Novel Technologies for Food Processing and Shelf Life Extension

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Lecture – 56
Algae Based Health Foods

Hello friends. In this lecture we will a study Algae Based Health Foods.

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Algae is defined as heterogeneous assemblage of organisms that range in size from tiny cells to giant seaweeds. Algae mostly are photosynthetic species which include eukaryotes and prokaryotes like cyanobacteria blue green algae and they live in aquatic habitats. To meet the nutritional requirements of the rising populations, researchers are looking for alternate sources for food which are easy to cultivate, which are cost effective and which produce large amount of bioactive compounds, which are useful for preventing major health diseases etcetera. And in this regard algae has a great potential for its utilization in health food development or functional food development.

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The algae on the basis of their bioactives present in it, their colours, etcetera they can be characterized into 4 major groups like blue green algae, cyanobacteria, it is a photosynthetic prokaryote you can see in the you can here it is a blue green algae picture. Then the red algae rhodophyta, eukaryotic algae and is found in the freshwater lakes, green algae which is called chlorophyta it has unicellular and colonial flagellates the phaeophyta or brown algae is branched and filamentous thallus. So, these are the major types of algae and their a specific characteristics.

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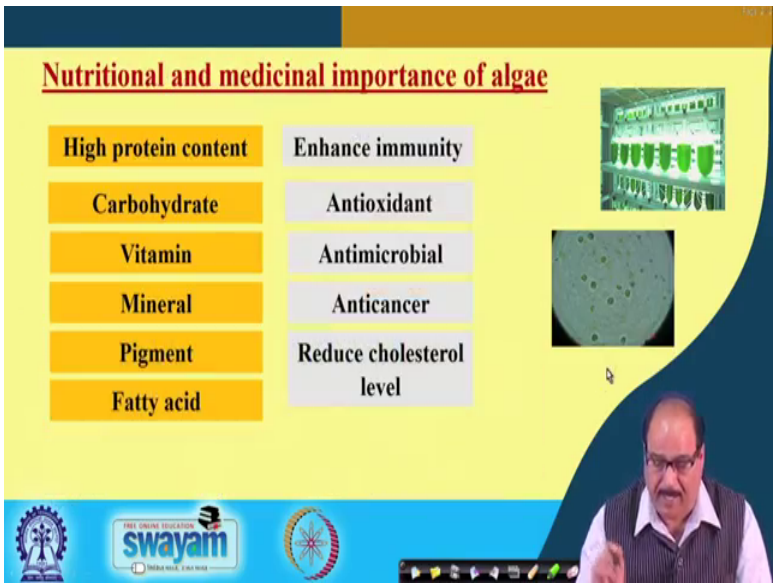

The nutritional and medicinal importance of algae lies in it is a high protein content, good carbohydrate material and their values, their vitamin, mineral, pigment, fatty acids etcetera which are contained in these different algae. These algae they enhance immunity, they are hub up the various antioxidants, they have antimicrobial compounds, anticancers compound in it and they reduce cholesterol level. So, they are very very beneficial from health point of view.

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In different countries algae different types of algaes are commonly used in the food as a food ingredients or even or cooking purposes or for such other purposes like spirulina blue green micro algae with a long history, it has a long history of use as a food source because of its high protein content and other nutrients. In fact, now in our Indian market also lot of spirulina based product like a spirulina powder, spirulina capsule, spirulina tablet etcetera are available.

Dulse, it is a red species sold particularly in Ireland and Atlantic Canada. Chlorella, it is a popular micro algae which has similar nutrition is provided by spirulina and dulse. It is the purple laver that in Ireland, it is collected and made into a jelly by stewing or boiling. Irish moss, it is the source of carrageenan for the stiffening of instant puddings, sauces, and dairy products. Sea lettuce is used in Scotland where it is added into soaps and salads. So, different types of algae in different countries are used for various food purposes.

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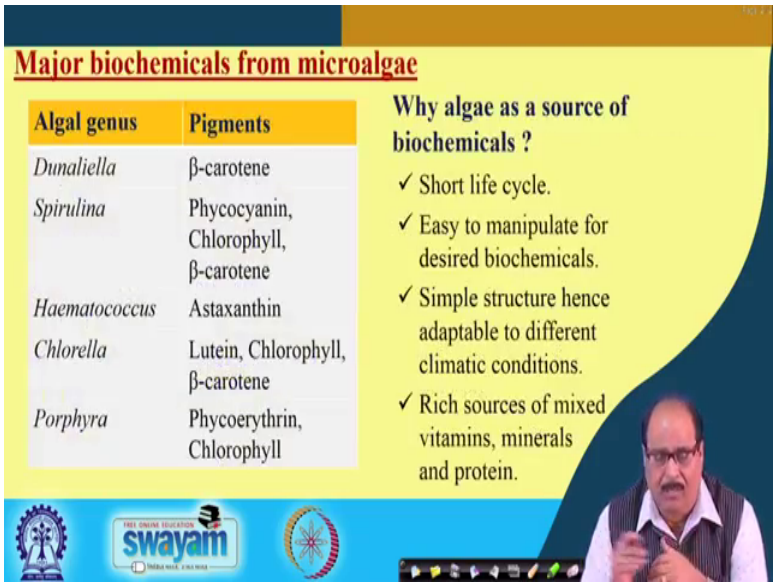

So, in the algae as I told you that they are the source or hub of bioactives, alright. So, why these algae that is different algae? Like Dunaliella it has a good amount of beta carotene; spirulina, it contains phycocyanin, chlorophyll, beta carotene, haematococcus, astaxanthin; Chlorella it has lutein, chlorophyll, and beta carotene; porphyra it contains phycoerythrin, chlorophyll etcetera; so, various bioactive compounds and are available.

So, now the question is why we look at algae as a source of biochemicals or bioactives. The answer is because the algae it has a short life cycle, it is easy to manipulate and have that is the a stress conditions in the environment can be easily created to encourage to go get more and more bioto a biochemical production in the algae. They are simple structure hence adaptable to different climatic conditions and they have rich sources of mixed vitamins, minerals and proteins etcetera.

