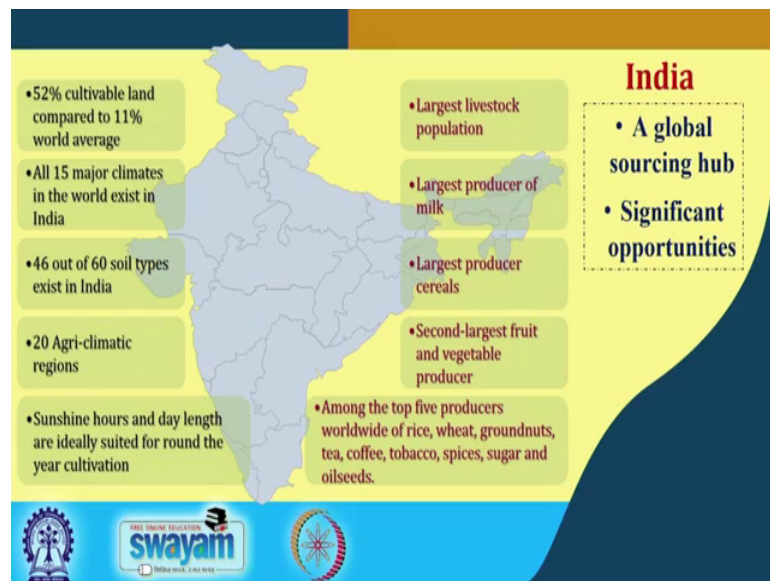


Novel Technologies for Food Processing and Shelf Life Extension
Prof. Hari Niwas Mishra
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur

Lecture – 60
Food Processing Overview & Course Summary

Hello friends, finally we have reached to the last lecture of this course on Novel Technologies for Food Processing and Shelf Life Extension. In this lecture, in the next 30 minutes or so, I will give you an overview of food processing situation in the country. Also, I will spend few minutes on summarizing whole course content what we studied in the last 60 lectures. And I will take this opportunity to give you an overview of R and D activities in my laboratory.

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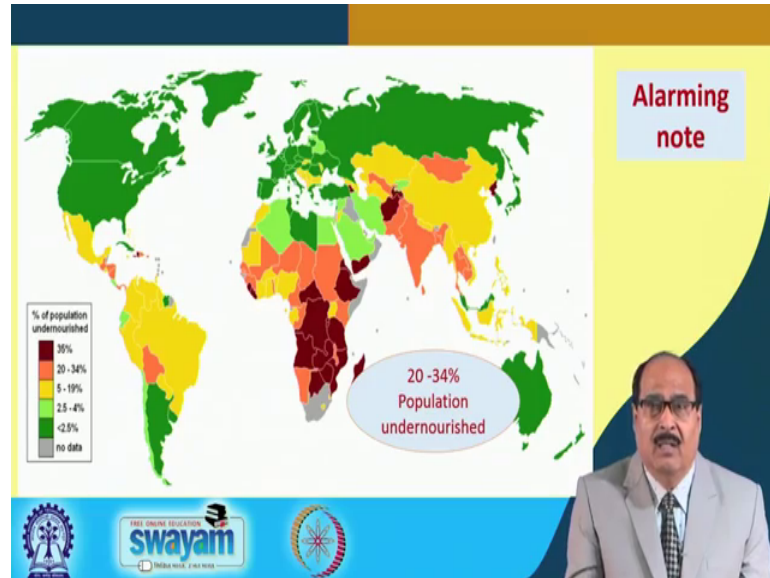


You know friends in India there are significant opportunities nowadays, it is being considered a global sourcing hub. India has 52 percent of the cultivable land compared to 11 percent world average. All 15 major climates in the world exist in India. It has 46 out of 60 soil types, there are 20 agri-climatic regions, sunshine hours and the day lengths are ideally suited for round the year cultivation.

And this situation has been exploited by our scientists, farmers very well. We now have largest live stock population in the country. India is the largest producer of milk; it is largest producer of cereals; second largest producer of fruits and vegetables. It is among

