Novel Technologies for Food Processing and Shelf Life Extension

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Lecture - 51
Iron Fortified Rice (IFR)

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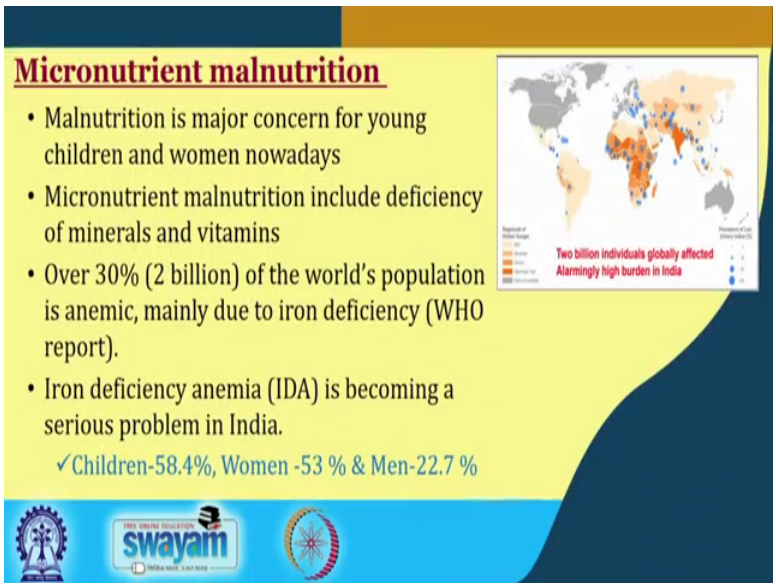

Hello friends. In this lecture, we will study about one very very important products from nutrition point of view that is Iron Fortified Rice. You know malnutrition is a major concern for young children and women nowadays and particularly the micronutrient malnutrition. The micronutrients malnutrition is because of the deficiency of various micronutrients, but like a minerals and vitamins. About more than 30 percent or over 2 billion of the world's population is anemic, mainly due to iron deficiency anemia, it is a WHO report.

Iron deficiency anemia is becoming a major concern a serious problem in our country in India also. According to the latest government survey about 58 percent of children, 53 percent of women and around 22.7 percent or 23 percent of men are anemic in India.

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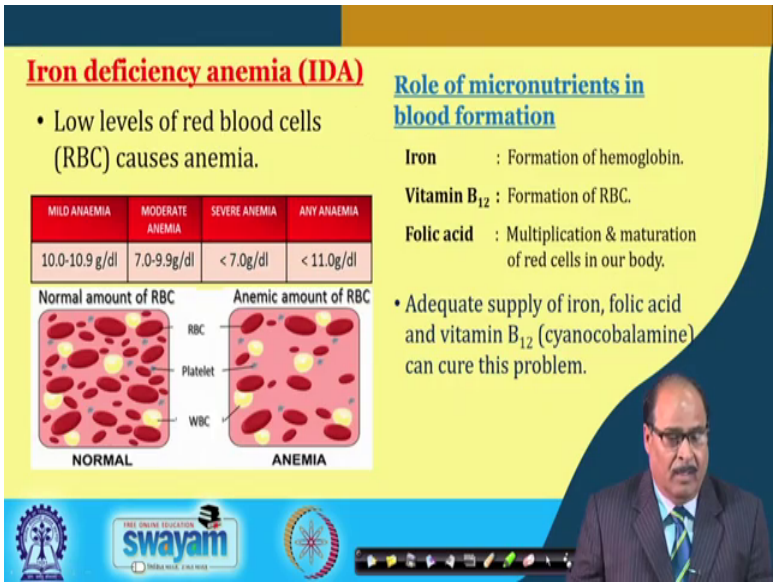

The iron deficiency anemia is mainly because of the low levels of RBC in the blood. The IDA-Iron Deficiency Anemia depending upon the type of the RBC or level of the RBC in the blood. It can be divided into different categories like mild anemia, moderate anemia, severe anemia or any anemia.

Any anemia where this a iron content is less than or RBC is less than 11.11 gram per decilitre. You can see that it is in this picture, it is clearly shown that RBC avoid with WBC and platelets. So, RBC count in the normal blood is comparatively more, where at in the anemic were RBC count is reduced.

So, in fact this iron, vitamin B 12 and folic acid. These three micronutrients have very important role in the formation of a blood or RBC that is the a iron causes the or helps as a role in formation of haemoglobin. Vitamin B 12 has a role in the formation of RBC, and folic acid a results into a causes the multiplication and maturation of the red cells in our body. So, adequate supply of iron, folic acid and vitamin B12 which cynocobalamine can cure this problem.

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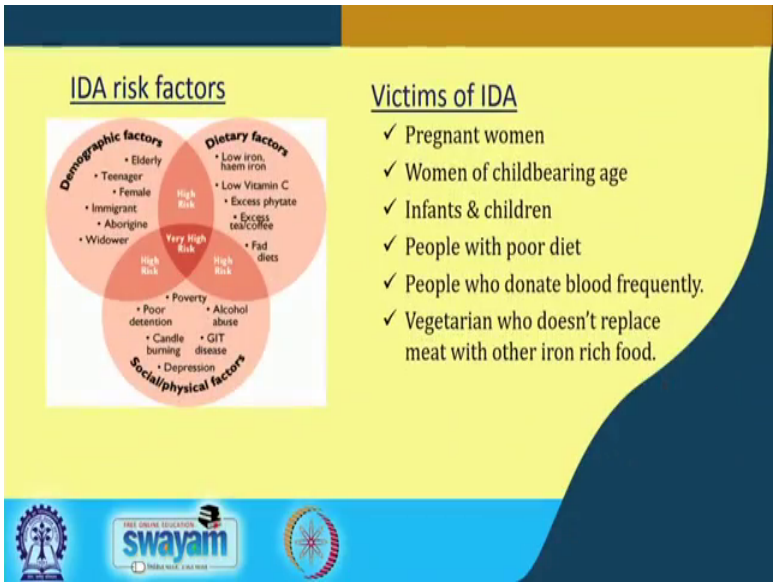

Different IDA risk factors are shown in this figure that is a it may be demographic factors, it may be dietary factor, low intake of hem iron, low vitamin C intake another component. And even their sociological or physical social or physical factors, so but in the net cell ultimately the because of these various risk factors or various causes, people do not get required amount of the iron content or folic acid and vitamin B 12 content.

So, the generally women or pregnant women, women of childbearing age, infants and children, people with poor diet or people who donate blood frequently or vegetarian people, who does not replace meet with iron or iron rich food etcetera in their regular diet. They are normally the victims of iron deficiency anemia.