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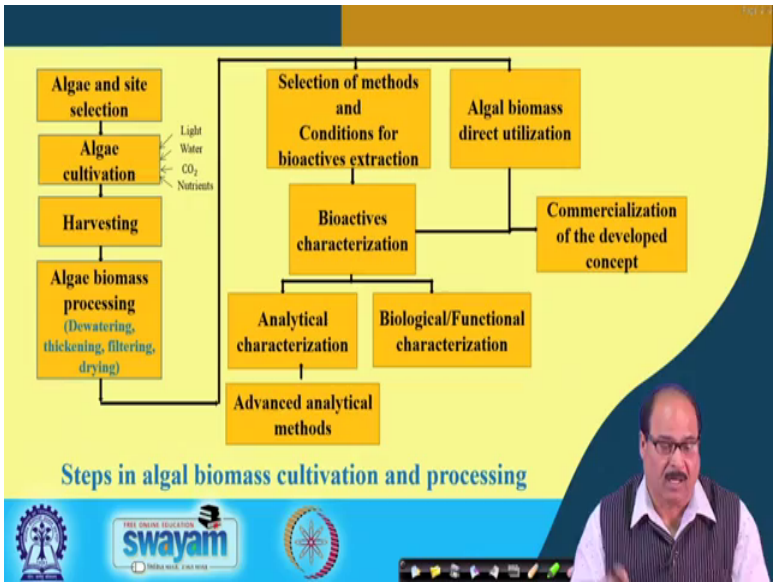

So, the algae for its use in the food and food supplements important thing is that that is number one expected the proper cultivation of the algae. That is for cultivation like; obviously, proper practices, standard practices should be followed, alright. For the cultivation of the algae I will tell you in the next slide what are the different cultivation methods. So, the nutrients required or other facilities required like light, water, carbon dioxide and different organic sources of nutrients and carbon-carbon etcetera they should be provided media should be, proper media should be provided and then algae it should be given required environmental conditions like temperature etcetera.

So, it grows it cultivates and then finally, was the algae is grown then it is need to be harvested that is the taking out the algae from its either cultivation medium and then this algal biomass like it is grown in the aquatic media that is a liquid media, so it is a very basic content lot of water in it. So, it need to be processed that is the processing of the algal biomass includes dewatering, thickening, filtering and finally, drying. So, ultimately that is in this using this algae is cultivated, taken from its cultivation pond or photo reactor, then water is removed filtered and it is dried. So, dried biomass now is a algal biomass is available for food utilization.

So, for its food utilization two approaches can be made, there is one as such that is algal biomass directly can be used in food preparation and food formulation. Of course, sometime this algae, algae they are they have some very strong flavors some people may

like but some people may not like. So, in that case that is the another approach can be followed that the bioactives may be extracted from these algal biomass and these extracted bioactives can be used for the formulation and preparation of the functional foods to provide a targeted benefits.

So, both approaches of course, that is the studied in the case of for the case of that is the extraction of course, so one has to see that these steps and procedures, extraction technology, methodology, etcetera should be properly standardized and properly optimized and for the extraction one drawback may be there. But, that for commercial production large amount of biomass might be required to get the desired amount of bioactives from this for using the food etcetera. But anyway that is the both approaches can be followed in the slide I will take this few example of Chlorella as well as this spirulina and I will give you some of the food products which are made using these both the extractor bioactives as well as the biomass.

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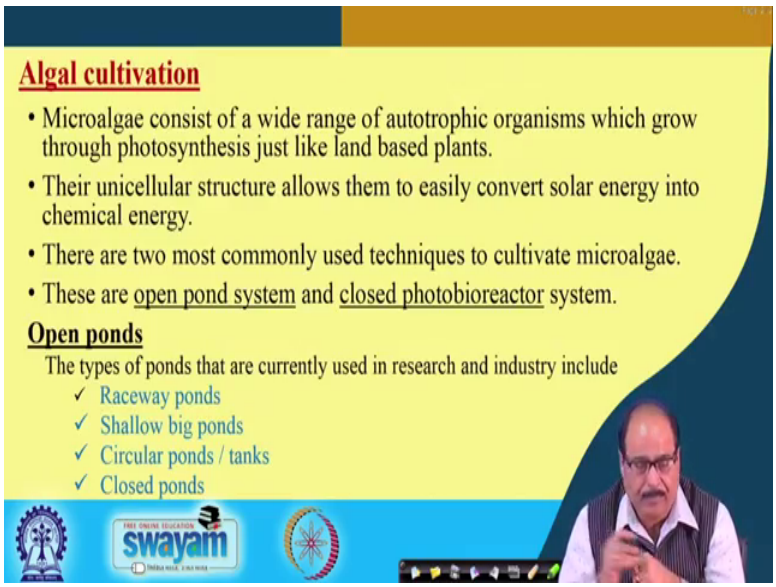

So, regarding algal cultivation as I told you that the micro algae there are two methods for their cultivation, one is the open pond system and other is the closed photo bioreactor system, right. This open different types of open pond which are use is can be used there are raceway ponds, shallow big ponds, circular ponds or tanks and closed ponds. But obviously, there is if it is closed pond and or is and there is the conditions the they have

the temperature and sunlight etcetera all those conditions it should be optimized and properly environmental conditions should be provided for the algae to grow.

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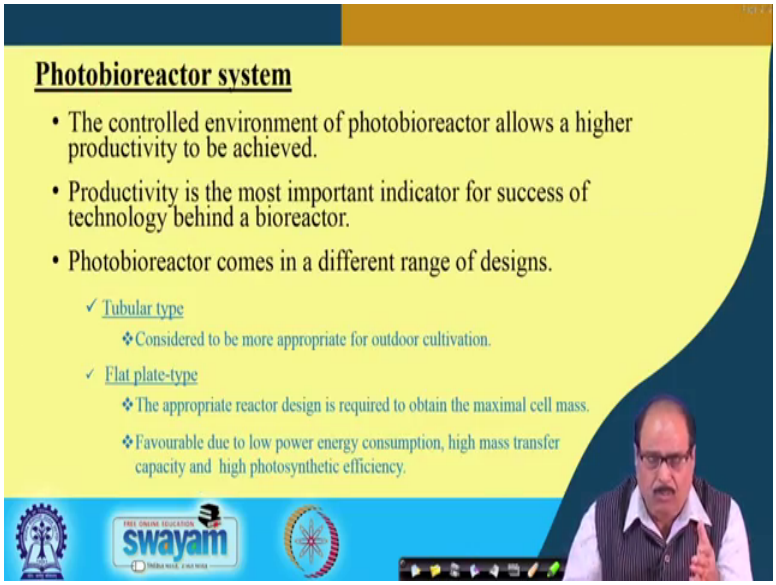

So, from those point of view photo bioreactor system appears better, the controlled environment of the photo bioreactor allows a higher productivity to be achieved. And productivity is the most important indicator for success of the technology behind a bioreactor. So, photo bioreactor comes in different designs, different ranges like tubular type this is considered to be more appropriate for outdoor cultivation or flat plate type this the appropriate reactor design is required to obtain the maximum cell mass, the flat plate type bioreactor is favorable due to its low pressure energy consumption, high mass transfer capacity and high photo synthetic efficiency.