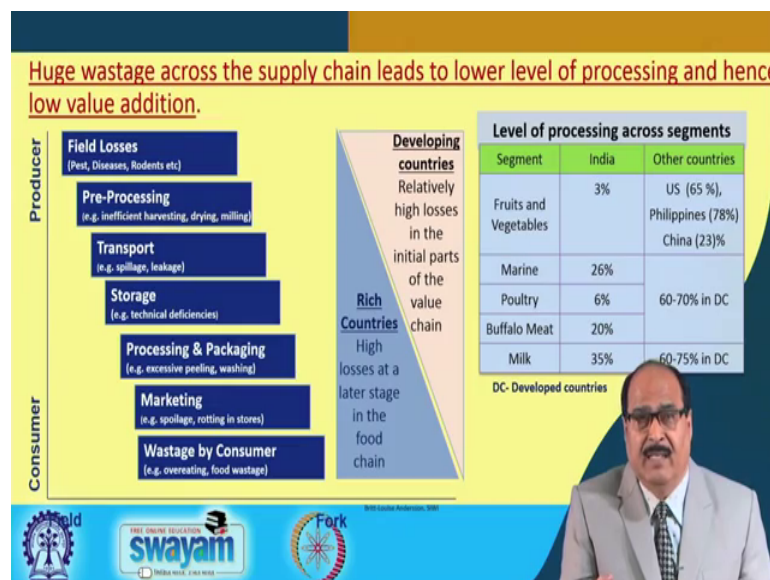
the top high producers worldwide of rice, wheat, groundnut, tea, coffee, tobacco, spice, sugar, oilseeds and what not.

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The situation as far as agricultural production is now very good, but there is an alarming note as well is still 20 to 34 percent of our population is undernourished.

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So, there might be different reason for this. One important factor is the wastage of agricultural produces, huge wastage across the supply chain leads to lower level of processing and hence low value addition. In our country, the high losses of the products

are towards the initial part of the value chain. If you can see in this slide, just I have summarized that different stages to which the food has to pass right from the harvest in the field till it reaches to the consumer and the table.

So, it passes in the from the different stages, like in the field, then in the processing factory, transport, storage, marketing and finally, in the home. And each and every stages there might be some losses. So, if comparison is made among the developing countries and the developed countries, we see that in the developing countries like ours there are relatively high losses in the produce in the initial parts of the value chain; where as in the rich countries whatever losses take place that is toward the end of the value chain maybe that at the end of the consumers and so on.

Regarding the level of processing across the segment if we look at in our country, still the perishable items like fruits and vegetables, we process only to the tune of 2.5 to 3 percent at present; whereas the countries like US, they process 65 percent of their produce, even Philippines processes 78 to 80 percent, China 23 to 25 of their fruits and vegetables are processed.

Regarding marine products, poultry, buffalo meat, etcetera the range of processing in our country is from 6 to 26 percent whereas, in developed countries they process about 60 to 70 percent of these products. If you look at the milk, 35 percent of the total milk production in the country is processed in both organized as well as in unorganized sectors whereas, in the developed countries about 60 to 75 percent of their products are processed.

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Paradigm shift in our approach to providing nutrition & health security to people is needed

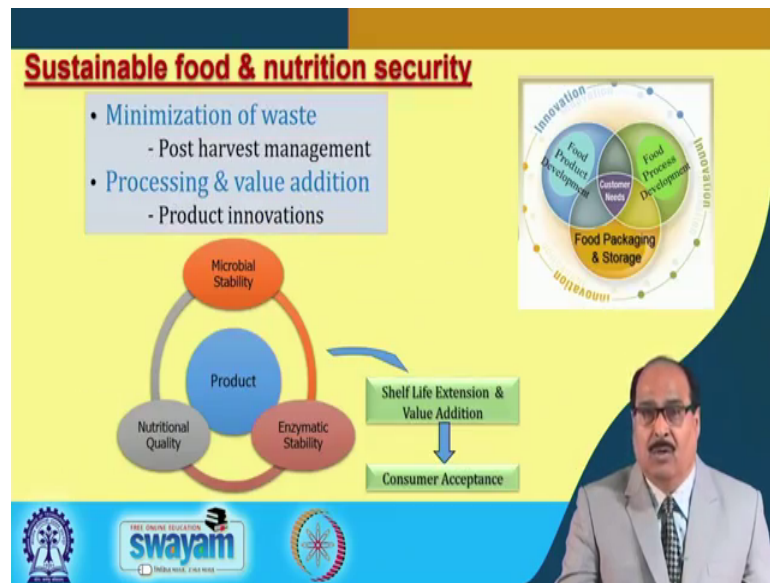
- ❖ From crop production alone to reduction in post harvest losses and value addition.
- ❖ From self sufficiency in food production to providing food items needed for meeting all the nutritional needs.
- ❖ From food security at the state level to nutrition security at the individual level.

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So, there are means at one stage we are producing more we are very good as far as the agricultural and food production is concerned, but there are much more needed to be done is for the post harvest management and processing and value addition is concerned. So, a paradigm shift is needed in our approach to provide in nutrition and health security to people means, that is from the crop production alone we cannot do the justice, we have to focus on the reduction in post harvest losses as well as to increase the value of the produced food.

The paradigm shift is needed from self sufficiency in food production to providing food items that are needed for meeting all the nutritional needs. From food security at the state level, we need to ensure nutrition security at the individual level.