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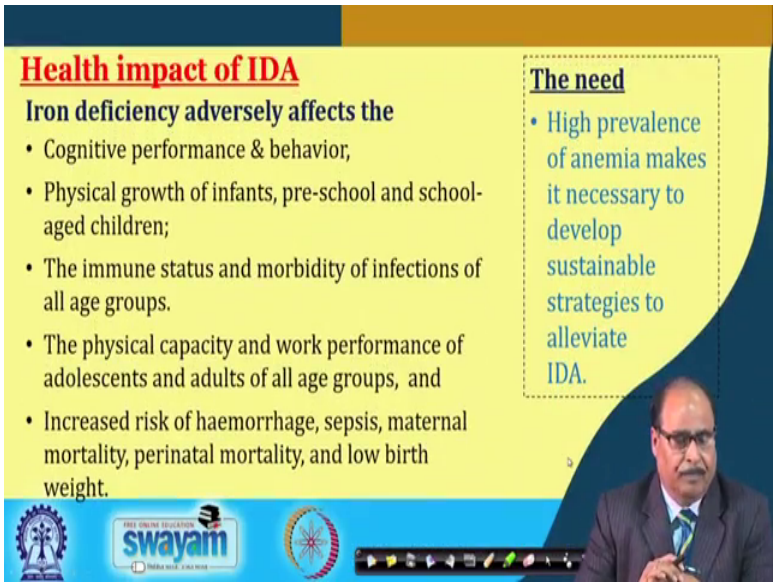

And this anemia are particularly the iron deficiency anemia has major influences or major impacts on the health, it adversely affects the cognitive performance and behaviour of the persons. It adversely affect the physical growth of infants, pre-school children, and a school children, it adversely affects the immune status and morbidity of infections of the all age group of the persons.

The physical activity and work performance of adolescents and adults of all age groups are also adversely affected by IDA. Even increase a risk of haemorrhage, sepsis, maternal mortality and low birth rate etcetera are the other risk factors because of the IDA. So, there is the prevalence of anemia makes it necessary to develop sustainable strategies to alleviate this problem of iron deficiency anemia from the nations.

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So, the there are different strategies for the prevention of anemia, this may be through dietary diversification that is we have our diet in regular diet, daily diet in such a proportion in a biology manner, so that we get adequate in takeaway take adequate intake of the required nutrients B 12 folic acid and iron or we visit the doctor that is provide improved health services by taking iron capsules, iron tablets, etcetera or by having iron folic acid supplementation with biannual de-worming.

And another most effective is a now that considered to be the food fortification. So, either of this strategies alone are in combination. In fact, in combination of the different strategies, may be an effective solution for the formation of iron deficiency anemia.

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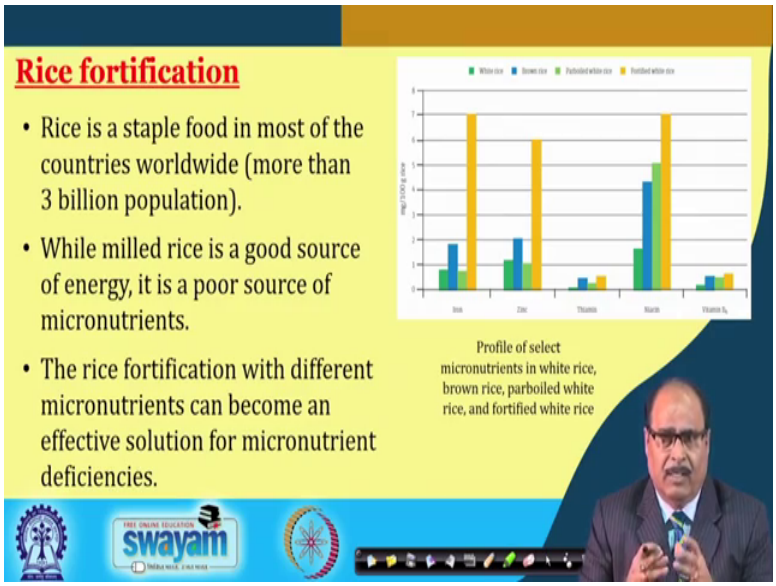

So, this thing in background, this iron fortified rice has been developed. So, I will tell you, what are the; why this rice is an important vehicle for iron fortification, because rice is a is stable food in most of the countries worldwide more than 3 billion people eat rice. Milled rice is a good source of energy, it is a poor source of micronutrient because most of the this micronutrients like iron, zinc, thiamine, aicin, vitamin, B6 etcetera, which are present in the rice in the paddy, they are present in the brown layer.

So, during milling that is when the brown is removed up in the polished rice that is almost all micronutrient are removed. So, the milled raw rice is basically a starch grain, it is a starch endosperm which we normally eat. So, in this figure, you can see bar chart that is the micro nutrient content of white rice, brown rice, parboiled rice and fortified rice that is during parboiling method.

Some of the micronutrient in diffuse into the kernel starch endosperm. So, the parboiled rice has little more this there labels in a in comparison to the raw rice or raw mill rice by fortification that the yellow picture this that is one can have in infused in the rice, the desired amount of micronutrients. So, the rice fortification with different micronutrients can become an effective solution for micronutrient deficiencies.

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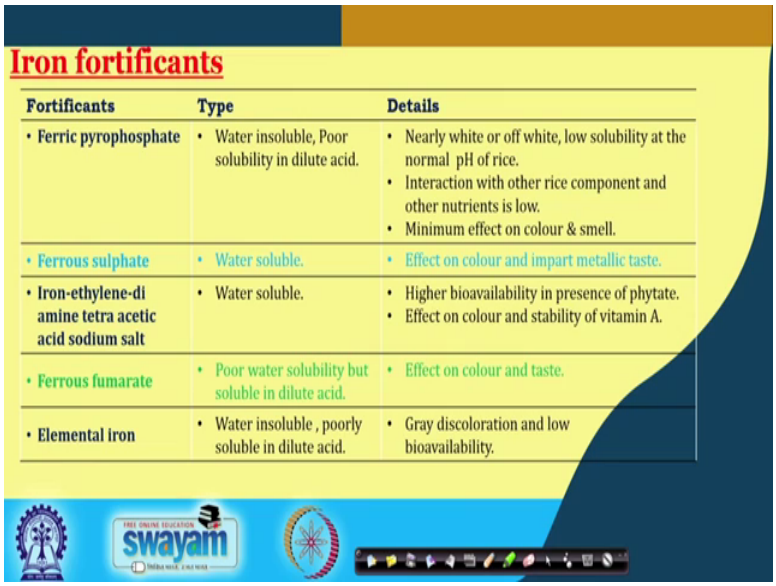

So, different means that is the fortification of rice different micronutrient that is the different compounds of rice can be used or incorporated in on the rice, I will tell you little later, what are the method of fortification and corporation of this. So, accordingly this iron fortified it rice can be manufacture.

So, different iron fortificants are compounds of iron which can be which has the potential to be used as a fortificant include iron pyrophosphate, ferrous sulphate, a iron-ethylene-diamine tetra acetic acid sodium salt or ferrous fumarate or elemental iron. And all this they have their particular characteristic like ferric pyrophosphate, it is water insoluble sorry the ferric pyrophosphate is water in soluble and has poor solubility in dilute acid. It is naturally white or half white, it has low solubility at the normal pH of the rice.

