Novel Technologies for Food Processing and Shelf Life Extension

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Lecture - 54
High Energy RTE Food Paste (Part 2)

Hello friends, let us study High Energy Ready To Eat Food Paste Part 2, in the first part of this lecture in the last class we studied general aspects of ready to eat food paste like what are different ingredients, how the ingredients are formulated and then what are the different processing steps. May be primary processing, batch wise processing or then finally, this continuous processing, post processing packaging and safety cleaning up the equipment etcetera.

So, we took an overview or in general process details of in general ready to eat food paste and those things can be in fact, applied with for preparation of such food of any characteristics, any type or containing, any specific micronutrient, any specific composition that is protein fat etcetera etcetera. So, now in this second part of this lecture we will concentrate on formulation processing packaging of a high energy ready to eat food paste for severely acute malnourished children and the most of this presenting on the basis of our own experimental results.

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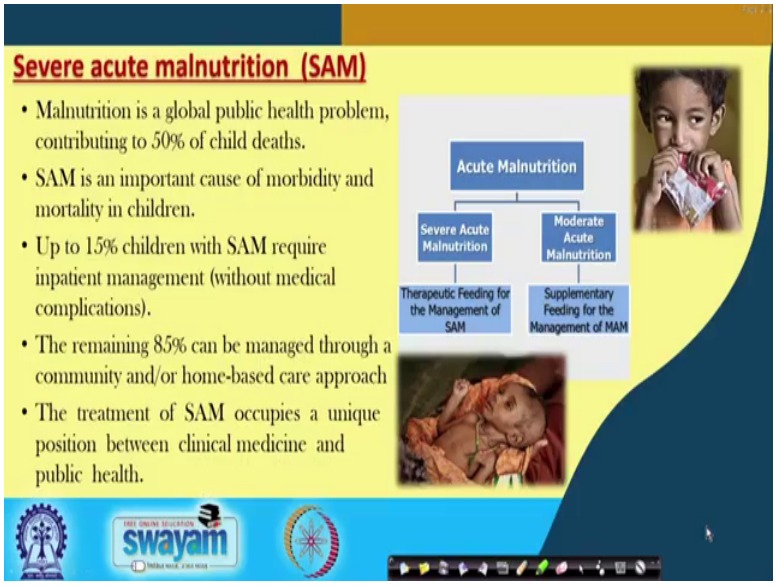

So, first of all let us see what are the severe acute malnutrition? In the earlier classes also we little bit deliberated and this when we were discussing iron fortified rice manufacturing or other like, malnutrition is a global problem global health problem, in fact, about 50 percent of the child death globally are because of the malnutrition. And among in this severe acute malnutrition is a major problem, it is a cause of the important cause of the morbidity and mortality in the children. You can see in this figure, this child is severely acute it is basically that is the protein and calorie malnutrition body is in deficient supply of energy.

So, and there is a deficit supply of energy then the requirement then, but uses protein for energy purposes and which ultimately results into the protein deficiency as well. So, overall in nutshell the body become deficient to protein and energy this protein and energy malnutrition normally causey worker or marasmus etcetera that is it may result into stunting or very less body weight and, so on, there are various symptoms.

So, in fact, WHO and FAO data say that about 15 percent of the SAM children worldwide, they might require in patient management; there may be some of course, they are also not some medical complication, but some medical attention doctor attention they should, they require feeding under the attention or care off some doctors. But, remaining 85 percent can be managed through community based or home based clear approach.

And the treatment of SAM therefore, occupies a unique position between clinical medicine and public health. So, it becomes very very important and of course, once that severe acute malnutrition or the child recovers from, then it may came and medium acute malnutrition. So, the for recovery for the child suffering from severe acute malnutrition, therapeutic feeding for the management of SAM is needed whereas, the moderate acute malnutrition can be taken care of by supplementary feeding.

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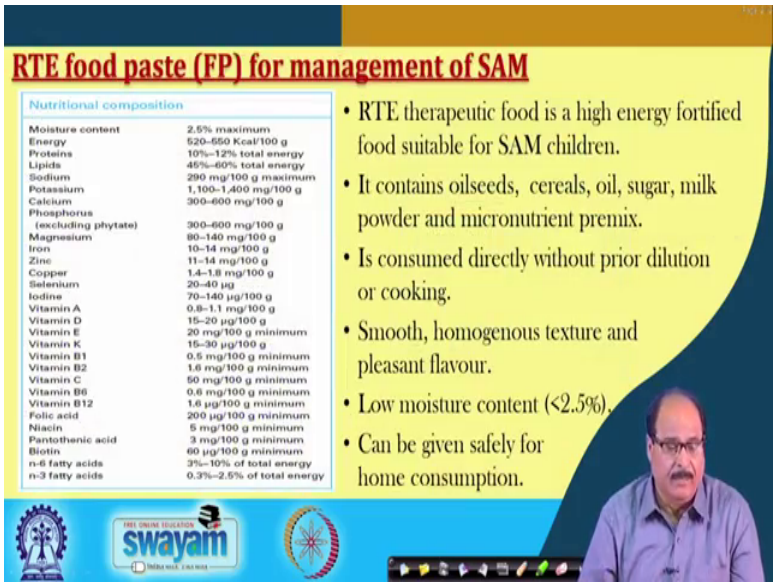

In the earlier class also I gave you this informations, so WHO and FAO they have recommended a specific formulation that is, the food therapeutic food for the management of SAM children should have the moisture maximum 2.5 percent energy 520 to 550 kilo calorie per 100 gram and then 10 to 12 percent of the total energy should come completely means 45 to 50 percent of the total energy, should come from fats etcetera and similarly the micronutrients.

So in fact, the preparation of this food paste, that is the appropriate raw materials is locally available raw materials peanut paste or such other materials are used and then they are formula in the proper proportion, decided by the linear programming formulation and then they are treated processed and packaged. So, may be in the next few slides I will tell you that we have how we have gone through the preparation of a ready to eat food, paste for the management of severely acute malnourished children.

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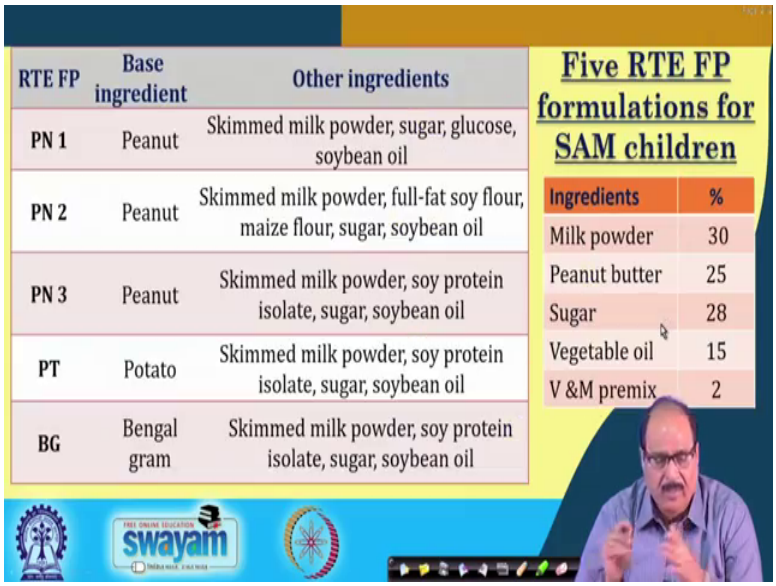

So, we at IIT Kharagpur using locally produced a raw materials have developed 5 formulations of ready to eat food paste high energy ready to eat food paste and these like 3 formulations are of peanut based PN 1, PN 2 and PN 3, that is PN stands for peanuts there is the main ingredients is peanut and supporting ingredients maybe skimmed milk powder, sugar, glucose, soybean oil or some has the maize flour or the soy protein isolate.