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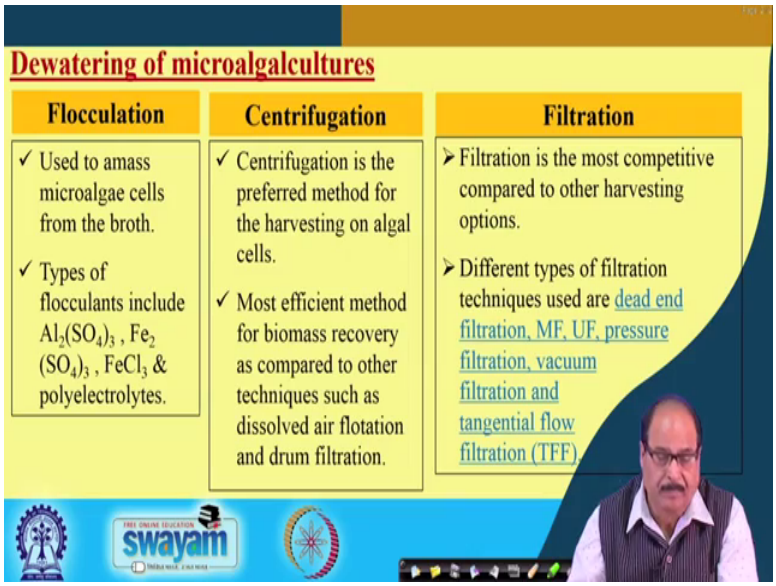

So, after the cultivation the dewatering of the micro algae and there are 3 methods which can be used flocculation, centrifugation and filtration. So, flocculation method is used to amass micro algae cells from the broth and the type of flocculating agents which are used for this purpose include aluminium sulphate, ferric sulphate, ferric chloride and poly electrolytes etcetera. Centrifugation is generally preferred method for the harvesting of algal cells it is a most efficient method for biomass recovery as compared to other techniques such as dissolved air flotation and drum filtration.

The filtration is the competitive method compared to other harvesting options different types of filtrations can be used for getting the biomass, like the commonly used filtration methods include dead end filtration, micro filtration, ultra filtration, pressure filtration, vacuum filtration, tangent flow filtration and so on. So, by either using mostly as I told you that is centrifugation is considered a better method are easily adaptable method. So, if they go for the centrifugation methods or some in the plants etcetera they also go by flocculation another.

So, depending upon the SLT infra structure any of this method can be adapted but the important thing that as far as possible as much as possible the water should be removed and you get a concentrated algal biomass.

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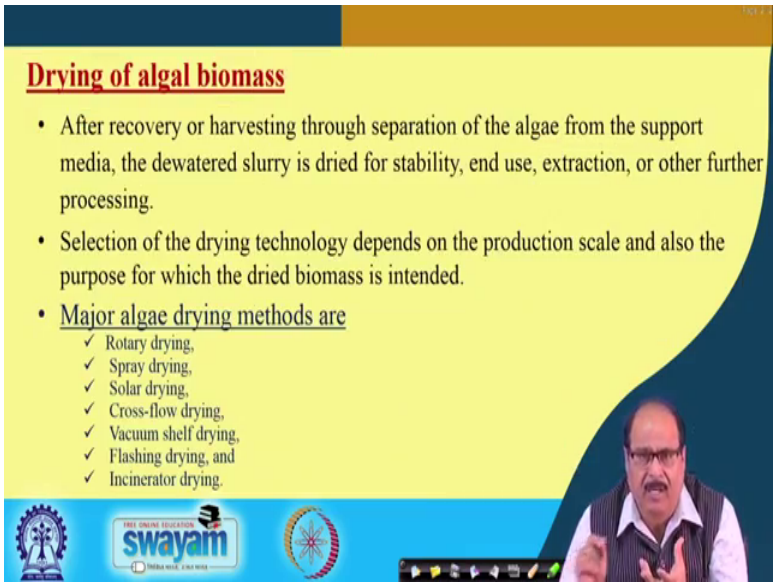

And then next step is the drying up the biomass. This after recovery or harvesting through separation of the algae from the support media, the dewatered slurry the concentrated slurry of the biomass is dried for its stability, that is obviously, the dried biomass is more stable, it is easy to handle, easy to store alright and it is easy to use in extraction alright or for further processing.

So, suitable drying method and suitable drying process needs to be used, alright. That is because that is during drying process, the bioactives, their functionality alright, should not be adversely affected. So, the selection of the drying technology accordingly depends on the production scale and also the purpose for which the biomass is being dried.

So, different drying methods are dryers includes rotatory dryers, spray dryers, solar dryer, cross flow drying, vacuum shelf dryers, flashing dryer or incinerator drying or incinerator dryers etcetera. So, any of these depending upon the requirement can be used, depending upon the availability of the drying system, but the important thing that that is the drying process should be optimized and bioactives should remain intact in the dryer algal biomass.

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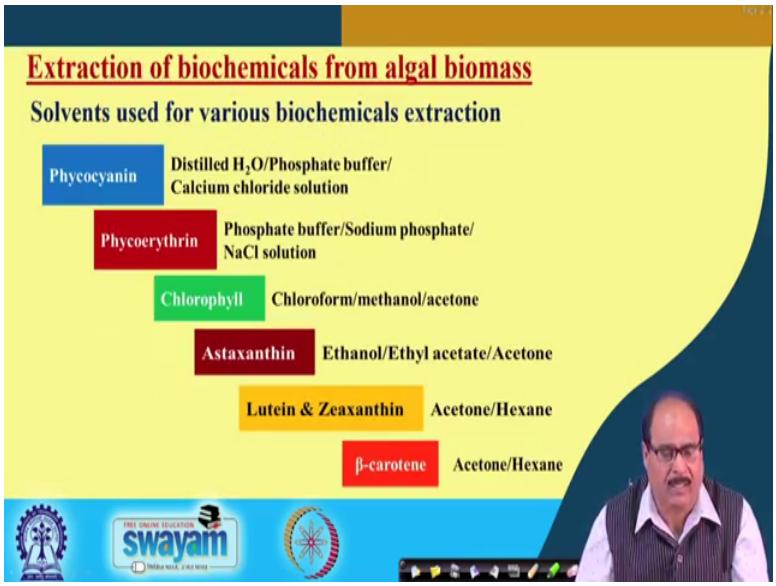

So, after drying that is now we have the dryer powder. So, it can be powder that is the algal biomass, dried algal biomass can be sent further extraction or the bioactives and then extracted this bioactives extracted bioactive as well as spent biomass after extraction both can be used in the food preparation or whole biomass can be used as a food preparation, food formulation and food preparation.

So, for the extraction now depending upon the bioactive agent their solubility in different polar their polarity etcetera, these are taken into consideration while deciding the extraction procedure and the solvents that also. In this slide I have given you like phycocyanins for their extraction, solvent extraction, distilled water or phosphate buffer or calcium chloride solutions etcetera can be taken because they are soluble in water, alright.

Then this phycoerythrin, the phosphate buffer, sodium phosphate, sodium chloride solutions etcetera they can be used for chlorophyll because it is soluble in organic solvents or chloroform methanol acetone. Astaxanthin can be solubilized or extracted using ethanol, ethyl acetate is acetone, lutein and zeaxanthin. They can be extracted in acetone and beta carotene, acetone and hexane.

So, the important point is that the if the solvent to be decided on the basis of their solubility and extraction capacity. And of course, important to the needle has to say that

whatever the solvent is being used that should be food grain because ultimately the bioactive is to be used in the food preparation ok.