Even in the interaction with the rice components and other nutrients in the grain is low. And it has minimum effect on colour as well as a smell, whereas the ferrous sulphate is water soluble, it has a effect on colour and import metallic taste. So, these are the different the means fortificants depending upon their characteristics that is the fortificant level should be selected that it should not have any interaction with the constituent of the food it should not import any undesirable colour and flavour etcetera.

Like for example, if ferrous sulphate is used in the fortification, it is a water soluble. So, chances will be there that measure most of this ferrous sulphate will be washed away unlashed out. So, the ferric pyrophosphate is one such because it is water insoluble. So,

chances of its retention in the rice during cooking, and during washing operations is more. In the earlier class, we discussed a in detail about the fortificants their slide, selection criteria etcetera. So, among these fortificants one can find out, most commonly used fortificant per rice is the ferric pyrophosphate.

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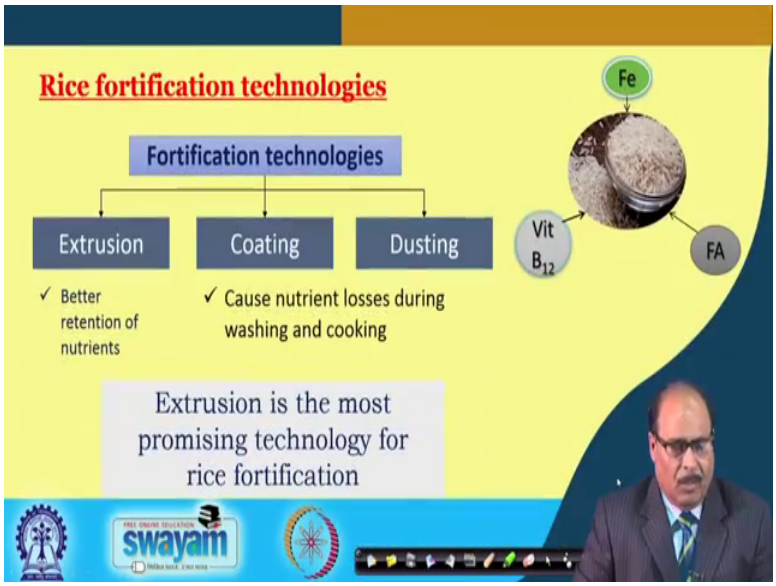

So, the technologies are method for fortification. The common methods include dusting, coating and extrusion. In the coating and dusting, the chances of, a losses of these nutrients that is p a Fe, B 12 and folic acid etcetera. They are more during washing at during cooking there. But, the extrusion, because in the extrusion technology that the micronutrient are infused inside the kernel, whereas by coating and dusting processes that the micro nutrients are present on the surface of the rice grain. So, extrusion a pH 2 be most promising technology for rice fortification.

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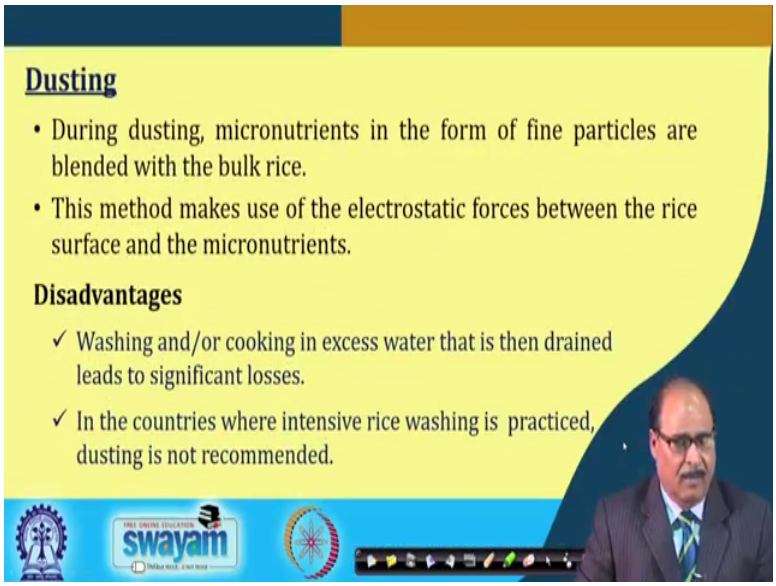

Dusting, as I told you during dusting; micronutrients in the form of fine particles are blended with the bulk rice. And this method makes use of the electrostatic forces between the rice, surface and the micronutrients. So, the rice micronutrients are coated or dusted on the a stick on the surface.

So, disadvantage of this method is that washing and are cooking in excess water that is then drained lead it is significant losses or in the countries where intensive rice was in his practice, a during cooking etcetera, dusting is not a recommended method for fortification.

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Coating, in this method high concentration of micronutrients are added to the rice followed by water resistance edible coating. Several coating layers, usually alternated with layers of coating material alone are added by spraying. In the coating edible coating, we studied the different methods, so by spray coating. This micronutrient layer is put on the surface of the rice. Coating may include even coating material a waxes, acid, gums, a starches are cellulosic polymers etcetera, may be used as a career for this micronutrients for the coating.

Disadvantages of these technology coating, technology include that is it results in loss of colour, taste and micronutrient during washing step. Majority of the water soluble micronutrients are lost during washing, because in this also the micro nutrients are present on the surface only. And the coating layer of the kernel makes them highly visible in the rice blend. So, the colour of the rice also gets some what affected.

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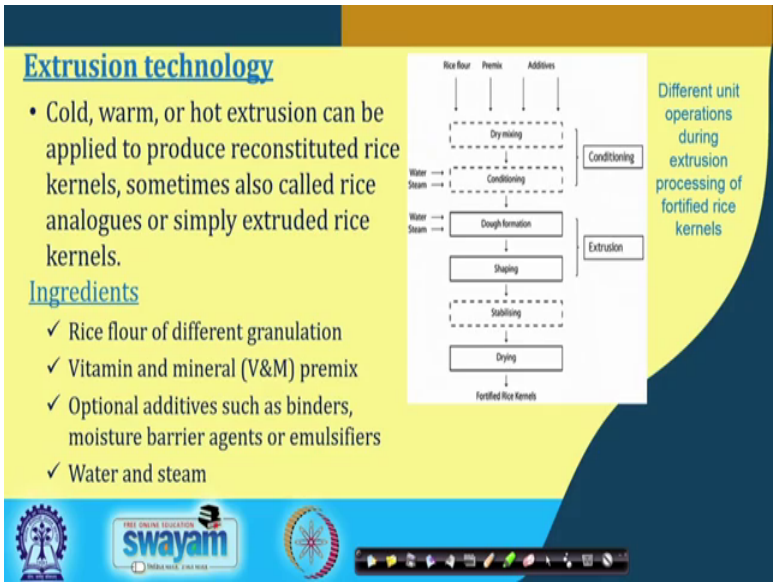

So, the extrusion technology. As I told you it is it is one of the promising technology for a fortification of a rice with the micronutrients ok and different unit operations, which during the extrusion processing of fortified rice kernel, include that rice is to be converted into powder, then powder is mixed with a additives and premixes etcetera, then dry mixing.