So, different combinations and the remaining two ingredients one is the potato based other is the Bengal gram based. On an average basis in these materials that is the milk powder in all these formulations milk powder on an average it can various up about 30 percent because as I told you in the last class that is the complementation of the protein essential amino because the milk children, growing children, new born severely a good malnourished a SAM is a major problem.

A newborn baby that is a baby from 6 months to 6 years that they should be provided adequate protein milk protein for their proper development right. So, the milk powder or milk protein about 30 percent, it contains peanut butter on an average about 25 percent sugar around 28 percent vegetable oil 50 percent and this vitamin and mineral premix about 20 percent. So, it is a general composition I am giving you just indicative range we have developed this process as patented. So, just indicative range I am giving you.

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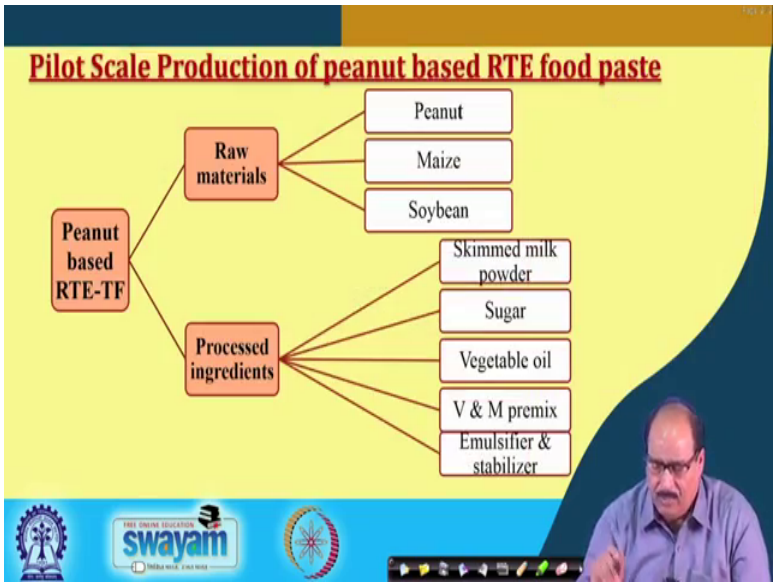

So, we have developed a pilot scale, manufacturing unit also. So, we will discuss the pilot scale production of these this product so; obviously, that is the and I will be discussing one peanut based one formulation and the same even the peanut based Bengal gram based also that can be done using by the same and the for potato based ingredient of course, some additional boiling or branching units might be required.

So, we have raw material two group of ingredient one group of ingredient raw material, peanut maize and soybean and processed ingredient we are using in our formulation skimmed milk powder, sugar, vegetable oil, vitamin mineral premix and some emulsifier and stabilizers.

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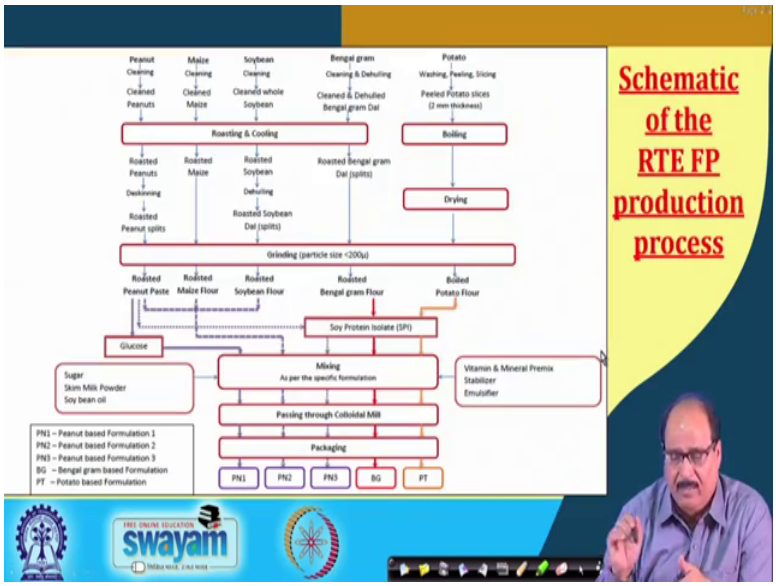

So, that it this is the process flow chart, this for preparation of those 5 formulations as I told you that these cereals and pulse grains food grains like peanut, maize, soya beans they are subjected to different treatments like cleaning, then dehulling and roasting.

So, this clean and de held maize etcetera they are roasted and cooled, then this roasted peanuts or all these roasted grains are ground to desired particle size and sometime depending upon the type of the grain, sometime even rosting can be performed before dehulling or that is the roasting can be done after dehulling because some grains where these husk is very very tightly adhering to the.

So, some initial that is the of course, little bit heat treatment it may facilitate the roasting process, but in general grains are dehulled and then roasted. So, this roasted peanut paste, roasted maze flour or soybean flour etcetera and the other the potato flour that is potato is boiled dried and this boil boiled potato flour.

So, basically we are having serial green flour, oil seed paste or the Bengal gram flour. So, they are given heat treatment roasting etcetera to improve the digestibility another properties and then they are finally, mixed as per the formulation to get the desired part of that is being mixed with sugar, skimmed milk, vegetable oil etcetera are mixed.

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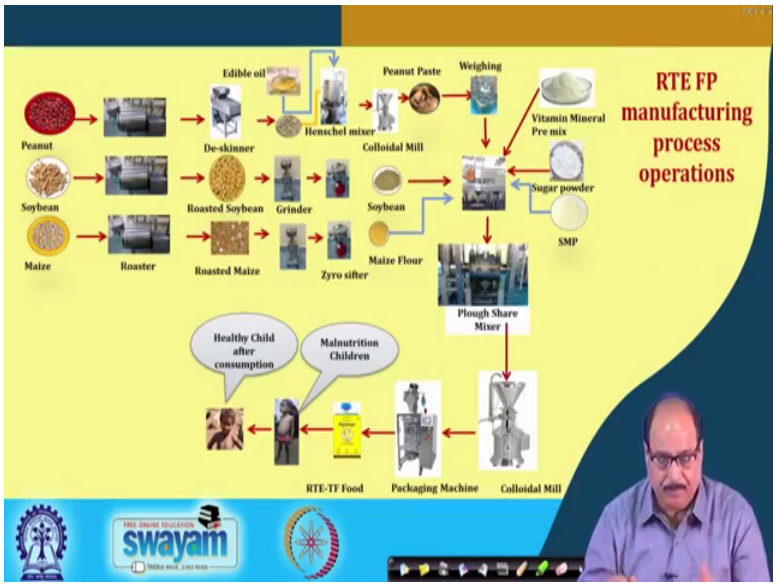

The same process you can see in this flowchart that is the ingredient wise, that is the ready to eat food paste manufacturing process operations that is three grains used is peanuts, soybean and maize. This is the passed through the roaster then de this peanut is de skinned, that is removal of the e skin red a skin.

So, you get a roasted peanut it splits and these roasted peanuts is splits or passed through Herschel mixture to convert it into paste, so we get peanut butter or peanuts paste right then these two grains soybean and maize, they are roasted and after roasting there is of course, before roasting, cleaning and grading etcetera.

Cleaning grading and dehulling splitting and then roasting after roasting they are ground have to pass through gyro scepter and then have a proper particle size flows. And, these all the peanut butter, this soybean, flour maize flour, vitamin mineral premix, sugar powder and skimmed milk powder.