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So, means that is for sustainable food and nutritional security, there are two important factors which food processors, food engineers or food technologists need to be concerned or the area two major areas which needs attention or focus of food engineers, food technologists are that the minimization of waste by applying good post harvest practices, post harvest management.

And we must ensure that the wastage in the agricultural produced is minimized, if not completely eliminated and the second aspect is processing to ensure that the maximum of our produced is processed and value added. And both things reply to both of these is the innovation, we should have innovative approaches in the product development, in the process development as well as in the food packaging and in storage.

Regarding product development obviously, we must ensure that the product which is produced it is microbiologically stable, enzymatically stable and it has a good nutritional value, it has good sensory characteristics and of course, it has a good shelf life and it is economically viable product.

But while doing all these things, one must keep into mind the consumer acceptability. The products which is developed, it must be acceptable local to the consumer otherwise whatever effort we make that if it is not like if the product is not liked by the consumer, so our efforts will be wasted.

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Business opportunities in food processing

Domestic market

- Upgradation from commodities to packaged and branded product.
- Convenience foods (RTE/RTD/RTS/RTC) which offer value for money.
- Products focused towards children, young adults which offer changing lifestyles.
- Health foods & beverages.

International market

- Indian traditional foods are becoming popular in global market.
- A number of Indian products are now globally competitive.

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So, at present there are a lot of opportunities in food processing, particularly if you look at the business opportunities in the food processing both in the domestic sector as well as in the international markets, lot of opportunities exist. In the domestic market, the business opportunities in food processing include from upgradation from commodities to packaged and branded products. We need to develop there is a lot of market for convenience foods, like ready to eat, ready to drink, ready to serve, ready to cook product which offer value for the money.

There is a lot of market nowadays for the products which are focused towards children, young adults which offer changing lifestyles. There is a lot of a scope for development and marketing of health foods and beverages. If you look at the international market nowadays, Indian traditional foods are becoming popular in global market. Even the foreigner people they eat, they like to eat now Indian food products a number of our Indian products are now globally competitive, but only important consideration for our product to be made saleable in international market is the quality, we must ensure good quality of our products and good safety of our products as per the international regulations.

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Constraints facing food industry

- Lack of right quality of raw material
- High raw material prices
 - ✓ Industry dependent on whole sale market
 - ✓ Control by middlemen
- Lack of year round availability of raw material
- Lack of cost effective packaging technology
- Outdated technologies & untrained manpower
- Infrastructural constraints
- Market highly price sensitive

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Indian food processing industries is still now facing certain constraints, like the lack of right quality raw materials are still not available. And if the good quality raw material is not available to the industry, industry cannot do miracle; for a good quality products, availability of good quality raw material is a must. The raw materials which are available, there the prices in fact generally they are high prices and these high prices of the initial raw material obviously, results into the high product prices. The industry is dependent on wholesale market, which is controlled by a middleman.

Another important constraint facing the food processing industry is the lack of year round availability of raw material. Lack of cost effective packaging technology, even the outdated technologies and untrained manpower, these are some of the important concern even most of the food processing industries in the country is still are run by the old dated technology or even the machinery being operated by un skilled manpower, untrained manpower. There are so many times infrastructural constraints that is that may be the industry is not up to date, the machinery functioning and other things and even good conditions, etcetera and the market is highly price sensitive. So, these are the some of the major constraints which are there which food industry faces from time to time.

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Key factors for success in food industry

- Assured supply of quality raw material at economical prices
 - ✓ Linkage with cultivators
 - ✓ Reduced wastage of raw materials
 - ✓ Increased shelf life of farm produce
 - ✓ Grading and storage of farm produce
- Systematic promotion and market development
- Ability to bear the high cost of entry
- Innovative product development
- Tapping the export market

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And obviously, in order to make sure that is a success key factors for success in the food industry are taken from these constraints, like number 1. If one want to be successful food entrepreneurs or if you want that your product should be a good quality, it has a good market. So you have to do certain things in order to ensure success of the industry that assured supply of quality raw material at economical prices is one important aspect.

And this should be done, either by developing linkages with the cultivators by following appropriate or taking appropriate measures to reduce the wastages of the raw materials by taking appropriate measures to increase the shelf life of the farm produce and therefore, making the more farm produce available for the processing. Even some of the primary processing, like grading, storage of farm produce, etcetera should be in current so that the availability of the raw material to the industry is made more it is increased.

Also systematic promotion and market development is another very very important factors. We should keep that is up our cell power our product are an always up to date that is we must say that what is the need of the hour, what is the need of the day, maybe the suitable surveys, etcetera should always be taken and the products. So, always be from time to time should be updated.