Then finally, it is a condition to suitable washer content. And after conditioning, it is a passed to the dough formation, shipping, stabilizing, drying. So, this dough formation and shipping takes place inside the extrusion barrel. And then finally, rice comes it is dried, and hence we get a rice kernel of suitable.

So, both cold or warm or hot extrusion can be applied to produce reconstituted rice kernels, sometimes these rice kernel fortified rice kernels are also called as rice analogues or simply extruded rice kernel are fortified rice kernel FRK. So, ingredients for this process include rice floor of different granulation. And this is very very important that is the particle size of the rice floor and vitamin, and mineral, premix, optional additives maybe binders, moisture barrier agents or emulsifier, and water and or steam. So, but the binders, moisture barrier agents etcetera are (Refer Time: 16:20).

The main a ingredients becomes rice floor of a particularly of a micronized form lower particle size, similarly vitamins and mineral premix of a lower particle size, because

micronized vitamin and mineral premixes in t the bio-availability of iron is very very high.

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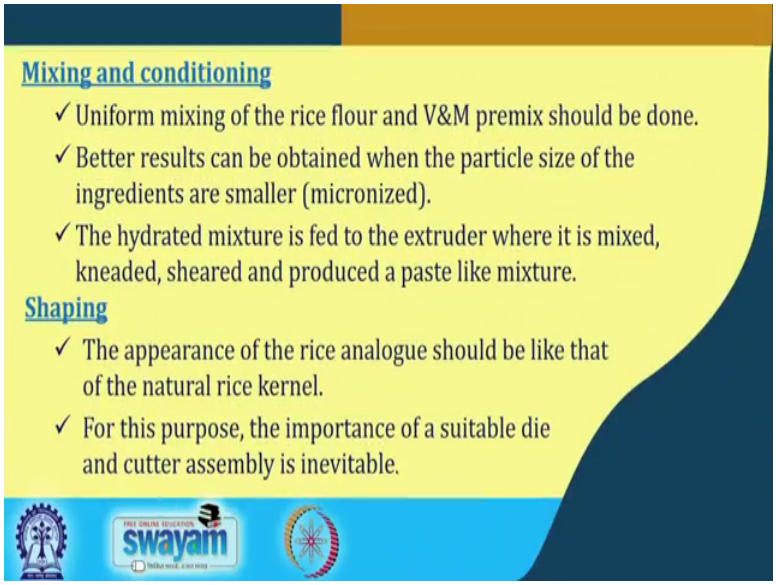

So, in the mixing and conditioning step that is it ensures uniform mixing of rice floor with a vitamin and mineral premix. And better results can be obtained, when the particle size as I told you of the ingredients are a smaller micronized. The hydrated mixture is then fed to the extruder where it is mixed, kneaded, sheared and produced in a paste like a mixture inside the extruder barrel. And that conditions inside the barrel temperature, and pressure and act are accordingly adjusted.

So, in the shaping process inside the barrel, the appearance of the rice kernel analogue should be like that of the natural rice. So, for this purpose, these material is moved that is a from the inside the barrel to outside through a especially designed die. So, a suitable die and a suitable cutter assembly, they are very very important component or constituents of this extrusion process. So, rice shaped die is a used to give a shape.

And another thing that is the temperature and pressure at the die head, that is the inside, because inside the extruder generally temperature and pressure high. Outside the extrusion temperature and pressure is low that in the environment. So, a proper balance has to be made by adjusting the temperature and pressure inside the extruder barrel, so that the when material comes out, it does not expands too much it gives a proper shape of the material arise a obtained.

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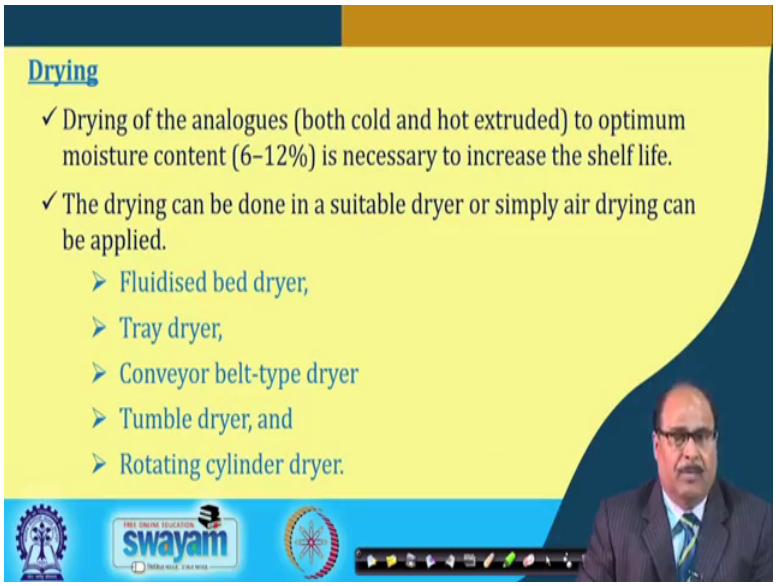

So, after that since in the conditioning process some moisture was added, just in order to facilitate a proper formation of the are proper giving proper safe to the material. So, some of the moisture content and when this rice are fortified kernel comes out of the dryer, it has come little higher moisture content. So, to make it stable at room temperature, it has to be dried and its moisture content, in fact, should be brought to the range of that of the normal moisture content.

So, maybe either any type of dryer like fluidised bed dryer, tray dryer, conveyor belt-type dryer, tumble dryer, a rotating cylindrical drum dryer etcetera can be used. In fact, the fluidized bed dryer maybe appear to be a good dryer or for the larger scale online manufacturer that continuous production conveyor belt-type dryer, also we will be more appropriate suitable.

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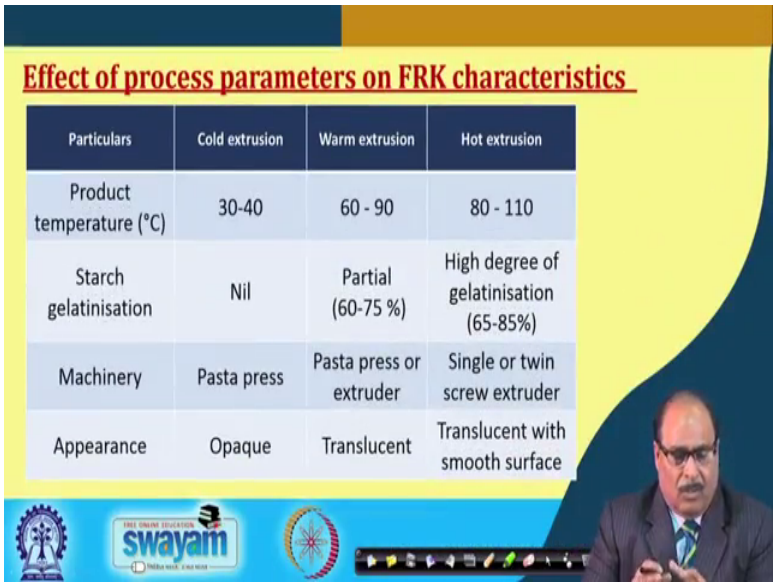

So, in this like just I have try to give you, the effect of because I have told you the effect of extrusion process parameter, whether it is a cold extrusion or it is a warm extrusion or hot extrusion depending upon the product temperature that cold extrusion 30 to 40 degree Celsius and warm extrusion the temperature is 60 to 90 degree Celsius in hot extrusion, it may be 80 to 110 degree Celsius the product temperature.