So, they are mixed in the plough share mixer and finally, in the collide mill they are homogenized or where that is all the particle it is secondary stage milling fine particles, after colloidal size may be 200 less then 200 micron or even as low as possible may be 100 micron or 50 micron it will be much better.

So, this gives a also uniform mixing and provide the paste makes the paste homogenous and finally, it is set to the packaging machine and you different size of packaging machine is applied.

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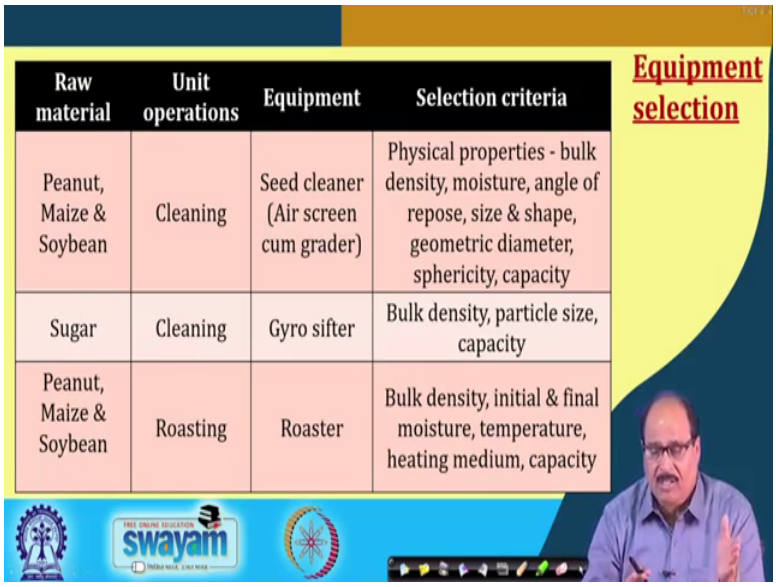

So, in this table just in the for the pilot plant what the equipment selection depending upon the raw material, depending upon the process operations, different equipments are selected and of course, the properties characteristics of the material their physical properties alright respective physical properties for which is a is important for the respective operation those are considered. For example, for the cleaning of the peanut, maize, soybean, a suitable air screen cleaner come grinder may be taken that is which can remove the and here physical properties like bulk density, moisture, angle of repose, size and shape, geometric diameter, sphericity capacity of the cleaner to be desired all these considerations are occur and accordingly appropriate size or appropriate make of the cleaner is selected.

Similarly, for cleaning of the sugar even gyro sifter may be used or equipment and the type of the seed etcetera in the gyro sifter which is to be then bulk density particle size or capacity etcetera considerations or selection criteria. For roasting of the peanut, maize other grains that is the suitable roaster the roster type and that should be decided on the basis of the bulk density initial and final moisture, content temperature and so on.

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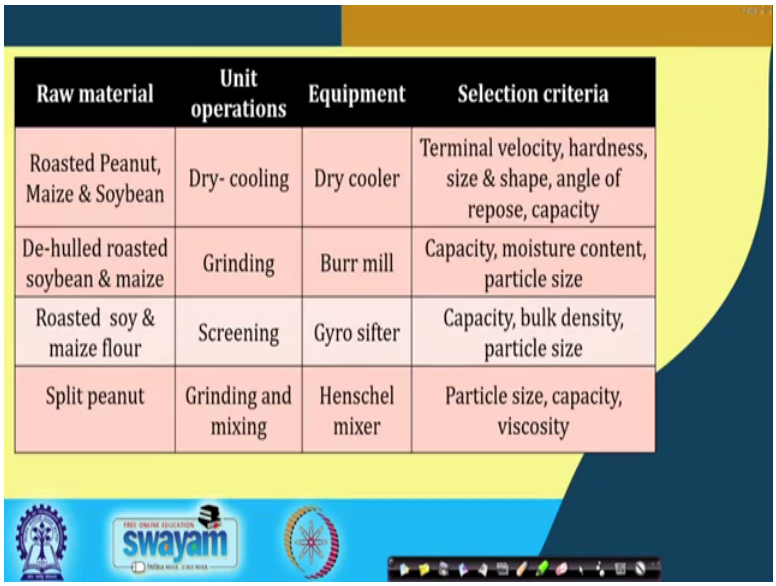

Similarly, for the different because after the roasting, before grinding some time the seeds might be required to be prompt cooling otherwise if the cooling is not done efficiently or cooling is not done immediately, then the grain may be of higher temperature for longer time and which may cause some change in the composition.

So, the dry cooling unit and then again terminal velocity, hardness, size and shape angle of repose etcetera are the criteria for the selection of the cooling unit. For the, then the grinding it may be burr mill or it may be other similar mill, attrition mill etcetera can be used and the capacity and moisture content of the grain, roasted grains etcetera and the particle size required particle size are the important criteria for the selection.

Similarly, for the roasted soy flour and roasted maize flour there is screening in order to get the these material proper size gyro sifter is may be used. And the capacity of the gyro sift, the capacity how much we want to shift? What is the bulk density of this material, their particle size required? These are some of the criteria for the selection of gyro sifter.

Then for the split peanut roasted peanuts these grinding and mixing the unit operation for this Herschel mixer is used and then Herschel mixture for the selection of the capacity size of the Herschel mixture particle size; what is the amount of the split peanuts to be ground or make it into paste or viscosity, the particle size all these are the important selection criteria.

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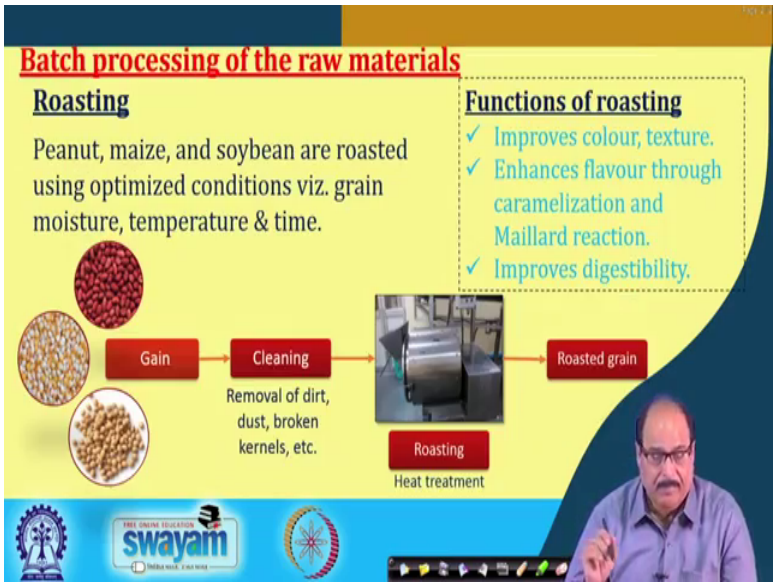

Then I will now with especially further those where in our piolet scale unit, these are the equipment pictures I am showing this we have a roster; roster which is a gives that thermostatically controlled and dry heating, we have the arrangement here where the temperature and time is set up properly can be maintained and even the temperature inside the grain, inside the roaster the grain temperature can be measured using this thermocouples or sensors.

So, the grains are passed into this for the desired time and temperature and they are roasted. So obviously, it will leave earlier also, roasting improves color texture enhances flavor and improves the digestibility of this.