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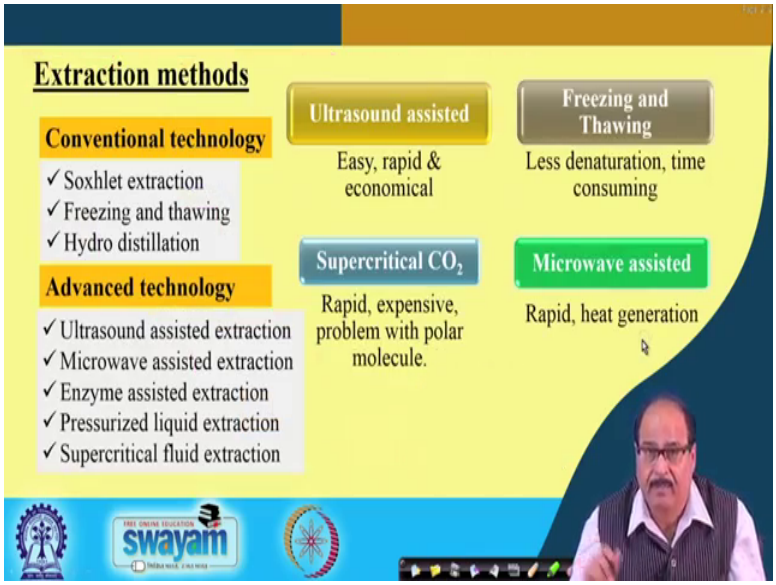

So, then there are different methods for extraction, may be conventional methods can be used like soxhlet extraction, freezing and thawing are hydro distillation methods are advanced technologies like ultrasound assisted extraction, microwave assisted extraction, enzyme assisted extraction, pressurized liquid extraction, or supercritical fluid extractions can be used.

Obviously, there is advance methods. They provide the as far as the functionality of the bioactives etcetera are more, some time they are rapid. So, in this here I have given you a brief comparison of the method like ultrasound assistant method is a easy, rapid and economical method, it gives more recovery of the bioactives, freezing and thawing method, it causes less denaturation of the protein or enzymes another, but it is a time consuming method.

Microwave assisted there is a, it is a of course, a rapid method, but some heat generation takes place and this a heat may have some influence or effect on functionality of the bioactives etcetera. Supercritical carbon dioxide whether that it is a considered a very good method green technology, it is a rapid inexpensive method, but here also that it has some issues with the polar molecules which are present in the. So, one has to cautiously choose the appropriateness extraction methodology, standardized this is the process

parameters for maximum recovery of the bioactives and once this bioactives are extracted recovered using appropriate method, then this need to be characterized.

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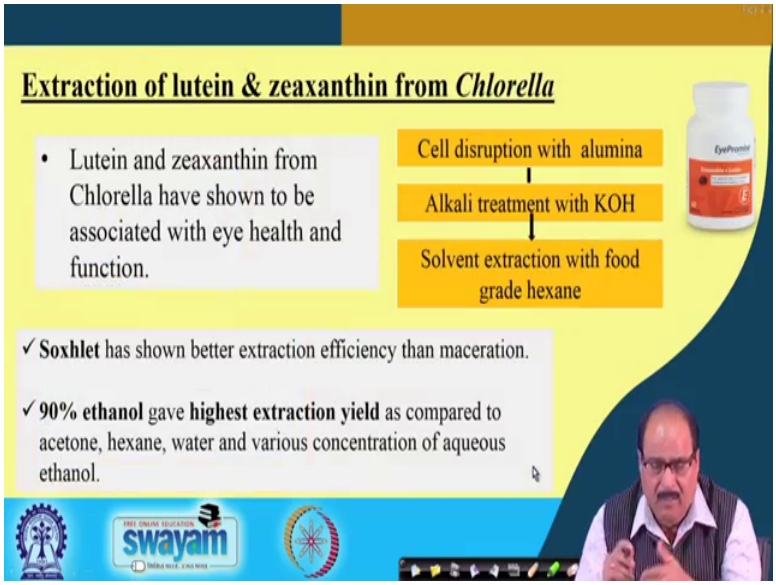

So, some cases studies I tell you that run basis up our own work that is the extraction of lutein and zeaxanthin from Chlorella. So, this for more recovery first the cell is need to be disrupted, so cell disruption with alumina, then it is given alkali treatment for membrane that is the cell membrane, breakup etcetera that is with the potassium hydroxide and then it is followed by solvent extraction with using food grade hexane.

So, we in our study studied different solvents alright and we found that ethanol give a highest extraction yield that is 90 percent extraction yield as compared to other solvent like acetone, hexane, water and various concentration of aqueous ethanol. So, 90 percent ethanol gives better.

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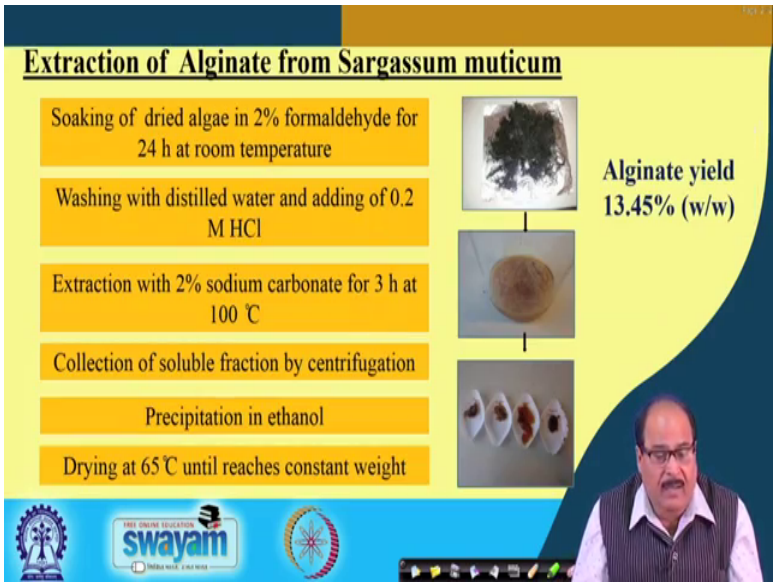

Then extraction of alginate from sargassum muticum, right; so, in this case sargassum are collected from the see the dried using suitable technologies and then next it the soaking of the dried algae in 2 percent formaldehyde solution for 24 hours at room temperature. After which that they are washed in distilled water and water containing 0.2 molar HCl then which is followed by extraction with 2 percent sodium bicarbonate for 3 hours at 100 degrees Celsius. And finally, collection of the soluble fraction by centrifugation precipitation in the ethanol and then drying at 65 degree Celsius until it reaches the constant weight.

So, in this way alginates are extracted from the sargassum and in our experiment we could get 13.5 percent alginate yield weight by weight.

