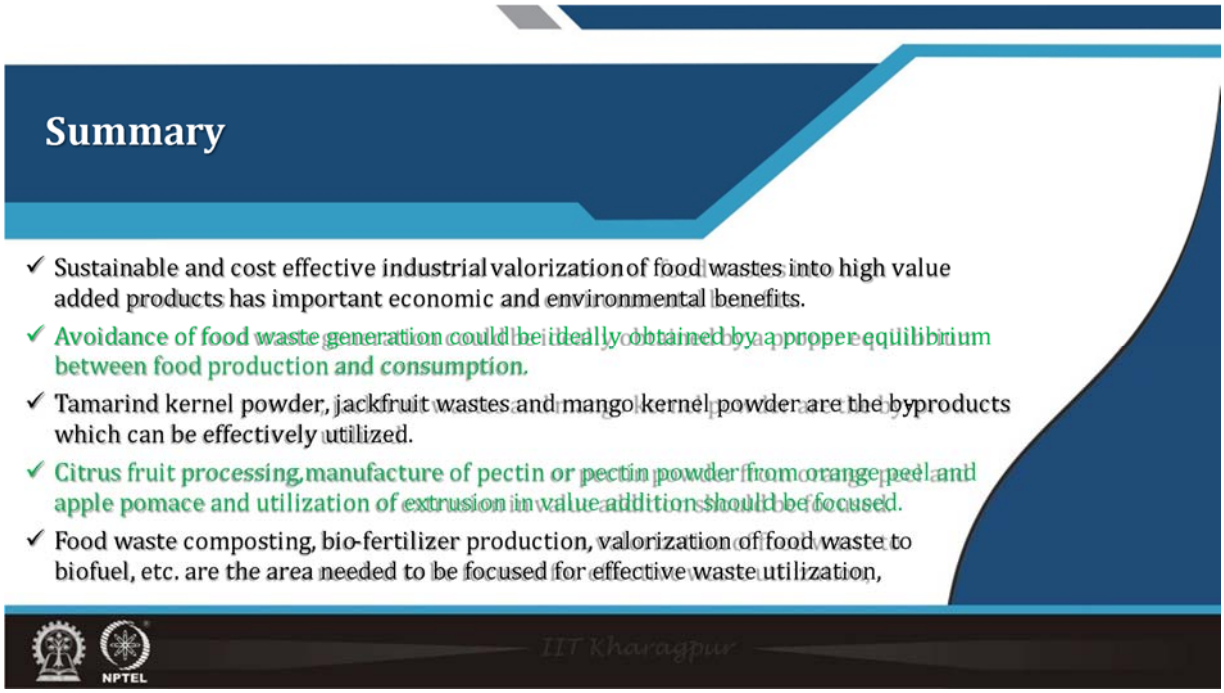
Conversion of food waste to biodiesel

The production of biodiesel from food waste requires extraction of lipids. Chemically, biodiesel is composed of fatty acid methyl esters (FAME). Biodiesel contain both saturated & unsaturated fatty acid methyl esters which depends on source of feedstock. So, there is simultaneous production of bio-oil, bio ethanol, biodiesel from the food waste using chemical and bio catalytic methods. By pyrolysis one can get bio-oil when subjected to hydrolysis treatment. After hydrolysis and centrifugation, the resultant product is carbohydrate rich portion undergoes fermentation and convert into bio ethanol and lipid rich portion convert into biodiesel.



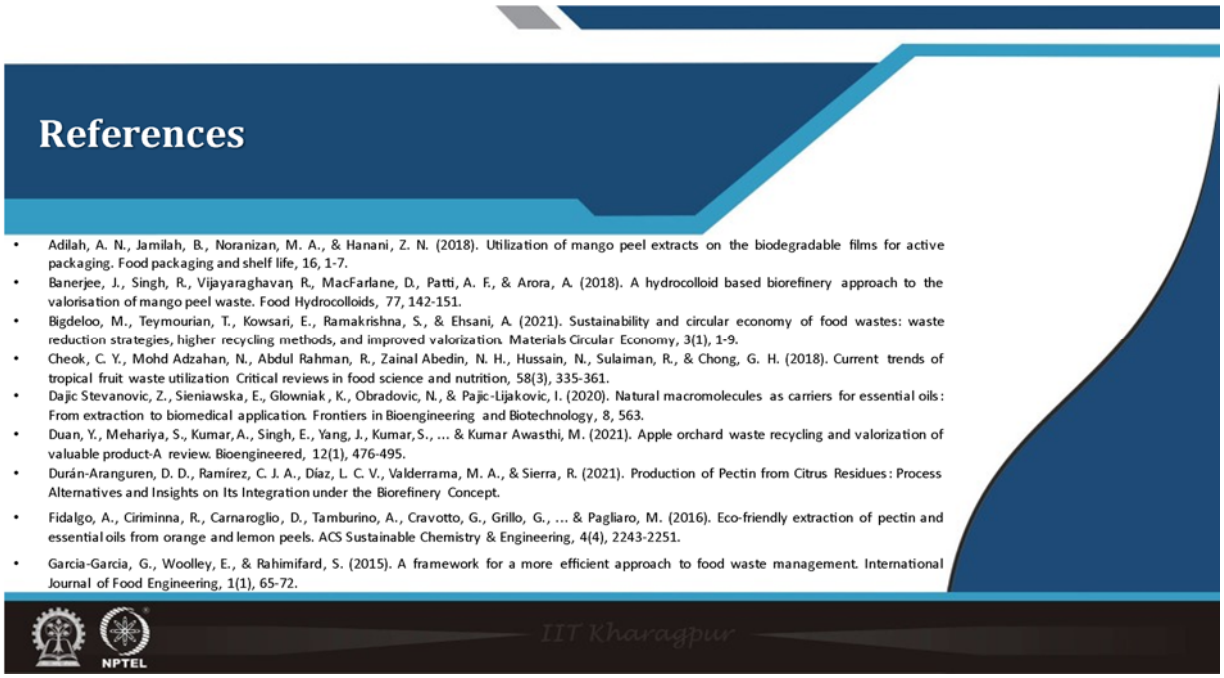
Then different extraction menthods can be used for extraction of lipid from the waste or isolation and purification of liquid followed by the transesterification to produce biodiesel. So, conventional extractions, solvent extraction and super critical extraction is being applied. So,

these are the 2 stages where the lipid can be extracted and then these liquid can be characterized and then subjected to transesterification process. Here that isolation and purification, transesterification biodiesel and glycerol this can be used.



Summary

Sustainable and cost effective industrial valorisation of food wastes into high value added products has important economic and environmental benefits. Avoidance of food waste generation could be ideally obtained by a proper equilibrium between food production and consumption. Tamarind kernel powder, jackfruit wastes and mango kernel powder are the by-products which can be effectively utilized. Citrus fruit processing, manufacture of pectin or pectin powder from orange peel and apple pomace and utilization of extrusion in value addition should be focus. Food waste composting, bio-fertilizer production, valorisation of food waste to biofuel, etc. are the area needed to be focused for effective waste utilization,



These are the references used in this lecture. Thank you very much.