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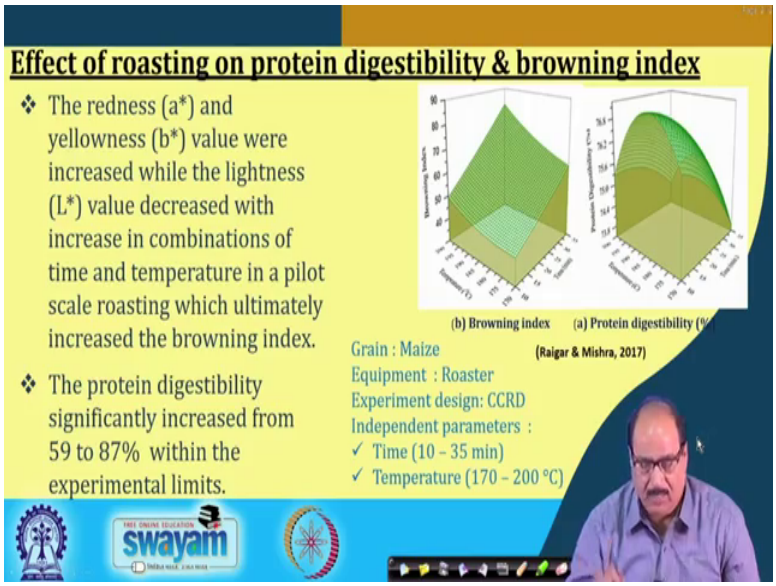

So, in this figure you can say it is a based on our result and we have published it, there is the browning index and protein digestibility of the material, how the roasting time and temperature influences? Similarly we have done in the case of a maize, in the case of Bengal gram also, in the case of soybean also we have studied, but here I am just reporting the maize, the equipment used as a as I showed you in the last slide the picture roster, design and developed and gut fabricated by us then experimental design uses the CCRD.

And independent parameters where that roasting time from ranging from 10 to 35 minutes and temperature of the roasting was 170 to 200 range. So, you can see here that both the protein digestibility as well as browning index, the varied significantly that is the time of roasting, temperature of roasting.

They had significant effect and even the roasting time and temperature combination, they had significant effect and the protein digestibility and browning index. In fact, the in the maize the protein digestibility increased from initial 59 to 60 percent level to finally, 87 to 90 percent. So, the protein digestibility was significantly improved, drastically improved the when the color index also you can see here that is browning index was increased so material.

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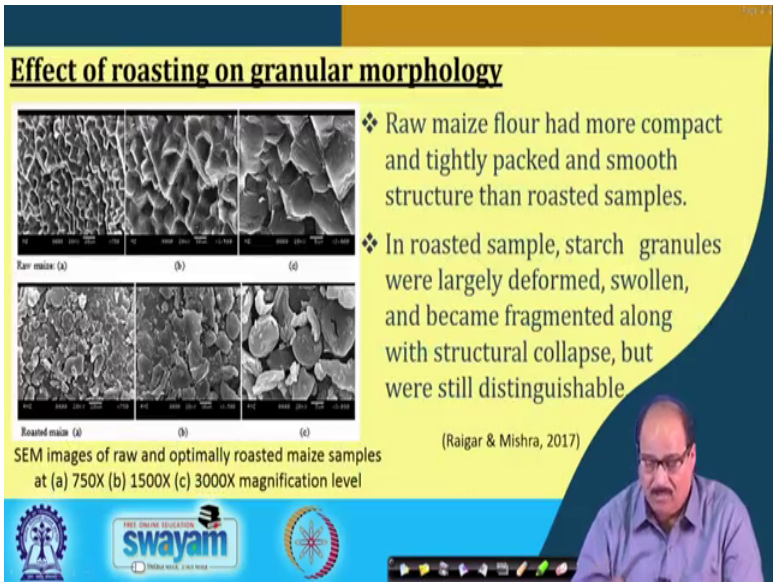

In this these are the Scanning Electron Microscope: SEM images of raw and optimally roasted maize samples right that is even a this is the raw and this is the roasted 750X, 1500X and 3000X magnification levels. So, you can see in the picture it clearly shows, that raw maize flour had more compact and tightly packed and a smooth structure.

Whereas, in the roasted sample: the starch granules where largely deformed they were swollen and become fragmented along with structural collapse, but of course, they were well distinguishable. So, this clearly says that is the roasting causes the structural change into the material.

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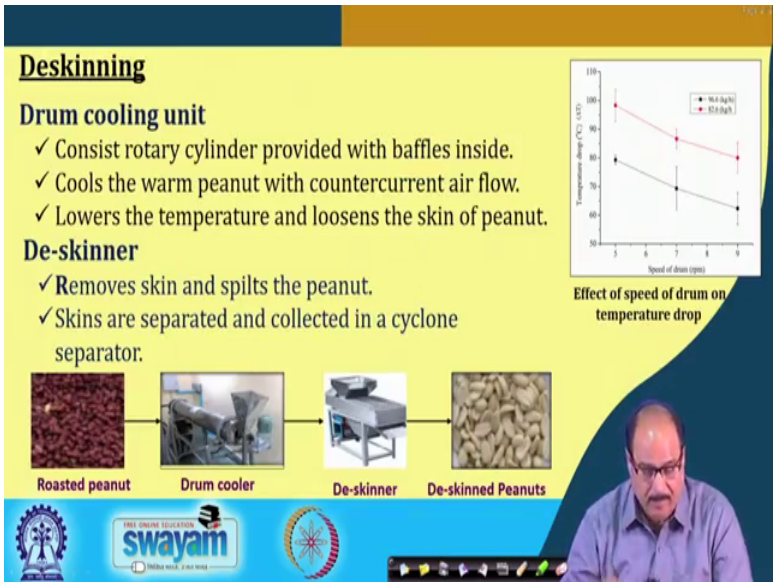

Then after the roasting that is de skinning is a important operation for the roasted peanuts, that is the our roster we have a another unit attached with it that de skinning it is a basically a drum cooling unit. This drum cooling unit consists of a rotary cylinder provided with (Refer Time: 20:00) inside, it cools the warm peanut with countercurrent airflow that is the peanuts is fed from here and the low temperature that is peanut is fed from this side and low temperature here is comes from the opposite direction, so as the peanut moves here this drum rotates.

So, there is a efficient heat transfer takes place and the peanuts get cooled down. And then once that is a temperature is cooled down brought down, then it also loses the adherence between the peanut meat that is the split as well as skin. So, this in the next in the de skinning the removal that is the de skinner that is the cooling unit is attached with the de skinning unit, where it is there are they are provided with that every that is the roller which removes skin and it splits the peanuts. So, the roasted peanuts finally, they are got skin de skinned peanut a splits right.

So, it is provided with a cyclone separator which removes the skins. In this figure you can see that the speed of the drum of the de cooler unit and the temperature of the air or temperature of the material they have the important influence, on the cooling time that is the effect of the temperature drop in the inside the drum. That is the this is the upper line red lines they have the material fed at 82.6 kilogram per hour and the bottom line has the

material feed rate is the 96.6 kilogram per hour. So, both the feed rate of the material peanuts in the cooling unit, the temperature of the cooling unit air and that is speed of the drum they have the important influence in the temperature draft that is the dt delta t.