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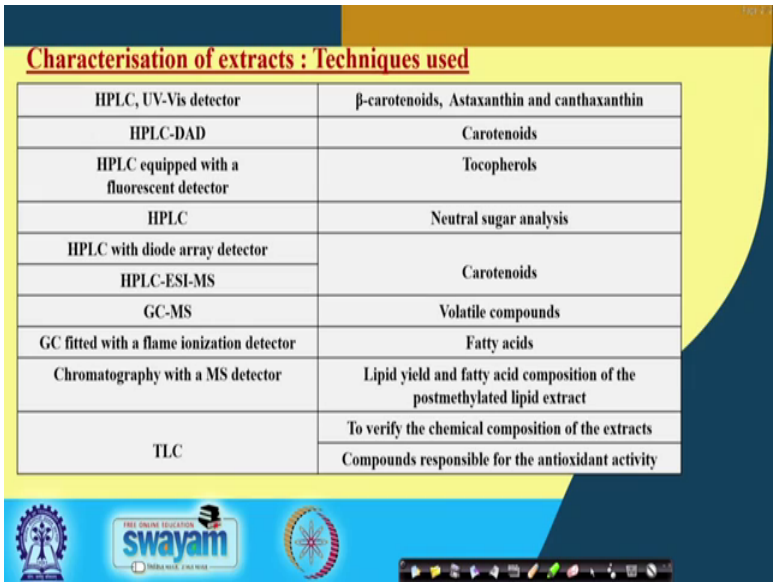

So, as I told you that is after their extraction. The important thing is that these biomolecules or bioactives they should be characterized, that whether what is their purity level or whether the bioactives which was a needed that has been extracted or not. So, different characterization techniques can be used like HPLC UV Vis detector, HPLC dead or HPLC equipped with the fluorescence, detector HPLC-ESI-MS or GC-MS or GC fitted with a flame ionization detector or thin layer chromatography.

So, details are given that is depending upon the compounds that is the for like for tocopherol, it is better to have a characterization by HPLC equipped with a fluorescent detector. So, carotenoids HPLC did that or beta carotene can be by HPLC or UV based detector. So, this they should be properly characterized and then this characterize are extracted and characterized biomass should be used in the is by food formulations.

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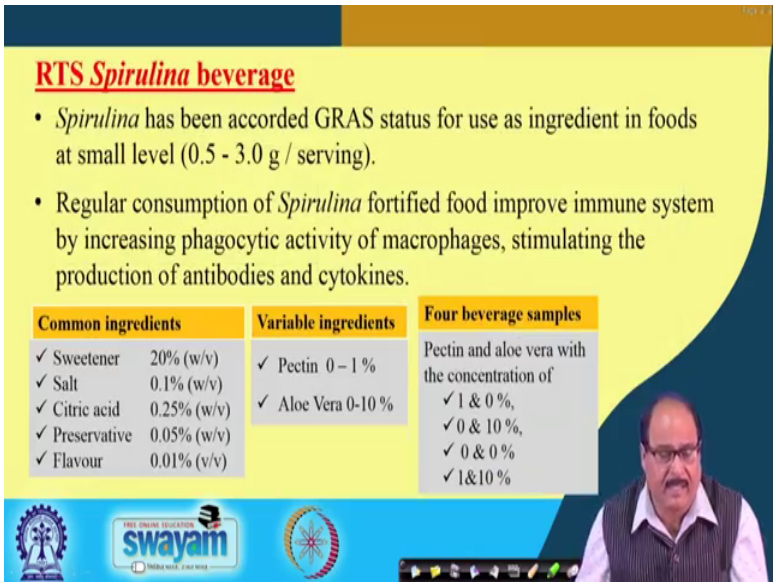

So now, I will give you some of the food products which are developed using these extracted bioactives as well as different that by biomass in our laboratory. So, one is the ready to serve a spirulina beverage. As I told you this spirulina is a very good algae and it has been given accorded grass status for use as ingredient in food at a small level may be 0.5 to 3 gram per serving. And, this whole spirulina powder tablet etcetera are available in the market. So, in our laboratory we formulated ready to serve spirulina beverage, alright, because the regular consumption of spirulina fortified food improves immune system by increasing phagocytic activity of macrophages, stimulating the production of antibiotics and cytokines.

So, ready to 4 variance of the ready to serve beverages we are used, alright. The common ingredients you used in the preparation of beverage included sugar as a sweetener, salt, citric acid some preservatives and some flavor their component composition is provided in this. And the variations that 4 variations invade by having different proportion of pectin as well as aloe vera in this. So, the pectin and aloe vera concentrations we are varied with 1 2 percent and 0 percent, 1, 0 and 10, 0, 0 and 1 and 10. So, different combination and permutation were used and all these were the using standard beverage making this a were made in this process.

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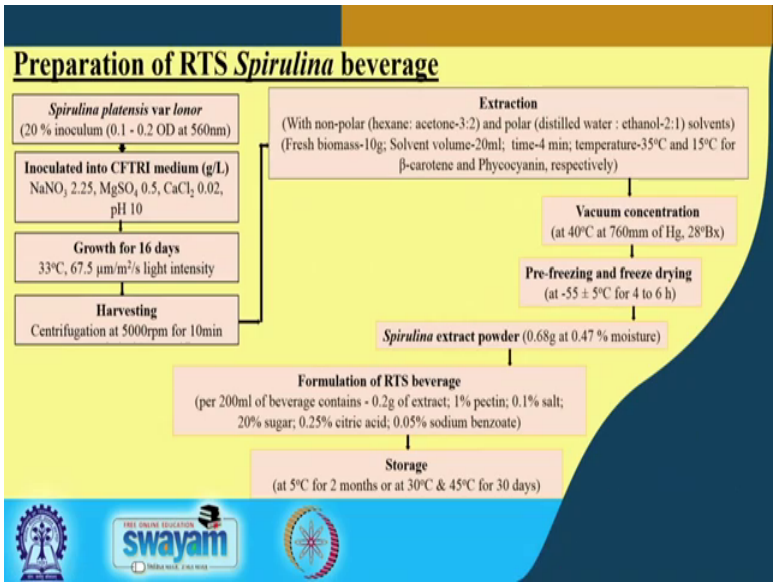

Flowchart, I have just tried to give you an overview that is schematic of the process what how the beverage was prepared like a spirulina, plantensis, variant lonor was used. So, this here up to here that is in our laboratory we had certain some bioreactor in which this was grown, alright. Media CFTRI medium was given containing sodium nitrate, magnesium sulphate, calcium chloride, pH was 10. So, it was grown for 16 days alright, at temperature 33 degrees Celsius.

There is a 67.5 per square meter per second light intensity was maintained and the biomass was cultivated, it was harvested, and then this biomass was sent to the extracted that is a bioactives were extracted with a non-polar that is hexane, ethanol mixtures and other components and this was followed by vacuum concentration pre-freezing and freeze drying and then spirulina extract powder was obtained. So, this spirulina extract powder alright which as a about 0.47 percent moisture containing 0.47 percent moisture, alright, and this was used in the preparation of or formulation of RTS beverage, alright.