For the industry that is it should have ability to bear the high cost of the entry. Innovative product development, tapping the export market, these are some of the other factors for success in the industry.

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Strategies to improve export

- ✓ Export promotion programmes
- ✓ Marketing intelligence & research
- ✓ Standards development & testing facilities
- ✓ Proper enforcement mechanism
- ✓ Quality assurance - GMP/GHP/HACCP
- ✓ Training & skill development
- ✓ Innovative approaches

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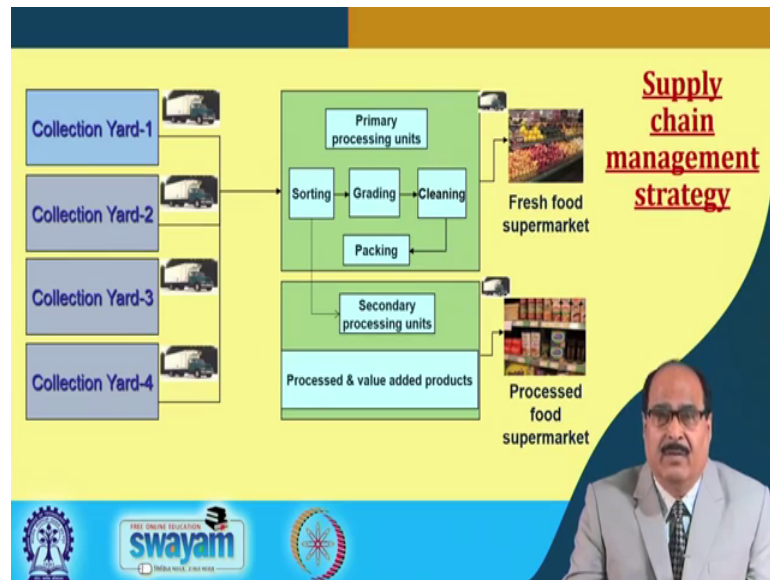
As far as the strategies to import improve export is concerned, because if in industries able to tap the export market, there are large much more chances for the success. So, as far as the in order to improve the export, one should take appropriate measures right like, export promotion programmes should be stagnant even marketing intelligent, intelligence and research as regarding the export should be stagnant then should be undertaken. Even standards development and testing facilities, because as I indicated you that is one major concern regarding export of the Indian product to foreign is to meet the regulatory requirement of those countries in which we want to export the product.

So, we should meet to the standard requirement, even if the need be that we should work for developing the standards and we should have the industry should have as approachable, here they should have proper testing facilities, where these eh their product they can get their product tested and make sure that their product meets to the required standards. Even then proper in force mechanism that is one should ensure that standards which are developed or which are tested that is all these are regulatory requirement, they should be properly enforced during each and every step in the value chain in the processing, in the product transport assigning, etcetera.

Quality assurance program like GMP, GHP, HACCP, etcetera should be stagnant. And even training and skill development programs should be undertaken within view to make sure that the product which is produced is of good quality. And of course, innovative

approaches should be undertaken in each and every aspect of the product manufacturing; whether it is packaging or its marketing, etcetera. So, if these things one can have a better exported of its product and better market.

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Regarding supply chain management strategies of course, this strategy can be used for all the agricultural producers, but this is much more likable in better with a particular for the fruits and vegetables. In fact, what has been done by Dr. Vargis, Korean in country in he filled of dairy processing. Similar approach is needed for the fruits and vegetables, because in our country that fruits and vegetables, etcetera are produced in scattered vein as small as many yards.

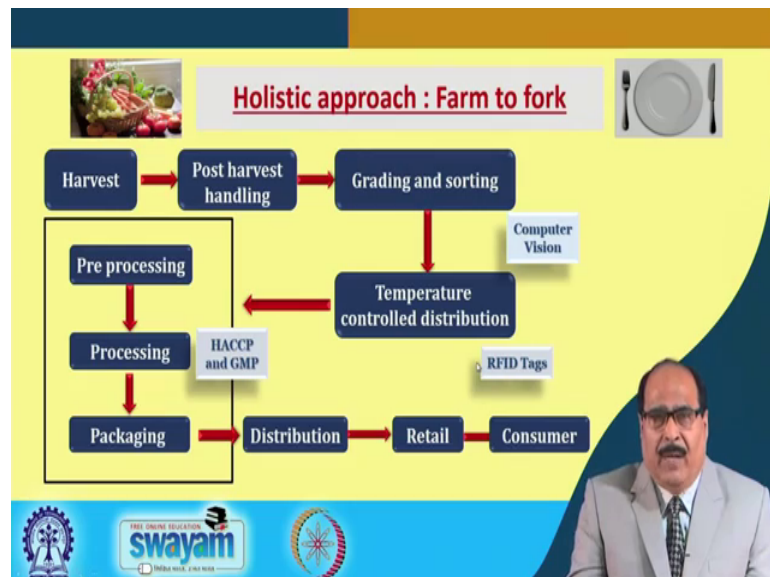
So, some arrangement should be made likewise in earlier classes we studied that refer vents, R C A M A, control atmosphere or modified atmosphere, refer vents, etcetera. So, using with appropriate these vents the materials, they can be collected from different collection centers or collection yards and they can be taken to the primary processing center or primary processing units and as far as possible. These primary processing units may be located near the production farms, near the agricultural farms.