So, depending upon the temperature of the material inside the extruder barrel, there might be different changes, it influences the characteristics of the so since this rice paste inside, it is a basically starch, starch gelatinization becomes important characteristics. So, in the cold extrusion, the recognition is not there, it is almost nil. In the warm extrusion, there when you partial gelatinisation like a 65 to 75 percent and in the hot extrusion, high degree of gelatinization is 65 to 85 percent may be there, so that is a the machinery used cold extrusion, maybe pasta press warm extrusion, pasta press are extruder are for hot extrusion, single or twin screw extruder.

And this single or twin extruder, hot extruder gives a translucent the product with a smooth surface, so that become that extruder selection, extruder process parameter selection becomes an important concern important matter that is for giving a for obtaining a proper size product.

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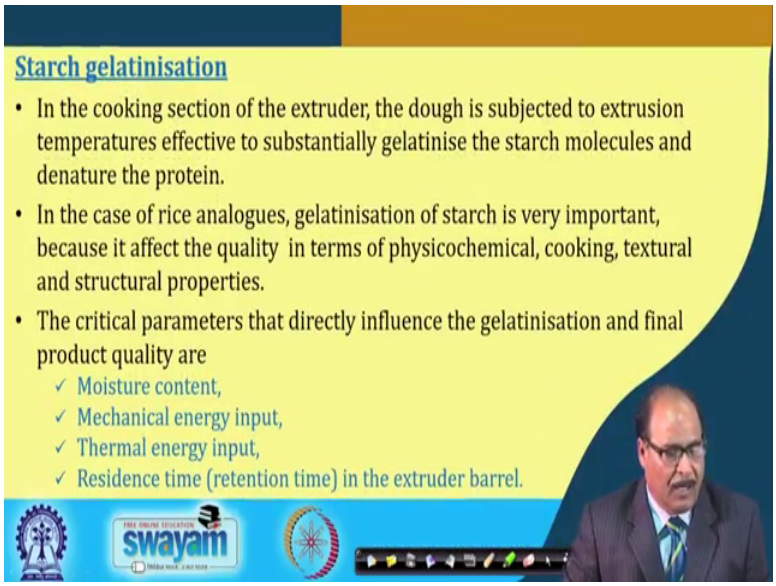

So, the starch gelatinisation is again an important aspect, which influences the cooking characteristic or other characteristics of the fortified kernels that is in the cooking section of the extruder, the dough is subjected to extrusion temperatures effective to substantially gelatinise the starch molecules and denature the protein.

And the case of rice analogues, gelatinization of a starch as I told you very very important, because its affects the quality in terms of both physicochemical, cooking, textural as well as a structural properties. So, the critical parameters that directly influence the gelatinization and final product quality are moisture content, mechanical energy input, thermal energy input and the residence time that is retention time in the extruder barrel.

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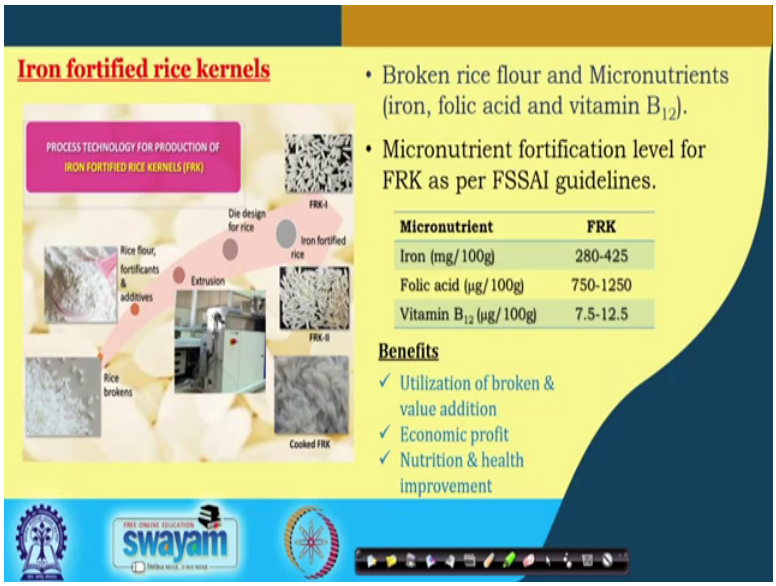

So, in this slide, I have just try to give you the process technology which we have developed in our laboratory, in fact we have worked on a extruder fortified rice kernel using extrusion technology right. So, one of the unique features of our technology include that we take we use broken rice.

In fact, in the milling during milling processes that on and every 10 to 12 percent of the rice gets broken and which the rice millers have to sell at in flu lower prices, because it then the broken rice results at good price in the market. So, what we have done, we have taken these broken rice ground them into fine powder alright and this powder is added with the vitamin and mineral premix conditioned as I told you earlier that process technology.

So, but here the particle size are the both micronutrients and the rice flour as well as moisture content and the proper given proper time for uniform mixing up all this a very important, so mixing and conditioning is done. And then this mix and conditioned, there is a flour rice powder is fed to the extruder.

And I already told you that it is pass through inside the extruder, the conditions are proper required, conditions are maintained. The material is pass through a proper die, I will as show you we have designed three types of die depending upon the sizes of the three long rice grain, medium rice grain and small rice grain are all this producing rice of

all the these three sizes, we have designed the die. And also we have developed a pilot scale facility that I will show you the in the next slide.

So, the micro nutrient which we use for fortification in this is as per the FSSAI-Food Safety and Standards Authority of India guidelines. And as them I told, showed in the last class that is the different items in the rice, they recommend that iron should have 280 to 425 milligram per 100 gram that iron, it should have 750 to 1250 microgram per 100 gram folic acid and 7.5 to 12.5 the microgram per 100 gram vitamin B 12. So, accordingly we are adding the rice the we are fortifying the rice as for the FSSAI guidelines.

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And this is the pilot plant facility that is the equipment required for the production of a iron fortified rice is starting from the grinding up the broken rice that micro pulveriser, then grinder and conditioner, twin screw extruder, then we use a tray dryer in our process so tray dryer and then rice polisher. It is just to the extruder rice which comes the rice a FRK fortified rice kernel is comes out of the extruder, it is given a surface finish just smoothening. So, to its appearance is better.

And then a that is their fortified rice kernel and normal rice mixture and finally the packaging machine. So, this equipment we have installed a pilot scale unit, where we can produce 100 kg of fortified rice kernel per day. And this all this a machinery required for this are this a fabricated indigenously in the country.