So, 0.2 100 ml of the beverage, 0.2 gram of the extract powder, 1 percent pectin, 0.1 percent salt, 20 percent sugar, 0.25 percent citric acid, 0.5 percent sodium benzoate etcetera we are added and then we studied in fact, pectin is one percent at pectin and aloe vera in different proportions in all the 4 beverage we are prepared and they were stored for 2 months at 5 degree Celsius or at 30 degree Celsius and 45 degree Celsius for 30 days. And we studied different effects.

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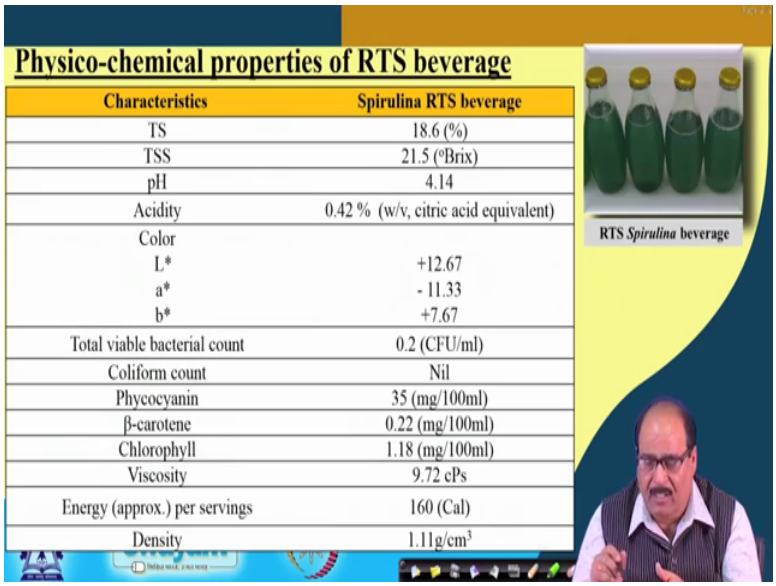

So, this is the content characteristics of this spirulina ready to serve spirulina beverage that is properties which is prepared this. So, that is the prepared RTS beverage in our laboratory alright. So, it has TS content around it in 0.6 percent, coliform count a nil, beta carotene 0.22 milligrams per 100 ml, chlorophyll 1.1 100 milligram per ml and its energy value per serving was around 160 kilocalorie.

So, these are the properties of the prepared RTS beverage. We can got conducted a sensory evaluation and its changes during the storage etcetera and you found it was good. In fact, this has a anti cancerous and anti that other anti mutagenic properties etcetera that are analyzed and we found it has a very good health promoting effect.

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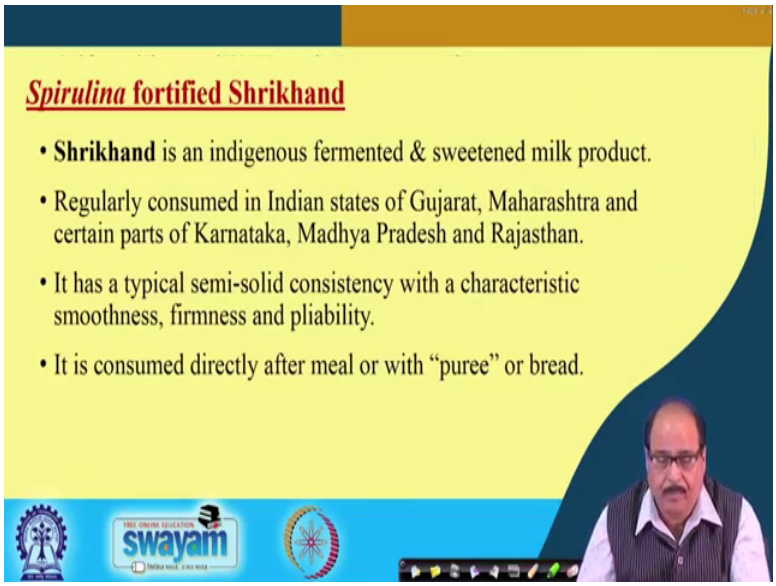

The other product is the a spirulina fortified shrikhand, that is shrikhand is an indigenous fermented and sweetened the milk product it is regularly consumed in Indian states of Gujarat, Maharashtra and certain parts of even Karnataka, Madhya Pradesh and Rajasthan. It has a typical semi solid consistency with a characteristic, smoothness, firmness and pliability. So, it is consumed directly after the meal or even sometimes some people use it as a that is consumed with chapathies or fried chapathies, purees, bread, etcetera.

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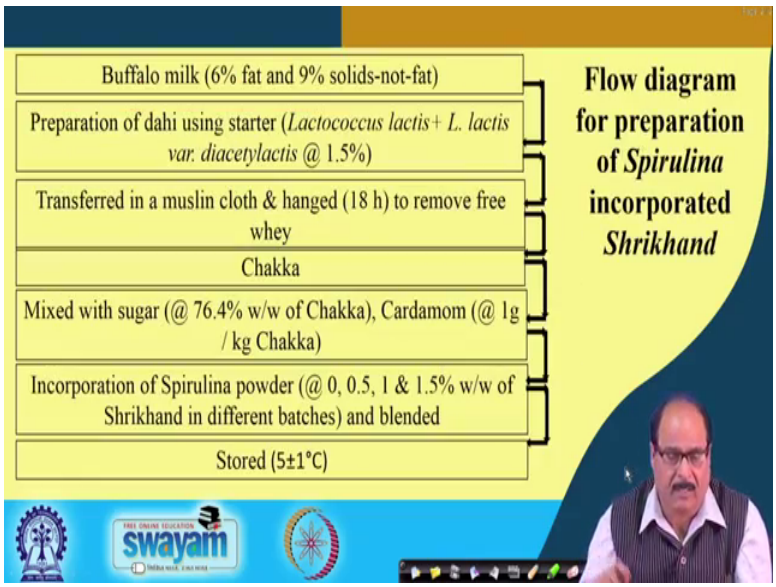

So, here it is the process flow charts for the preparation of the spirulina incorporaters shrikhand. That is the spirulinized sorry, shrikhand is prepared that as per usual standard procedures and then this shrikhand once is obtained in this we conducted a study by incorporating spirulina powder right dried spirulina powder whole biomass that is may be point up to a different level 0, 0.5, 1 and 1.5 percent weight by weight, right. And these were properly blended, homogeneous blend was made and they were restored for 5 plus minus 1 degree Celsius for different period of time to study their effect.