And in these primary production unit these produce can be exposed to different some primary processing condition, like sorting, grading, cleaning, packaging, etcetera. And then a sub a part of the product which can we sent from here to the fresh food supermarket, and the remaining it can be sent to the secondary processing unit for

processing and value addition. And these processed products and value added products, may be then sent to the processed food supermarket, because in the fruits and vegetables we find that not all the produces are processable. So, it becomes important that if the produce is directly send to the factory that is there may be chances for that this product is if it is not processable, if it is not of good quality, the it may result into the last.

So, it is a better approach that these products are graded and one grade which can be directly sent to the fresh food market as a fresh produce, it can be sent and the remaining can be sent for the secondary processing and value addition.

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So, finally means that is end to end holistic approaches needed like from farm to fork that is right from the harvest till it reaches to the consumer. One has to as a industry or as the processor, one has to make sure that at each and every step in the value chain like in the for handling or grading or sorting by having proper or appropriate post harvest, management and primary processing steps or even temperature control distribution.

Once if it is ensure that the product, which is delivered to the processing line to the factory is of good value, it has a good quality; maybe computer vision system or RFID, distribution system during distribution RFID tags, etcetera. Other than there are many such approaches which can be used to make sure or to see that the quality of the produce is maintained during transportation, storage and primary processing, etcetera. So, by this one should ensure that the processing plant, good quality material, and then is delivered

and then in the processing and packaging plant by following or by utilizing HACCP, as well as following good manufacturing practices, good hygienic practices etcetera. One should prepare the good quality products.

And finally, again in the product distribution, product packaging, retail, etcetera; the good condition should be maintained and by this one can ensure that the product by the time it reaches to the consumer table, it maintains it is maintained in good it is good in quality and it is a safe product which is delivered to the consumer, so that is important.

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In fact, there are for this in there are different approaches we have already discussed in the earlier classes that all this starting from the raw material, till it reaches to the consumer tables, in the value chain there are different steps. And accordingly in this course, in the last 12 weeks we have taken various stages, like we initially in the first week or so, we devoted some time on the components of the food, food structure, we studied what are the different reactions which undergoes that is major reactions like gelatinization, (Refer Time: 23:20) reaction, (Refer Time: 23:22) etcetera or protein denaturation and other related reactions, which influence both quality and safety of the food during processing handle in any storage, because these are the reactions times needed they should be care should be taken that these spoilage causes reaction should be minimized.

And other so we have had a good exposure in these areas, then we follow we studied that is the novel methods of food processing like high pressure processing; membrane technology, irradiation, dielectric heating, supercritical fluid extraction, freeze drying, extrusion technologies, microencapsulation, aseptic processing and packaging, hurdle technology, food nanotechnology, etcetera. And all these methods are now becoming reality.

And they are the novel methods, if they are applied by the industry in proper manner, they will result into good quality food products are many of them are economic, the economically viable, safe, and healthy food products. After studying these novel technologies, various novel technologies, we also discussed we took a few commodity based product like, we and we studied the processing of oil seeds, extraction of oil, refining of the vegetable oils. And the use of different antioxidants are natural antimicrobial for extension of the products of food materials processed food products.