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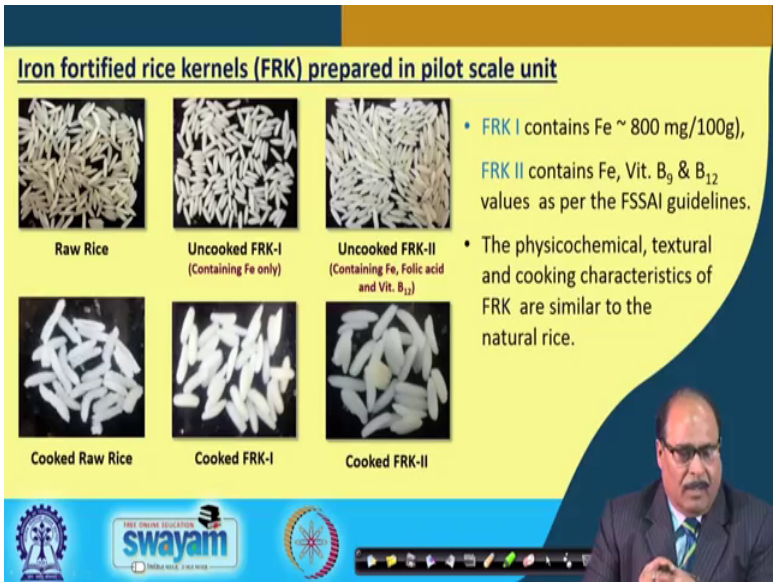

Then these are the pictures of the fortified rice kernels, which we have a produced through our that is both raw as well as cooked rice. You can see here it is there raw rice picture, this is one is cooked rice. And these two these are the uncooked FRK that is fortified rice kernel, which comes out of the extruder.

And this is there are two types of a fortification, we have done. In one case, only iron is added to (Refer Time: 26:52) 800 milligram per 100 gram of the rice. And in the FRK 2 a it is at for the FSSAI guidelines. So, and after cooking the pictures that is the raw rice cooks, after cooking look like this. And you can see here that is even this fortified rice kernel also. So, they have the all the physico chemical characteristics, structural characteristics, cooking characteristics or sensory characteristic of this fortified rice kernels are quite similar, they resemble very well with that are those of the normal rice.

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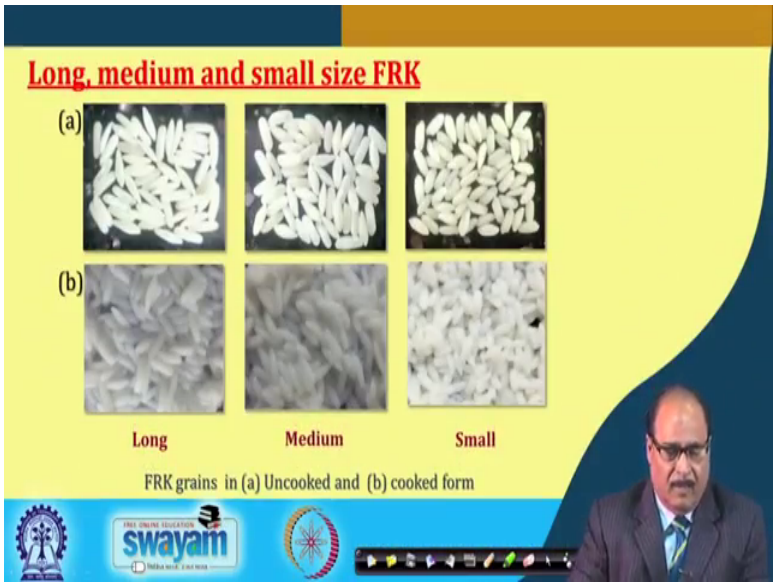

These are the both long medium and small rice kernels produced by the true through the extruder and both cooked and uncooked the upper part, this pictures are uncooked. Another lower part, they cooked rice pictures produced in the pilot plant using the different dice; three different dice that is along medium and a small.

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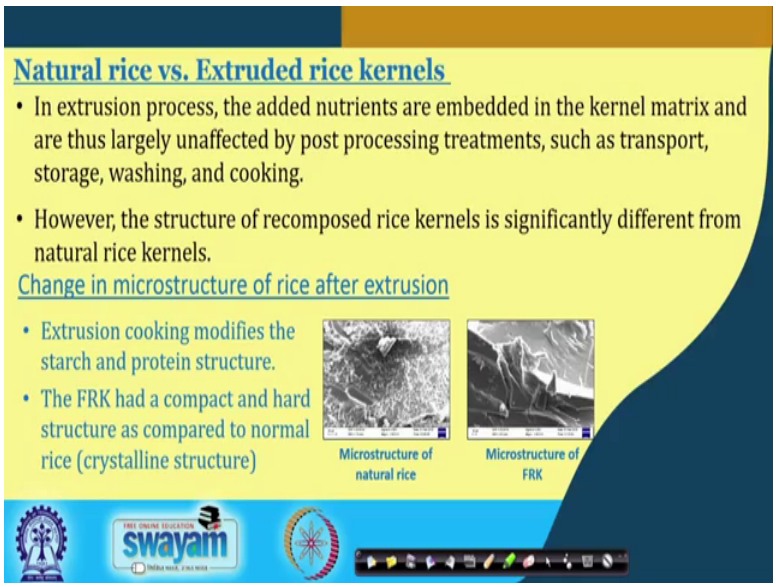

So, in the extrusion process, the added nutrients are embedded in the kernel matrix I told you, because these nutrient micro nutrient are mixed with the floor. Then they are largely unaffected by post processing treatment such as transport, storage, washing, cooking,

during cooking etcetera. The losses of the micro (Refer Time: 28:19) we have conducted, the all these aspect extensively, thoroughly in our laboratory. And found there are almost nil are in significant very very least a less significant changes in the micronutrient post processing.

However, a structure of the recomposed rice kernels is significantly different from the natural rice kernel, you can see here these are the microstructure of the natural rice and this is the microstructure of the fortified rice kernels. So, extrusion cooking maybe because the gelatinisation is occurring and this protein is getting denatured. So, the a starch and protein is structure are drastically change. So, FRK has a compact and hard a structure as compared to the crystalline structure of the rice, normal rice.

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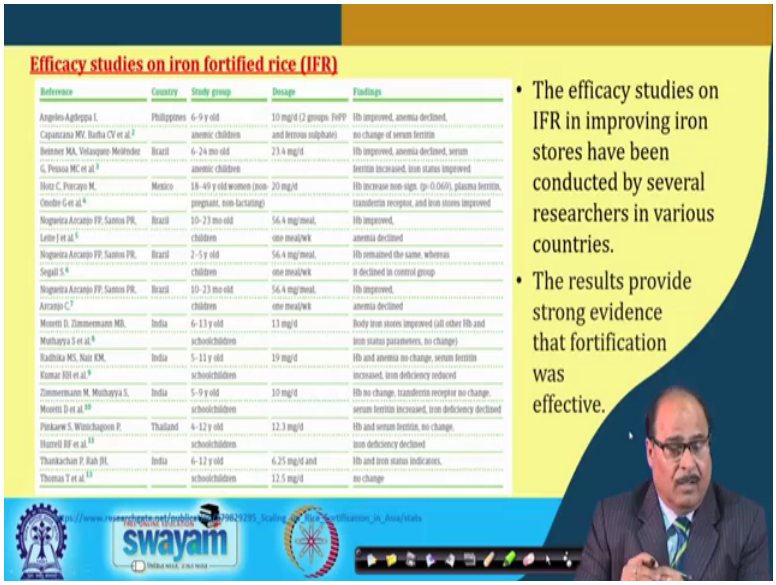

This a now the various people various workers researchers have worked on the because, it is very important to find out that the iron folic acid etcetera which is added to the rice, what its bio-availability and how actually it is helping or working inside the system, when we consume this iron fortified rice, how it is in helping to improve iron stores in our blood etcetera.