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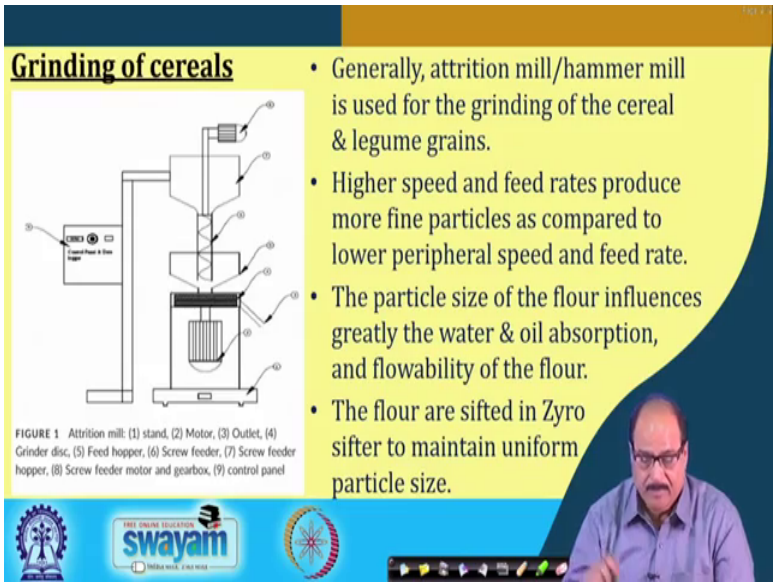

Then after this the material has ground, so grinding of the cereal and (Refer Time: 22:19) told you in the attrition mill or hammer mill, they are used for the proper grinding. And high speed and feed rates produce more fines particles as compared to the lower peripheral speed and feed rate. So, the feed rate as well as peripheral speed has important influence. The particle size of the flour greatly influences the water absorption, as well as oil absorption and also the flow ability of the flour. So, the flours are finally, after grinding they are shifted in gyro sifter to maintain the uniform particle size.

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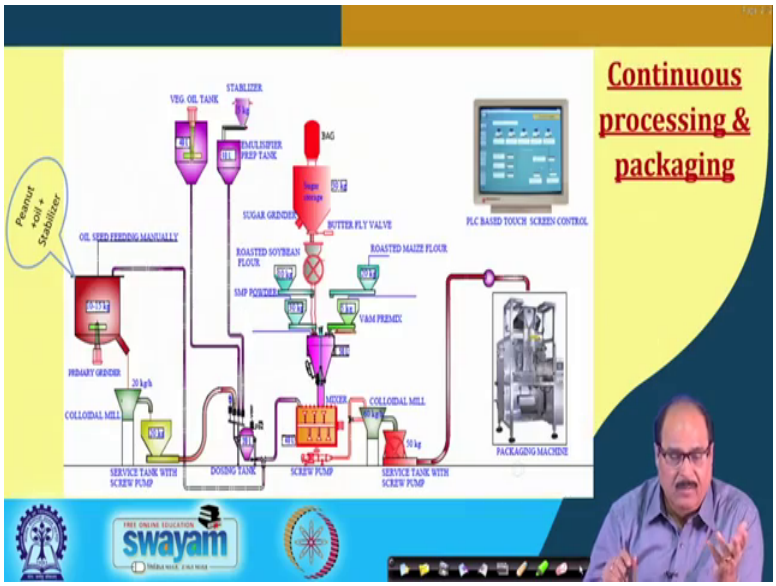

This is the picture, as I this you see that here for the groundnut that peanut plus oil plus stabilizer which are of that in the required formulation as decided by linear programming they are put here and then this is the vegetable oil tank stabilizer and dry ingredients they are put into various containers this is all primary that batch vise affect. This is this section is your continuous processing and packaging, I will show you in the actual machinery also pilot plant (Refer Time: 23:40) graphs this earlier also I explained.

So, the peanuts and oil and stabilizer and antioxidant they are converted into fine paste, the paste is a obtained here and then all the dried dry ingredient like soybean, flour, roasted soybean flour, roasted maize flour, then sugar powder, vitamin mineral premix they are all as per the formulation. They are collected here in this so in this secondary stage, they are put to this mixer where this paste as well as solid powders ingredients they are mixed and then finally, they are passed through colloidal mill.

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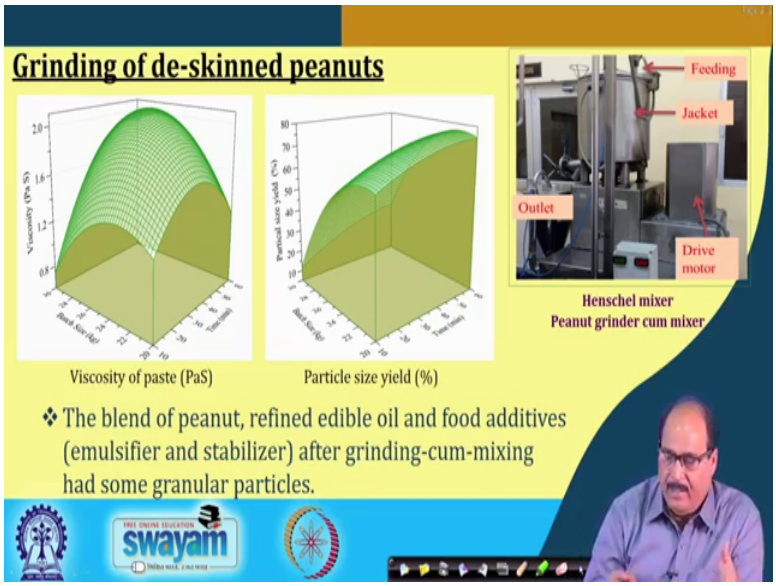

So, the this picture so that this is the picture of the Herschel mixture which is used for peanut grinding, cum mixing and this figure response surface graphs shows the effect of this time, temperature as well as batch size time of batch size and the viscosity of the peanut paste produced, as well as particle size that is particle size yield in the person particle size is are the peanut paste.

A these both time of a grinding as well as size of the material used in the grinder size of the batch, they have had significant effect or influence time the blend of the peanut refined oil and food additives after grinding cum mixing has a smooth granular particle.

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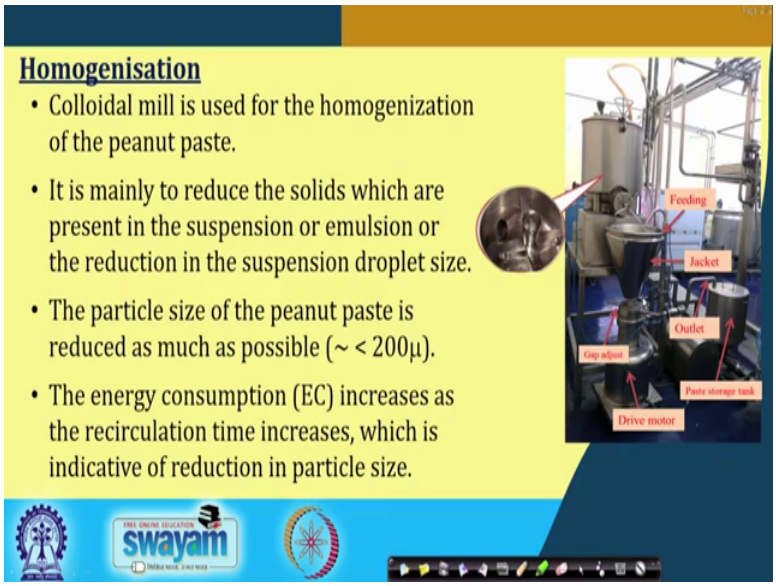

Then homogenizer, this is the picture of the actual or pilot scale unit, the material come it is a colloidal mill where the gas are properly adjusted rather to give the desired size particle size ok. So, finally, after the colloidal mill we get a homogenized paste material are of uniformly mixed material ok. So, in this basically this colloid mill reduces the solids which are present in the suspension or emulsion or the reduction in the suspension droplet size may be their.

So, ultimately because may be that depending upon the conditions some powder, the period paste also may have a little more hire consistency, the powder size is may be vary, but this finally, when they are mixed together are there may be some lump formation in the mixing, so in the collide milling these all they are smoothen.