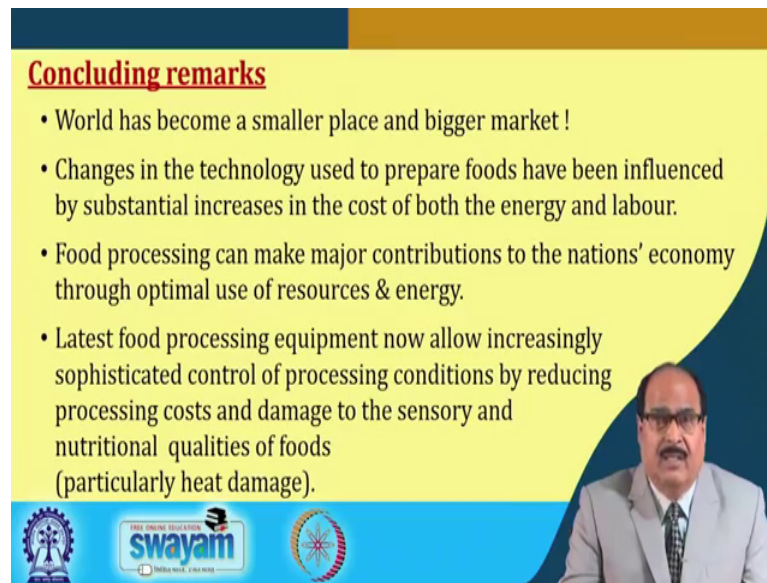
We also then studies that shelf life extension methods, novel methods for the extension of shelf life of perishable product like, fruits and vegetables methods are at modified atmospheric storage. I have two packaging controller must be a storage, edible coatings and how to maintain the quality during handling and storage of the fruits and vegetables.

Even and we also devoted ample time and the grain storage, how to maintain the good quality in the grain during its storage. And we also discussed various methods, may be quick methods for analysis of the grading storage infestation and another quality attributes in the fruits, vegetables, like hyper spectral imaging, FTI and such other methods electronic logs, and so on.

Finally, we discussed the novel technologies for manufacturing of ready to eat, ready to cook health foods and beverages, we devoted good time and that is the algal food technology or other products food fortified foods and nutraceutical, various products like iron fortified rice and high energy food paste, snap food products, etcetera we studied.

So, we in the last 60 lectures almost covered the major technologies for processing and also few are quite a sufficient number of food products which have different potential for the commercialization. Food products of commercial importance, we discussed in this course in the last 60 hours.

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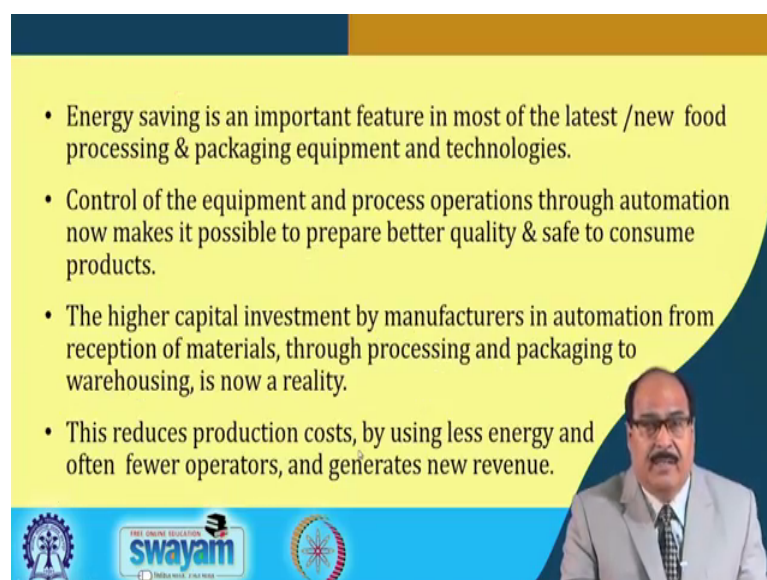
Concluding remarks

- World has become a smaller place and bigger market !
- Changes in the technology used to prepare foods have been influenced by substantial increases in the cost of both the energy and labour.
- Food processing can make major contributions to the nations' economy through optimal use of resources & energy.
- Latest food processing equipment now allow increasingly sophisticated control of processing conditions by reducing processing costs and damage to the sensory and nutritional qualities of foods (particularly heat damage).

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So, I will now conclude this lecture or this course by saying that world has become now smaller place and bigger market. Changes in the technology used to prepare foods have been influenced by substantial increases in the cost of both the energy and labor. Food processing can make major contributions to the nation's economy through optimal use of resources and energy. Latest food processing equipment now allow increasingly sophisticated control of processing conditions by reducing processing costs and damage to the sensory and nutritional qualities of the food, particularly the heat process related damages.

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- Energy saving is an important feature in most of the latest /new food processing & packaging equipment and technologies.
- Control of the equipment and process operations through automation now makes it possible to prepare better quality & safe to consume products.
- The higher capital investment by manufacturers in automation from reception of materials, through processing and packaging to warehousing, is now a reality.
- This reduces production costs, by using less energy and often fewer operators, and generates new revenue.

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Energy savings is an important feature in most of the latest or new food processing and packaging equipment and technologies. Control of the equipment and process operations through automation now makes it possible to prepare better quality and safe to consume food products. They higher capital investment by manufacturers in the automation from reception of raw material to processing and packaging to warehousing, is now a reality. And this reduces production costs, by using less energy and often fewer operators, and generates new revenues.