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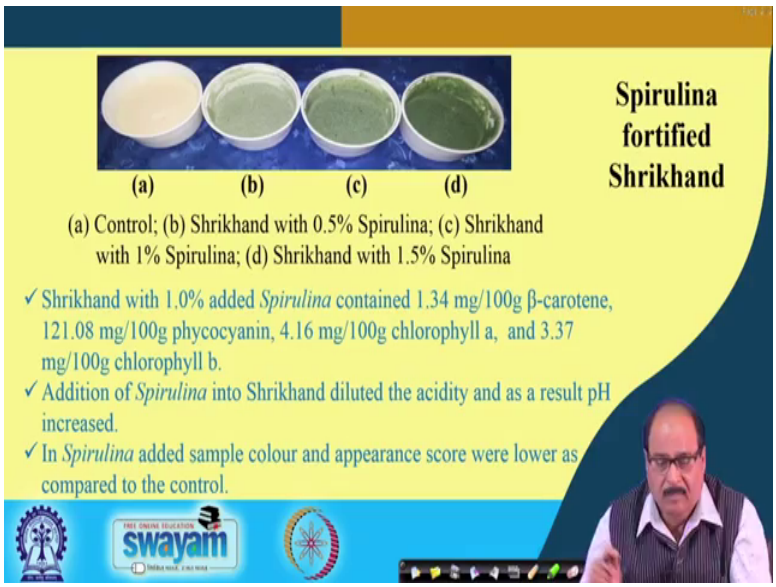

So, this you can see in the picture that is this is the photographs or samples prepared in our laboratory. That is here is the control silicon, no addition of spirulina but this b, c and d contains spirulina by 0.5 percent, 1 percent, and 1.5 percent weight by weight. So, in our the storage studies or effect of these addition and sensory, another characteristics was done.

And it was finally, found that shrikhand with 1 percent added this spirulina was liked by the consumers because beyond that it has some, so the colour and the flavor are some issues the consumers did not because increase in the spirulina contained had some effect on the colour, maybe darkening of the shrikhand and that were some consumer did not like that is peralist did not proved. So, 1 percent addition of spirulina you can found sufficient and it has it did not have any adverse effect on sensory another characteristics

it contained 1.34 milligram per 100 gram beta carotene and phycocyanin and chlorophyll a and chlorophyll content also were very good, right.

So, addition of spirulina into shrikhand also diluted the acidity and as a result the pH of this was increased. So, it has some because above 1 percent, up to 1 percent there were not significant change, but beyond 1 percent it has it did had some effect.

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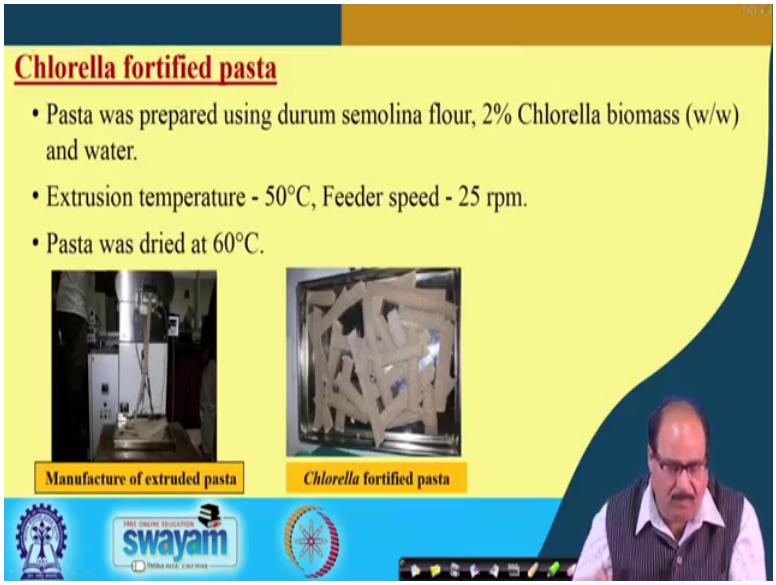

Then Chlorella fortified pasta again the pasta was prepared using durum semolina flour, 2 percent Chlorella biomass and water. The two in extrusion method was used standard procedure of pasta making was followed. The temperature in the at the extruder were 50 degrees Celsius, feeder speed was kept at 25 rpm and the pasta was obtained, it was finally, dried.

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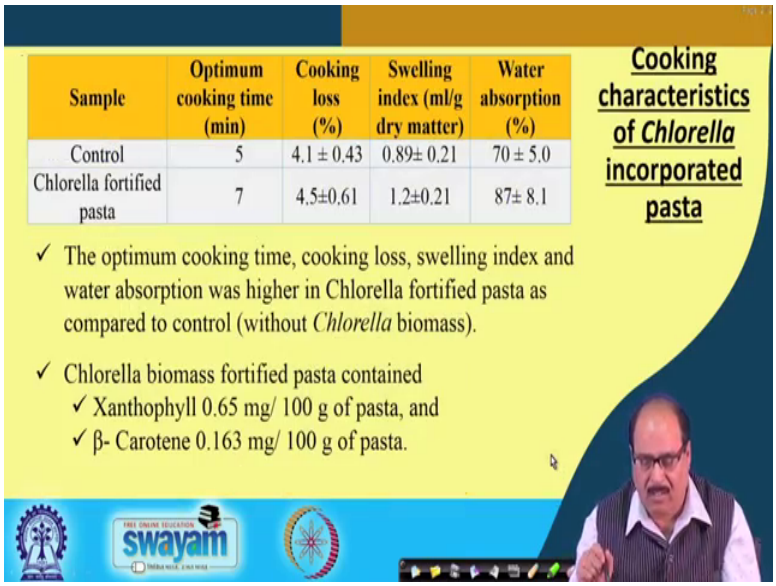

You can see here in the picture if the chlorophyte fortified Chlorella pasta and then the cooking characteristics and other characteristics of this pasta were studied. And it was, you can see here in this table that experimental results and say that the optimum cooking time, cooking loss, swelling index and water absorption was little bit higher or almost similar in the different samples of Chlorella fortified pasta as compared to control sample Chlorella biomass fortified pasta contain xanthophyll 0.65 milligram per 100 gram in our experiment as well as beta carotene 0.163 milligram per 100 gram of pasta within our experimental limits.

So, means that this is a indicative that they people can make that these products can be commercialized and made this Chlorella fortified pasta.