The particle size of the peanut paste is reduced as much as possible may be less than 200 micron in fact, in our pilot scale unit we can go up to 150 or even 50 micron 150 micron. The energy consumption increases as the recirculation time increases, which is indicative of reduction in the particle size. The homogenization and the colloidal mill, so energy consumption increases as there is a circulation time increases.

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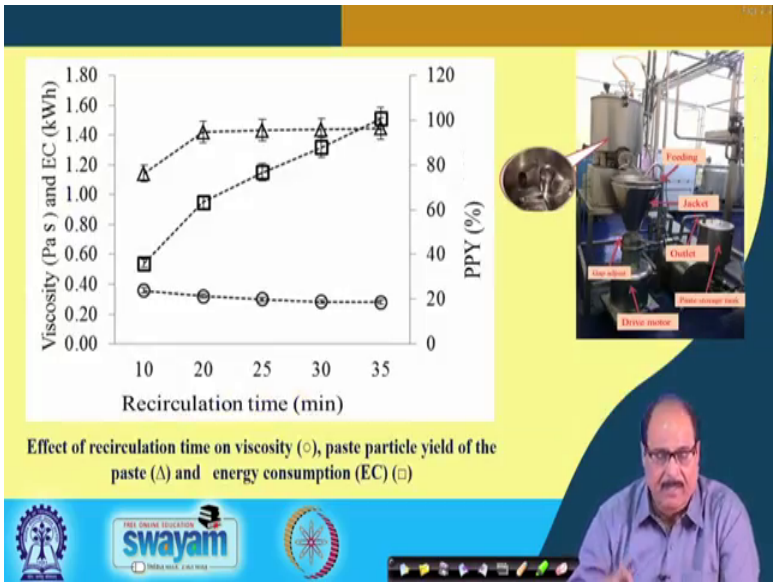

This consist this is the picture, so there is circulation time and then viscosity of the paste as you rise energy consumption and this paste particle yield. So, this is squares, these lines, this was the energy consumption, these your triangle points they show the paste particle yield and the circular points round points they show the viscosity.

So, you can see here both the recirculation time right and this they have the important in if has important if a influence because this ground and it is recirculated alright. So, for how long it should be recirculated in the Herschel mixture? That in as important influence on the.

So, from this right you can see that around recirculation of about 20 minutes this because after 20 minutes there is almost they say paste particle yield is becomes straight line so there is not much right. Also this viscosity, but the energy consumption is increasing in more increasing. So, it may be that is the recirculation time of 20-25 minutes might be desirable best better.

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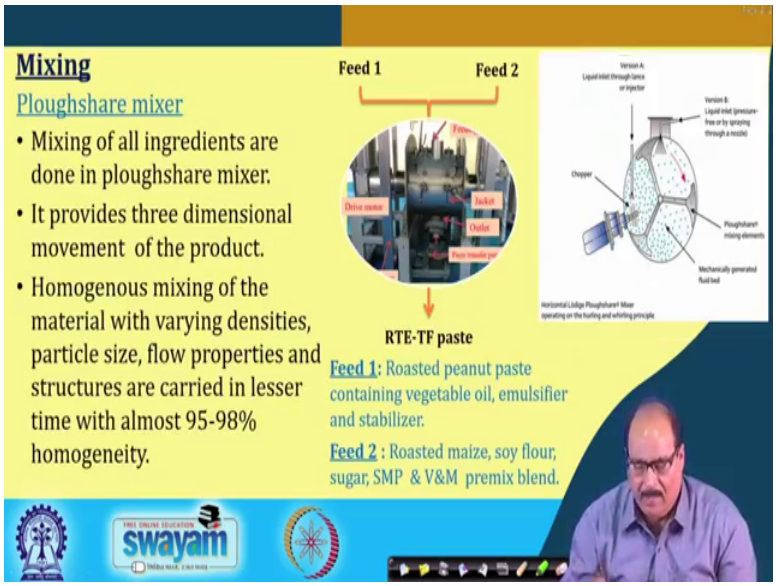

After that the next step is the mixing, in the ploughshare mixer you can see this is the picture. So, this as I showed you in the earlier flow diagram that there are two stream feed 1 and feed 3, feed 1 is the paste and feed 2 is the powder it is basically that is the solid and liquid mixing liquid or solid and paste mixing together. So, is the feed 1; feed 1 roasted peanut paste containing vegetable oil, emulsifier and stabilizers there.

And in the feed 2 is the roasted maize, soy flour, sugar powder, skim milk powder, vitamin and mineral premix blend, so blend of all this as per the formulation and this two or now mixed in the ploughshare mixer. So, it is basically to make sure that all the ingredient again are properly mixed, it provides three dimensional movement of the product. And it results into better mixing or homogenous mixing up the materials with bearing densities particle size flow properties and structures they are carried in less time with almost 95 to 98 percent homogeneity is obtained in few minutes.

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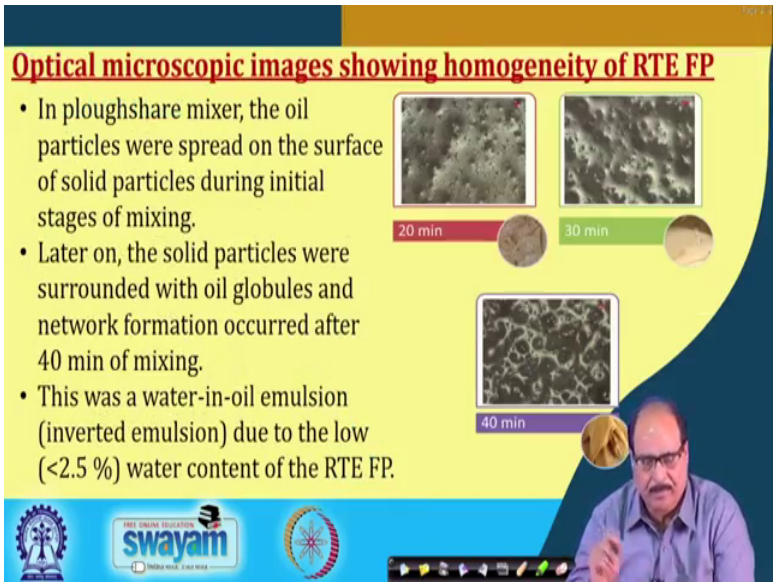

Then this shows that optical microscopic images, showing the homogeneity of the ready to eat food paste produced in our pilot plant and you can see that the oil particles that is spread on the surface of the solid particles during the initial stages may be before twenty minutes or less. So, later on at the time of mixing increases as you can see here after 30 minutes, the sample after and after 30 minutes that is here solid particles we are surrounded with oil globules and network formation occurred after finally, after 40 minutes of mixing network formation occurred.

So, this was water in oil emulsion form which is inverted emulsion these are due to the because it is a water in oil emulsion because water content is completely very low, that is less than 2.6 percent.