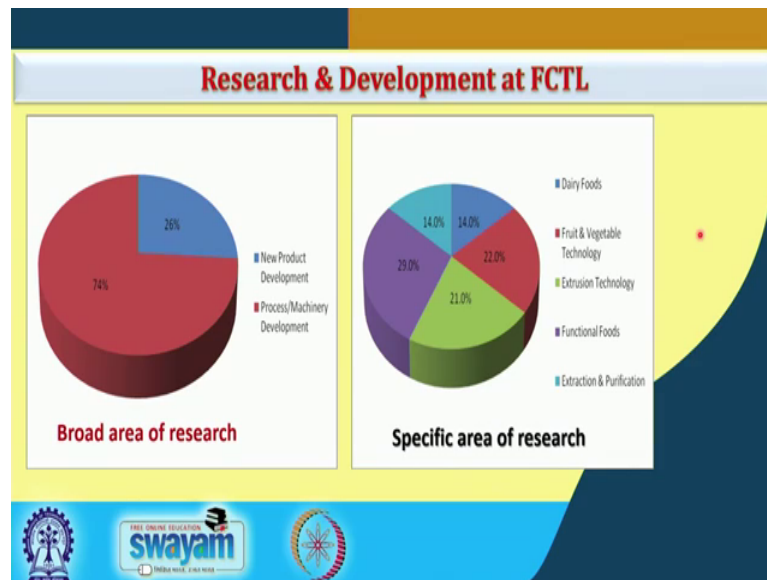
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With this I that is the general thing about this course or course summary whatever we thought we studied or discuss in the earlier classes ok. I would like to just a 2, 3 in 2, 3 minutes, I would like to give you an overview of my research and laboratory at IIT, Kharagpur that is food chemistry and technology laboratory right.

If one is interested to know about this you can visit to this www.fctliitkgp.in. The R and D thrust areas of my laboratory are ready to eat healthy foods and nutraceuticals, extension of shelf-life of perishable foods, novel food products and process development, food safety and quality control and so on.

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The way if we just see at overview that research and development that is work that is being done in our laboratory, about 25 to 26 percent of the total workforce our efforts are on the new product development, where are the three-fourth around 74 to 75 percent of our work is on process and machinery development.

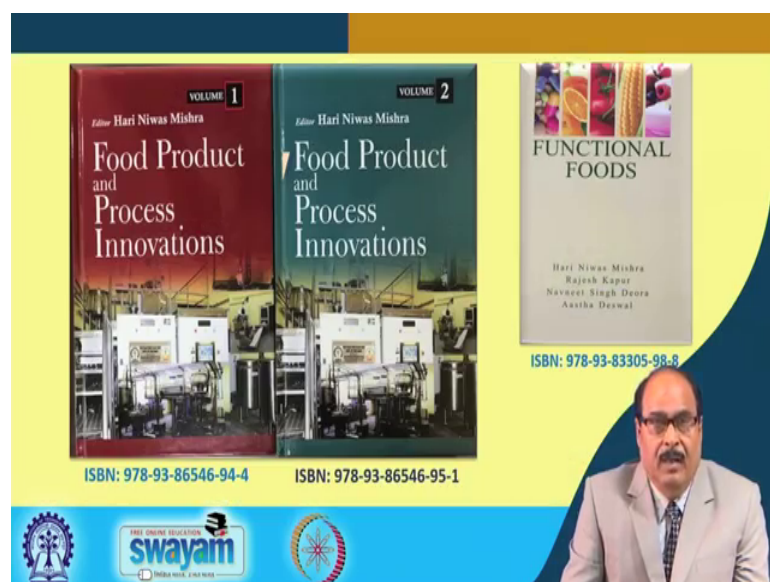
If we look from the sector wise about 14 to 15 percent of our work is on dairy foods, about 20, 22 percent on fruits and vegetables technology is a sizable amount equal amount of about 20, 21 percentage on extrusion technology. About 29 or 30 percent of our work is devoted and development of functional foods, and again 14, 15 percent extraction and purification of bioactives and utility its utilization in different food products development.

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These are some of the products which are developed in my laboratory, and many of these we discussed in earlier classes right. They are some of them or many of them are already patented right. And they are technologies; they are many these technologies are ready for commercialization, if you have already been commercialized, so these are I will just pictures of the products which are samples prepared in our laboratory.

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These are the books like food product and process innovations in two volumes; this is I am the editor of these two books and the authors are my present and past researchers

scholars mostly. So, there is ISBN number is there. So, the information that is which we covered in the about products and processes in this course, you can be found in these books also. There is another book third book is the functional foods written by me and with my few researches scholars and colleagues. So, the information if anyone is interested these books are available online, as well as hard copies of the books are also available ok.