So, in different countries, different researchers have work done that all this etcetera is a given in this tables around those a study. And almost all these a studies, they have confirmed they provide a strong evidence that the fortification process was found effective in controlling or improving the iron stores.

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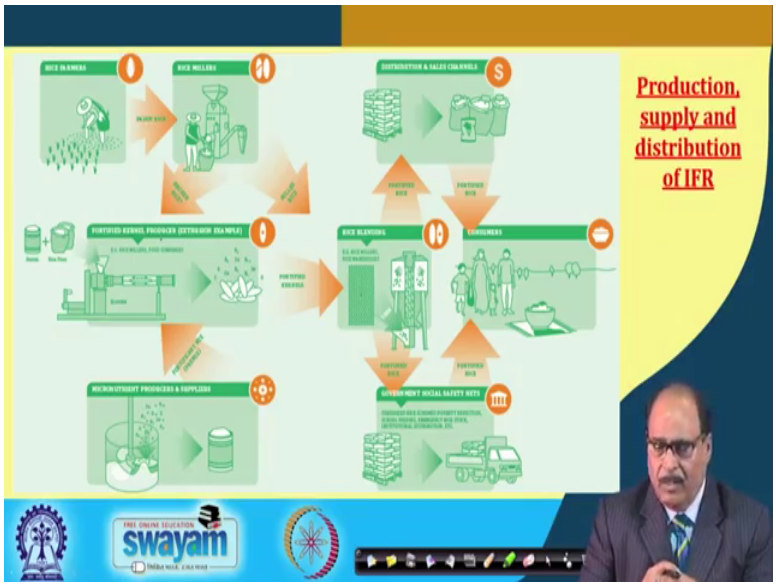

So, then another important aspect is the production supply and distribution of iron fortified rice that is the for production like this iron fortified rice take that is a the broken etcetera using in the extruder facility, it has we to be produced. This is a pictorial distribution, I have given that is starting from the paddy, you get paddy milling in the rice mill and then the brokers are obtained, these brokers maybe in the fort fortified the FRK manufacturing unit, they can be manufactured.

And then finally, these FRK a may be either, it may be two channels may fallout that is either it can be blended with the rice, normally it is recommended that is in the FRK which is produced in the through the extrusion technology. It is given may be 100 times more in micronutrients are added.

So, finally these fortified rice kernel, they are mixed or blended with the normal rice, natural rice in the proportion of 1 to 100 and is just to reduce the costs, so blending becomes an important steps; issue. So, their if different strategies for this blending, and this distribution to the consumer to the government agencies that is in one way, it can be directly through market agency directly supplied to the consumers or another channel through government is agencies etcetera, government distribution agencies, it can be taken up to the people those, who are needy the consumers.

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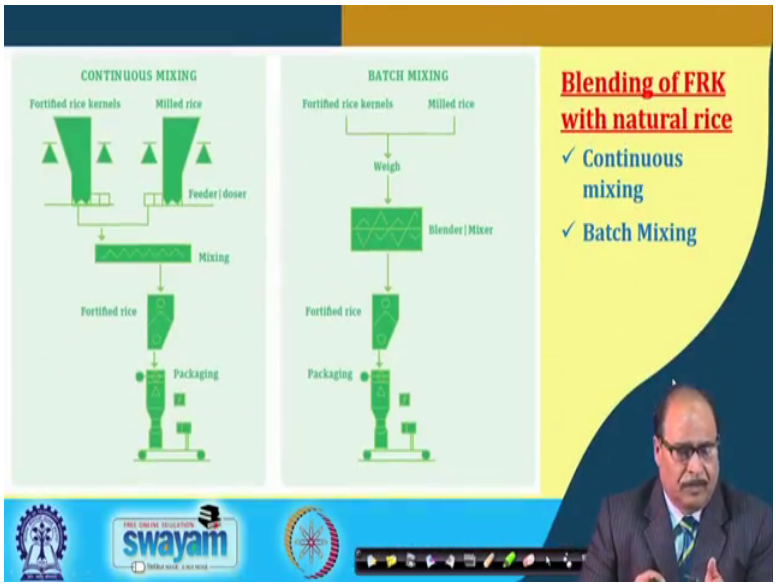

So, this is the regarding the blending, blending of the iron fortified rice kernels with the natural rice, we batch mixing may be there. And the continuous mixing will be there that is in the batch mixing, obviously that is the fortified rice kernel is made separately, milled rice is obtained separately from the rice mill etcetera. They are weight in a proportion, then they are fed to the blender mixer. And we get fortified rice that is refer to iron fortified rice means which has both a mixture a blend of fortified rice kernel and natural rice, so it is packaged.

In the continuous mixing, obviously that is both that is as fortified rice production unit, and then milled rice from the rice mill. They can be both connected as a blender to connected by appropriate conveying lines metering and conveying lines can be (Refer Time: 32:51). And then continuously, this can be fed to the blender, the blender be also a screw conveyer blender type that material which gives fortified rice, and it is packaged.

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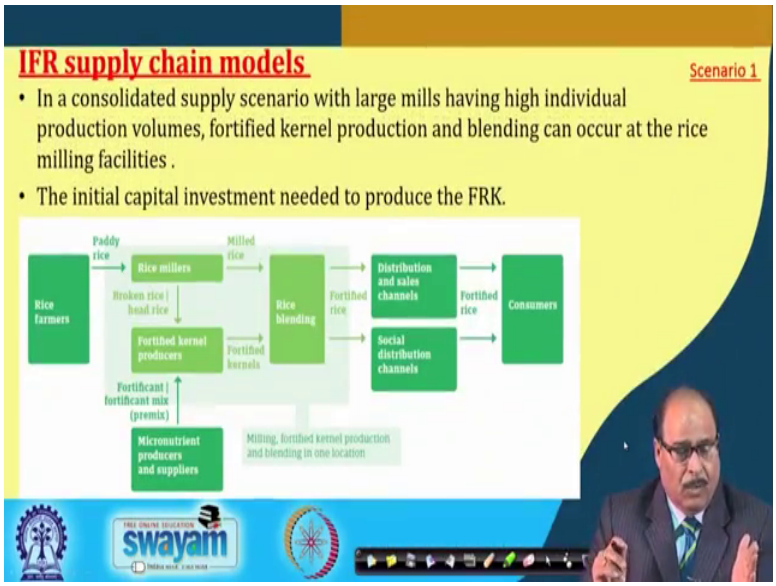

So, the iron fortified rice supply chain models will be different that is in the consolidated supply scenario, that is if there are three four sceneries made with their, and now it is depending upon the governmental programs, depending up on a the suites through the one or the other country or one or the other (Refer Time: 33:25) for one or the other particular program. They can take any scenario.