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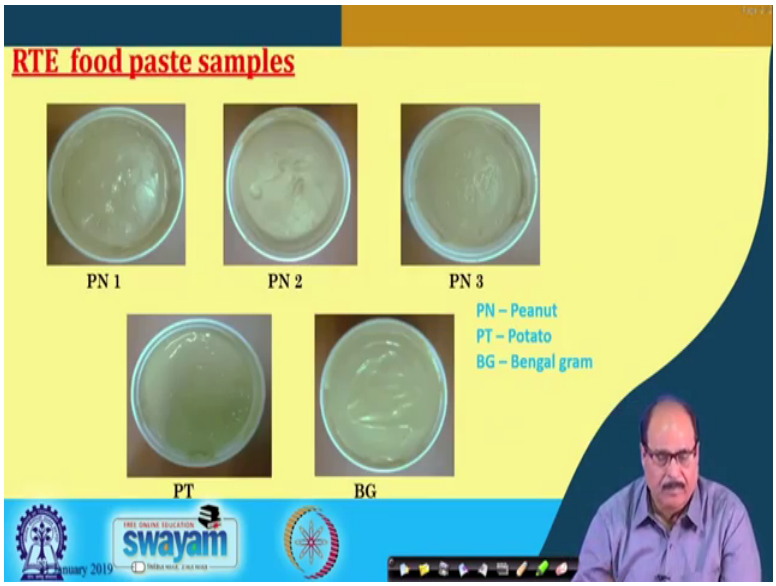

These are some of the 5 formulations, this 3 peanut paste samples and potato based sample and Bengal gram based sample prepared in our ready to in our pilot scale unit only.

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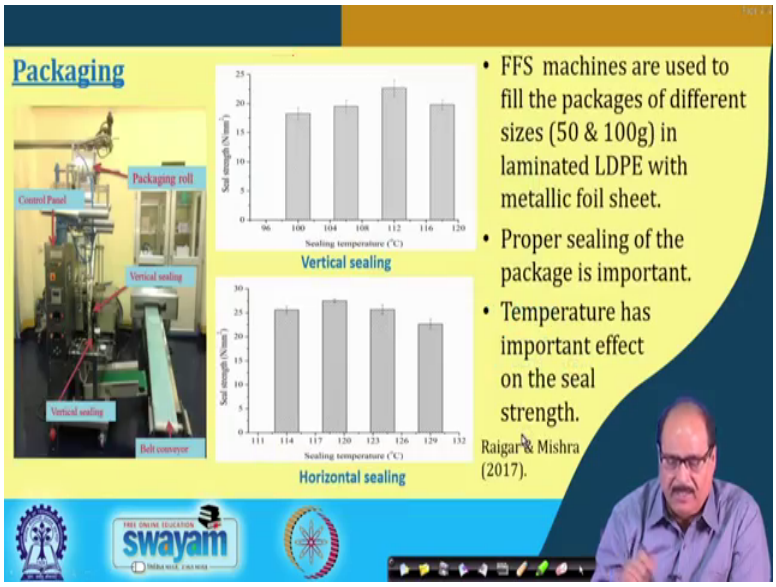

Packaging this is the form fill and seal machine which is used for the packaging of the size charts and in these packaging machines packets of starting from 50 gram to 100 gram or even more, having appropriate size and packaging machines. So, appropriate

size package size jets can be obtained, we are using LDEP with metallic file seat are packing of the prepared at ready to eat food paste in to sizes and 50 gram and 100 gram.

And then sealing; obviously, there is a packaging machines should be provide should be able to provide effective sealing as I told you in the earlier class also proper sealing of the package is very important. Temperature of the sealing has important effect on the seal strength that is the seal should have sufficient strength should not break during storage or handling ok.

So, you can see here in the particular sealing as well as in the horizontal sealing, that is the sealing temperature has important has the almost as a round 117 into 120 degree Celsius temperature, it gives as it is the sealing strength of about 28 29 Newton per mm per square millimeter ok.

Whereas, in the case of vertical sealing 112 degree Celsius temperature again can gives about that is 20-25 Newton per millimeter square. So, the temperature of sealing; sealing temperature is very very important factor which should be controlled to get the desired sealing strength.

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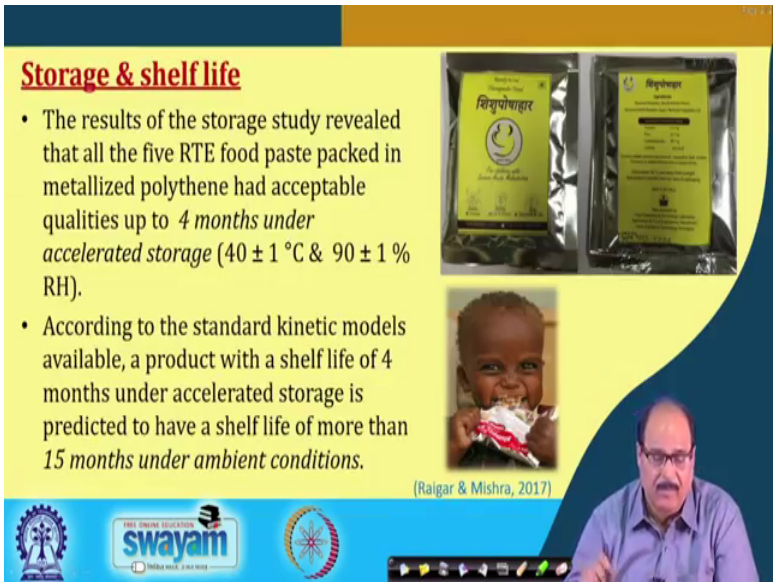

For storage and shelf life we are conducting storage study result of our storage study that is the packets which are restored under accelerated conditions at 40 degree Celsius temperature and 90 percent relative humidity in our experimental results we could get 4

months shelf life right, there was no oil separation. And according to the standard kinetic models available in the literature, the product with the shelf life of 4 months can be stored 4 months under accelerated storage, can be stored for more than 15 months under ambient conditions. So, that is these are the pictures of the packets produced in our pilot scale unit.

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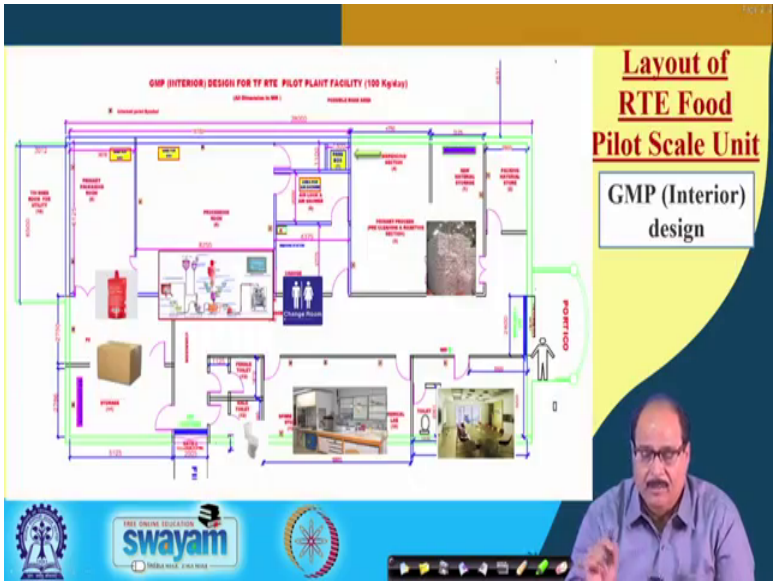

This is the design layout of the ready to eat food pilot scale unit at GMP, interior design, good manufacturing practices, interior design these are the primary processing section, continuous processing section from the primary processing section is provided with as some interposed box which is UV facilities.

So, that all the ingredients which are entering the main plant they are sterilized surface treated, so as to avoid any contamination. So, because finally, this product is to be ready to eat and it has to be consumed directly. So, it should be made that it is, it should be ensured that it is any contamination tree, then also the persons those who are entering in the pilot plant here it is a change room facilities provided. So, the change itself then here cut and here hours are there here lock and its hour.

So, the person enter through its hour means there is here is the primary actual processing facility there is no contamination whether from the materials and human person though personal those who are working here in the they are all contamination free and even the

environment, there is processing hall is provided with a h your handling units etcetera. So, that always positive pressure is maintained.