(Refer Slide Time: 32:51)

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TA

- Contributions of Teaching Assistants & Ph D research scholars of the FCTL are thankfully acknowledged.
- Special thanks are due to
Ms. Sanchita Biswas
Ms. Gayatri Mishra
Ms. Pooja Pandey
Ms. Anjali Thakur
Ms. Monalisa Pattanayak
Mr. Sourav Misra

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So, this now I the important task which I want to perform is mostly, which is otherwise I will be failing my duty, if I do not acknowledge the hard work put by the teaching assistants of the course. The teaching assistant Dr. Danie Shajie, he has been post doctoral fellow with me, he did his PhD with me at IIT, Kharagpur; earlier he has done M.Tech in food process engineering and B.Tech in biotechnology from Karunya university.

The other teaching assistance is Mr. Chandrakant Genu Dalbhagat, he is at present doing PhD with me at IIT, Kharagpur; earlier he did M.Tech in dairy and food engineering and his M.Tech projects he did with me. He before M.Tech, he has done B.Tech in agricultural engineering from MPKV, Rahuri.

The third teaching assistant in Ms. Jayashree Majumdar, is at present doing PhD with me, before doing coming here for PhD, she has done M.Tech from Jadavpur university in

food and biochemical engineering. And B.Tech in food engineering from Allahabad agricultural institute.

The other teaching assistant is Chirasmitha Panigrahi, she is also doing PhD with me at IIT, Kharagpur; also before PhD she is in fact a joined M.Tech and PhD. So, she did her master's degree in food process engineering also from IIT, Kharagpur and her M.Tech project with me. And before joining IIT, Kharagpur, she you did her B.Tech agricultural engineering from OUAT, Bhubaneshwar.

So, the contributions of all these teaching associate assistants in fact, whatever you have seen that this force this the major credit goes to these teaching assistants are the other researchers scholar the both present and past research scholars of the food chemistry and technology laboratory, as well as the staff associated with the food technology and the food chemistry and technology laboratory.

So, contributions of all these is thankfully acknowledged and placed on record. I will be failing if I do not mention the names of few present and past research scholars, who significantly contributed in the preparation of slides (Refer Time: 36:01) and it includes Ms. Sanchitha Biswas, Ms. Gayathri Mishra, Ms. Pooja Pandey, Ms. Anjali Thakur, Ms. Monalisa Patnaik and Ms. Sourav Mishra, so a special thanks to all them.

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Next is the excellent job I do to acknowledge from my core of my heart, the excellent job done by the NPTEL team, the video recording and lecture recording team. And this team is led by two project officers Mr. A.V. Ramacharlu that I sincerely acknowledge they have all done very very excellent and remarkable jobs and which I am sure you are seeing the quality by the quality of the videos, etcetera, which you are getting.

The other project officer is Mr. Debopriya Chakraborty, they equally both this team Debopriya Chakraborty and Ramacharlu, they have been the master mind in the whole this arrangement of a recording this and preparing this nice videos, thank you Mr. Chakraborty.

The Mr. Devesh Prasad, project assistant his contribution is a thankfully recorded and is praiseworthy. He has always been available whenever I needed for any type of help in this regard he was available, so thank you Mr. Devesh Prasad. Mr. Uttam Sharma, project assistant is also equally that is job he has done a marvelous work in the recording of these lectures and videos thank you Mr. Sharma.

Mr. Sourav Bhattacharya, Mr. Sourav Bhattacharya the other project assistant, he also along with his team did a very good job. Ms. Sagarika Barik is that she is a project assistant in NPTEL team and whole team, they did marvelous job and last but not the not the least see Mr. Ajay Malik, oh he is here; so I would like to acknowledge, the services rendered by Mr. Ajay Malik and thank him.

So, finally, there is a whole team of this NPTEL that is the video recording team, I would like to give a special thanks to Mr. A.V. Ramacharlu for his help as well as even guidance to me as far as this delivery of the lecture and other matters are concerned ok. So, whole team their excellent job is praiseworthy and it is placed on records.

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Finally, the NPTEL team of whole NPTEL team of IIT, Kharagpur, IIT Kharagpur my parent Department Agricultural and Food Engineering Department, and other associated departments of IIT, Kharagpur. The I wish to express my sincere thankfulness to them, for providing the infrastructural facilities and other facilities for conducting this course for recording.

And in the last but not the least finally the I put I am sincerely thankful to the Ministry of Human Resource Development, Government of India for providing me this opportunity of doing this course on Novel Technologies for Food Processing and Shelf Life Extension. So, finally I hope you all enjoyed the course, wishing you all the best for your future endeavors.

Thank you very much, [FL].