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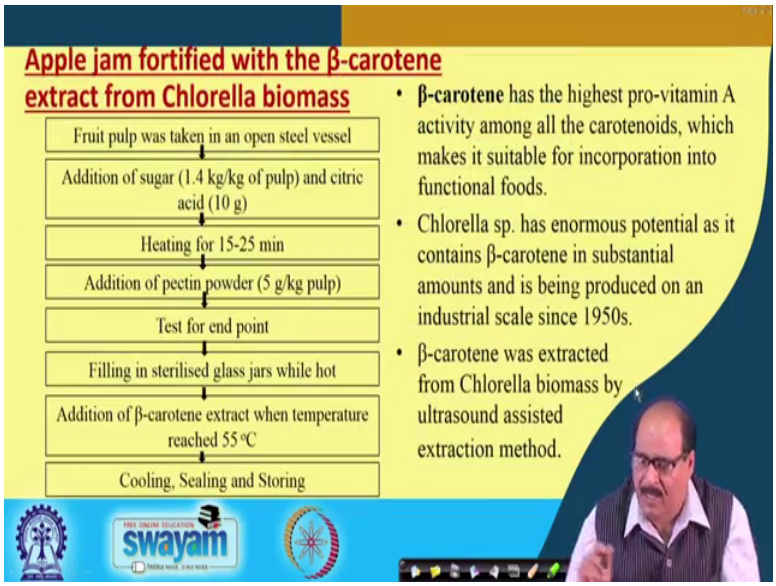

So, our study has demonstrated similarly we have used that is the beta carotene extracted from Chlorella biomass it has been used in the for the fortification of apple jam. So, apple jam is prepared using a standard process, standard technology and towards the end before filling into that is once the concentrated jams after it has been taken out from that heating source, alright, before setting just at that point it is added and mixed properly that is addition of beta carotene extract when temperature reached to around 55 degree Celsius and then finally, it is allowed for cooling setting and then storing.

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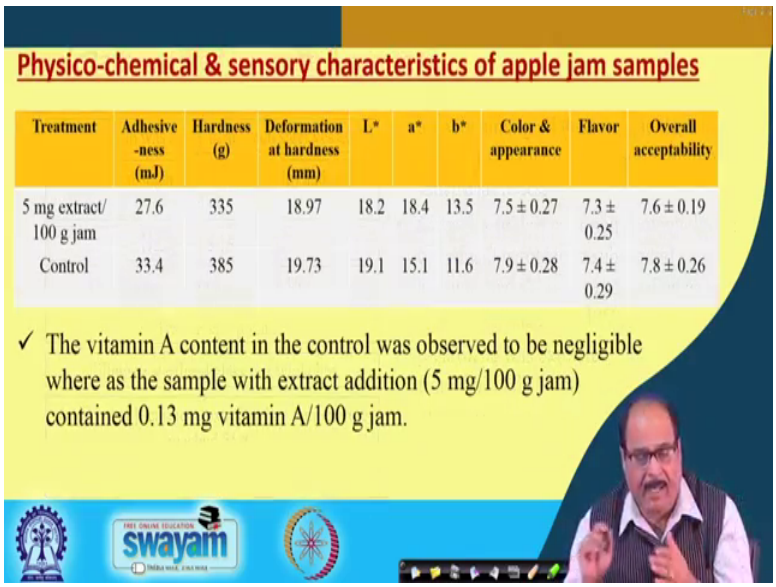

We realized differently than the physico chemical sensory characteristics of apple jam alright, like that adhesiveness, hardness, deformation at hardness, colour like L a b values, overall sensory colour and appearance, sensory scores, flavor and overall acceptability. So, both instrumental methods were used as well as a sensory methods were used, and it was found that is their data results almost to get it in fact, the hardness almost it match little it increase little bit by addition of that Chlorella whether beta carotene. That is deformation at hardness values they were all most same. L a b values there are not very significant change simply a value there were little a star, ok, b star and L star almost similar.

That is colour and appearance not much difference ok, flavor also and even overall acceptability that is it was liked with the same 7.8 . right as 8 and 7.6 with the overall acceptability scores. So, the vitamin A content in the control was observed to be negligible whereas, the sample with the extract addition had 5 milligram per 100 gram jam that is the content 0.13 milli gram vitamin A per 100 gram of jam. So, vitamin A content was or pro vitamin A content of the jam was significantly increased.

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So, this a few products which we have told you here included here in this these are the indicative that it is this gives a quite good reasonable data, that is the these processes can be developed, they can be commercialized and this will increase the algal base food products can be prepared.

So, in the finally, I would like to say that this algal base usefulness of the algae in the food industry like the natural products derived from algae which may include proteins, pigments, sulphated polysaccharides, alginates, carotenoids, polyphenols, flavonoids, omega 3 and omega 6, fatty acids, minerals and other essential nutrients. So, I will give have up all these. So, microalgae derived additives like luteins, zeaxanthin, beta carotene, they have huge application in pharmaceutical industries and food industries as a natural colorant and natural antioxidants. Alginates produced from macro algae are widely used in bakery, ice cream and pharmaceutical industry.

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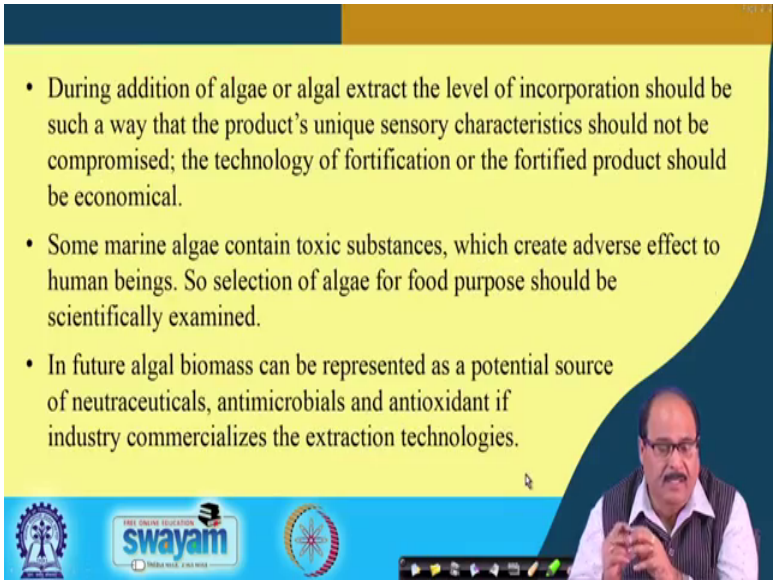

During addition of algae or alkali extract the level of incorporation should be such a way that the products unique sensory characteristics should not be compromised; the technology of fortification or the fortified product should be economical that is. So, some marine algae contain some toxic substances which create adverse effect to human being. So, the selection of algae for food purpose should be scientifically examined. So, I can say that in future the algal biomass can be represented there is a potential source for neutraceuticals, or antimicrobials and antioxidants.

Of course, importantly if the industry commercializes the extraction technologies, also but the proper there is a systematic approach may be as you to be to be taken that is the mass cultivation of the algal biomass, because the availability of the algal biomass for the extraction purposes is a big issue, major challenge, large amount of dried biomass

need to be made available to the extraction industries. So, having a proper well planned systematic approach of algal cultivation, its dewatering and drying, and then extraction, and finally, use of these extracted bio-actives or the biomass obtained after extraction or even whole biomass as such they can be used to prepare various functional food products, health food products or food containing various ingredients.

I have already shown some of these successes in made in our laboratory and some products which we have prepared, those products they have very good health value and nutritional value. So, such products they are indicative, they indicate that several such products can be developed can be formulated or even these products industry can commercialize and make. So, if they are done; obviously, these provide a very good alternative source of the protein and this algae can be easily cultivated and it can meet provide a major boost in the protein requirement of the body and as a protein source it can be used.

With this, I thank you very much.