So, the material is processed here and then it is automatically sent to the packaging line you also in the oil plant we have, so that laboratory facility. So, to conduct samples are taken intermittently they are sent to the laboratory for this testing. So, laboratory testing the material is entering here all the material processes based are disposed and then finally, the finished group there is finished group storage and the processed material out. So, there is a GMP interior design for the pilot scale facility.

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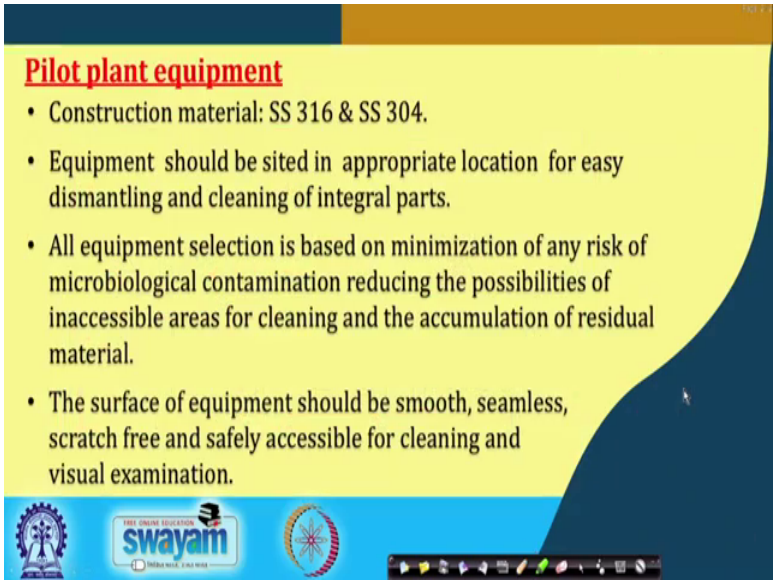

So, plant pilot plant equipment there is construction material normally SS 316 and SS 304. Equipment should be properly sited in appropriate location for easy dismantling and cleaning of integral parts. All equipments section is based on minimization of any risk of microbiological contamination including the possibilities of in accessible areas for cleaning and accumulation of residual material.

So, every possible as I told you that the inside the main processing hall that is a contamination free are micro organisms free environment is maintained. So, the surface of the equipment should be smooth, seamless, scratch free and safely accessible or cleaning and visual examination.

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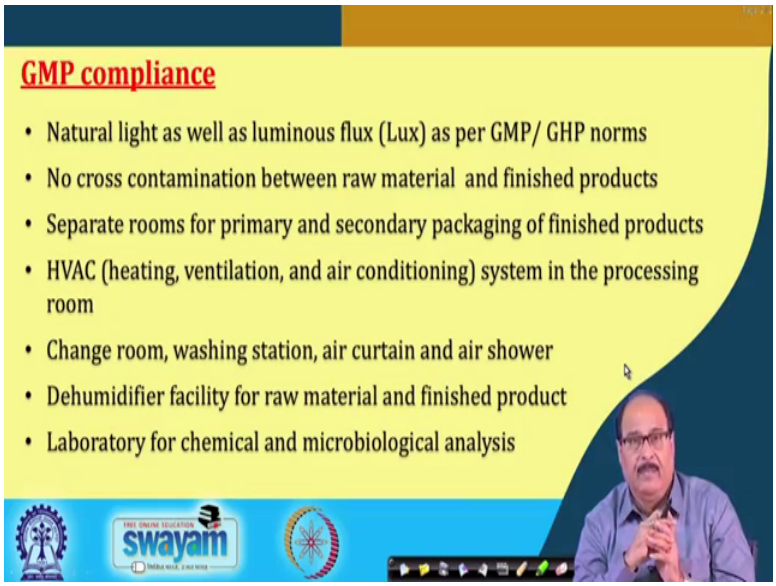

The GMP complaints is that is the plant is provided is to be provided for any plant which is GMP complaint here it should be provided for natural light as well as luminous flux as per the GMP GHP norms, that should not be any chance of any cross contamination between the raw material and finished products, the material handling some wind regulated in such a way. Similarly, there should be separate rooms for primary and secondary packaging of the finished ingredients.

This HIV system that is heating and vend heating, ventilation and air conditioning system should be provided to maintain proper conditions in the packaging room; in the processing room; in processing room. The there should be a provided a provision for a change room, washing station, air circulation, air shower; dehumidification a facility for raw material and finished good storage. Laboratory for chemical and microbiological analysis these are the GMP complaints of the pilot plant.

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So, this is our actual photograph of a pilot scale unit you can see this is the primary processing where we are roasting the grains as well as peanut and then converting them into the powder of different sizes that is the it is not shown here we, on the other side we have a same that is the grinding unit these are the gyro sifters. And this is the roaster as I explained you earlier that is the drum roaster a material is filled through here and through thermo couples where we can this rotates, this is the electrical energy is used for heating the grind inside.

And once it is roasted this is the cooling unit is provided here it is sent to the put to the cooling unit and then finally, cooled down at DSK. So, it is and here it is the these all the materials even sugar; sugar may be grind here or minerals. So, all the material passes through this through some trolley it is passed through there is a UV facility in, so it moves through the main processing room.

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Now, here it is the actual main processing room where you can see I showed in the schematic, these are the actual thing that is the where the solid materials are kept and this a liquid that is your peanut etcetera on the other side's they are kept there is this unit it is the peanut, oil and stabilizer antioxidant is kept here. So, this is ground here and paste collect paste is collected here that is recirculated and paste is finally, collected in this tank.

Then other material from the top solid material they come and they are collected here. In the secondary stage that is they are sent to the paste. And, these solids this is the other mixer that is ploughshare mixer is put here and the ploughshare after ploughshare mixer comes to the packaging the colloidal mill and through the with the help of pipelines there is after it is sent to the packaging section.

In the packaging section, there is the packaging machine where this is different structures are produced and this let us are passed through, these a metal detection unit and then further bias coating. This pilot plant facility is provided with the GMP as a it could with the CIP unit that is there are as you can see here these are the two tanks, two other tanks are there which are not shown with this photographs.

So, in one very hot water another is the hot acid another has the hot alkaline and then and fourth one is at hot sanitizer solutions. So, as soon as the material process material after mixing browser mixing, collide milling it is put to send to the packaging unit this

automatically this hot water cleaning followed by rinsing, then or hot AC alkaline cleaning followed by hot water rinsing, then acid cleaning followed by hot water finally, sanitization and then dry air cleaning etcetera.

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So, all this thing is done this is this is the same a bigger view same view of the primary that is the batch PLC control continuous processing unit. So, this is a here you can see the PLC in fact, through this once we said that program. So, after that it is a automatic process, that is the mixing, grinding, mixing, homogenizing convening and packaging all this are the automatic process PLC control process. And, even through the software is made in such a way that if there is any particular machine in the whole some problem, it will indicate software you can indicate the problem and remedial corrective measures can be taken.

So, with this I thank you very much for your presence hearing and I think we have got in this two lectures in the part 1 and part 2, a quite good idea of the preparation that is the formulation, processing and packaging of any ready to eat food paste as well as the formulation processing and packaging of specific high energy ready to eat food paste for malnourished children. And, these food paste high energy, ready to eat food paste which are produced using locally available raw materials if systematic approach is taken for their hygienic manufacture.

And providing are manufacturing and distribution through proper channels to the affected children and other affected people. And if they are feeding is done by proper feeding mechanism they are provided with these materials; obviously, I am sure that this will go a long way, this will help in eliminating or eradicating the problem of severe acute malnutrition from the nations.

Thank you very much.