So, in scenario 1 that is in which is a consolidated supply scenario with large mills having high individual production volumes, fortified kernels production and the blending can occur at the rice milling facility itself. And where this fortified rice kernel is coming, rice is coming and then through continuous online etcetera. So, it can be a continuous production or of iron fortified rice and including even packaging.

But, here the capital investment cost maybe high and maybe that even usability that is the because it is only one, it is mixed blended into 1 is to 100 proportions. So, use efficiency of the fortified rice kernal manufacturing unit may not match with the rice mill.

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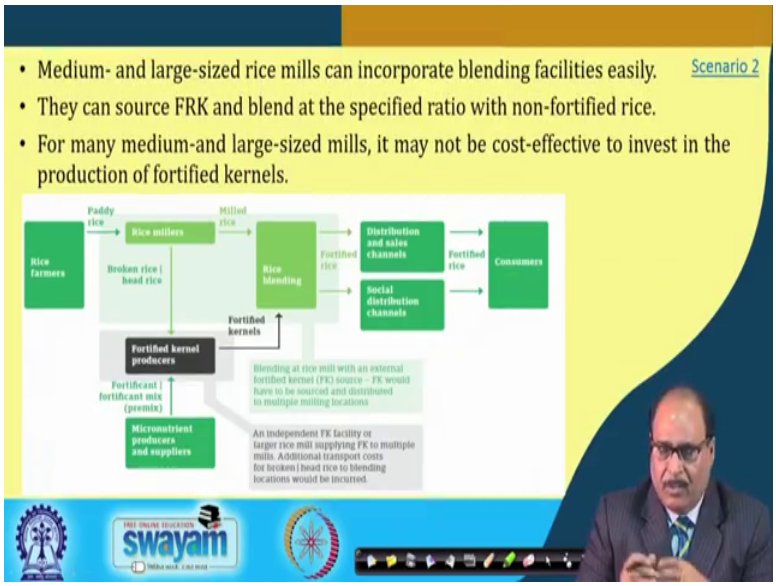

So, in the scenario 2 medium and large-size rice mills can incorporate blending facility easily. They can source FRK and blend at the a specified ratio with non-fortified rice means that is the, they can have a blender blending unit incorporated in this rice. FRK manufacturing can be done at a some other location. And the FRK can come they can procure the FRK, and then do the blending job.

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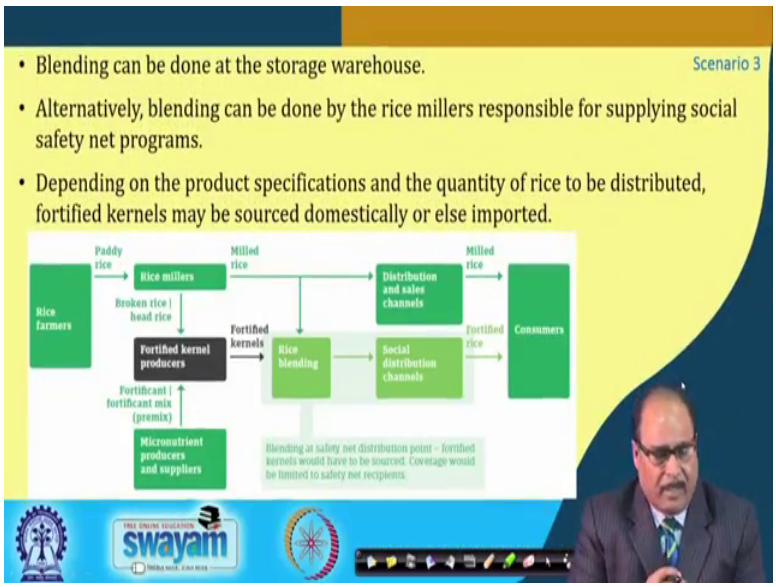

In third scenario that is blending also can be done at some other places that is at a storage warehouses, mainly in the there are different agencies, which try to store rice for public

distribution say etcetera. So, in those storage warehouses that blinding unit can be install. So, the rice comes from the rice mill is store there, they FRK can be produce some where the FRK can come also. So, in those warehouses only the blending is done and then package is done.

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In the scenario 4, the consolidated rice can be blended with fortified kernel at a consolidation point in the supply chain. For example, if rice from many rice mill is consolidated at a wholesaler or trader, then the fortified kernels can be blended with the non-fortified rice before the rice is transported to the retailers.

So, in this case, it is that a big trader that is a who collects the rice from different versus and then sends to the different retailing, retailers etcetera. So, they the blending unit can be put in those places and so a either or the which is true which can be workable, either are these strategies can be use, and the fortified rice kernel can be supplied to the people.

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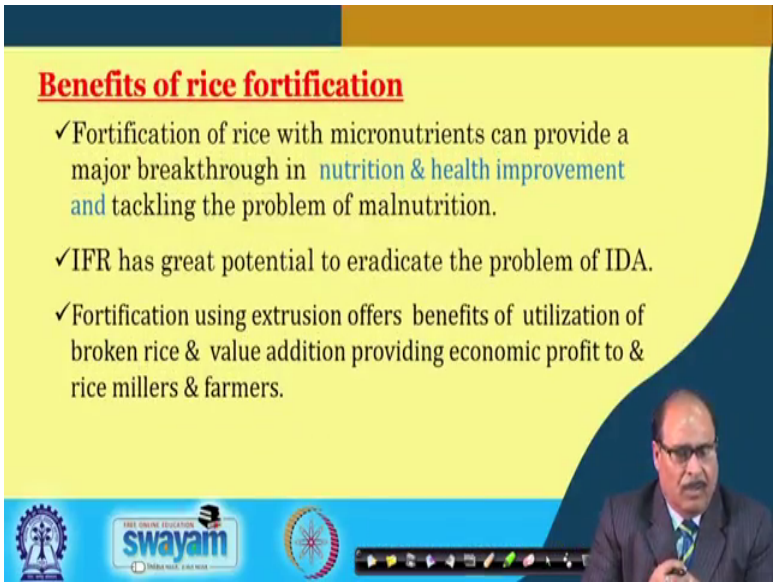

So, but I will like to conclude this let us talk by saying that this iron rice fortification is a very very important technology, it has lot of advantages. And fortification of rice with micronutrients can provide major breakthrough indo nutrition and health improvement as well as in tackling the problem of malnutrition.

Iron fortified rice has a great potential to eradicate the problem of iron deficiency anemia from the nations. Fortification using extrusion offers benefits of utilisation of the broken rice, so it becomes a part of value addition that is a and it a provides a value addition. And therefore, providing economic profit both to the rice millers as well as the to the consumers or to the farmer. So, this becomes a very good our technology for the nutrition and health improvement programs.

Thank you for your present hearing, thank you very much.