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 – 57

Gluten Free Products (Bread & Pasta)

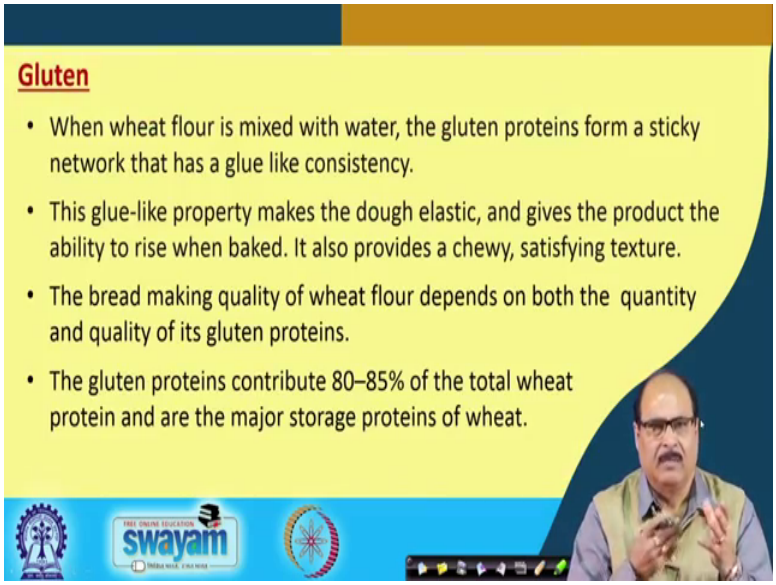
(Refer Slide Time: 00:29)

Hello friends. In this class let us study about gluten free products, particularly gluten free breads and pasta. In fact, these gluten free products are commercially available now in American markets, European markets etcetera. In India also it is becoming increasingly popular day by day. So, before going to the discussion on gluten free products, let us first understand what is gluten? Actually the gluten is a protein found in cereals like wheat, rye, triticale and barley.

It starts as two protein strands called glutenin and gliadin when wheat flour or such other materials containing these glutenin and gliadin are mixed with water. And they are given the mechanical force during the kneading process, that are by kneading. Then, these glutenin and gliadin, they interact with each other and a coherent network structure of gluten is formed. That is, in this structure the starch and other molecules or other

materials which are present in the four flour components of the flours etcetera, water molecule they are embedded.

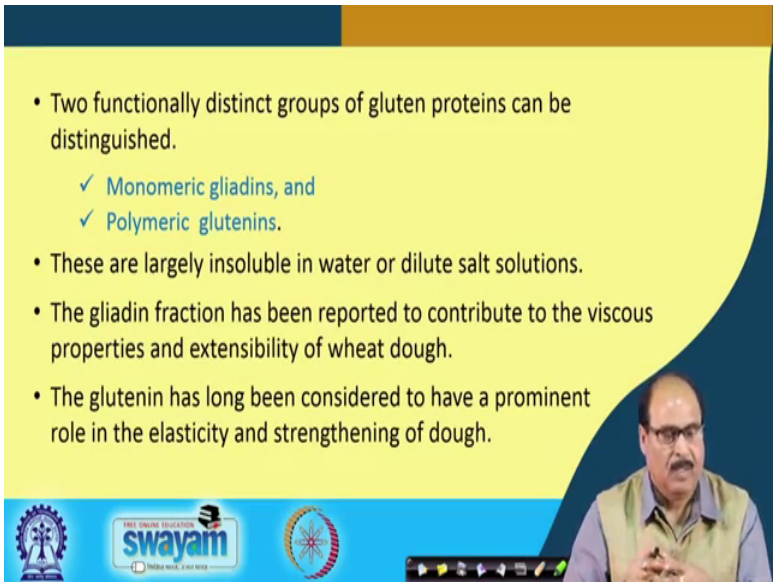
(Refer Slide Time: 01:59)



So, in fact, it is the characteristic protein of wheat which makes a wheat a very very ideal ingredient for preparation of bakery products like bread, pasta, biscuits, etcetera, etcetera, alright. So, as I told you, when wheat flour is added with water and it is worked mechanically, that is the when the force is applied. Then, there is interaction between these molecules. And this gluten develops and this a glue-like property there is a gluten makes the dough elastic and gives the product, bakery products its ability to rise when baked during baking process.

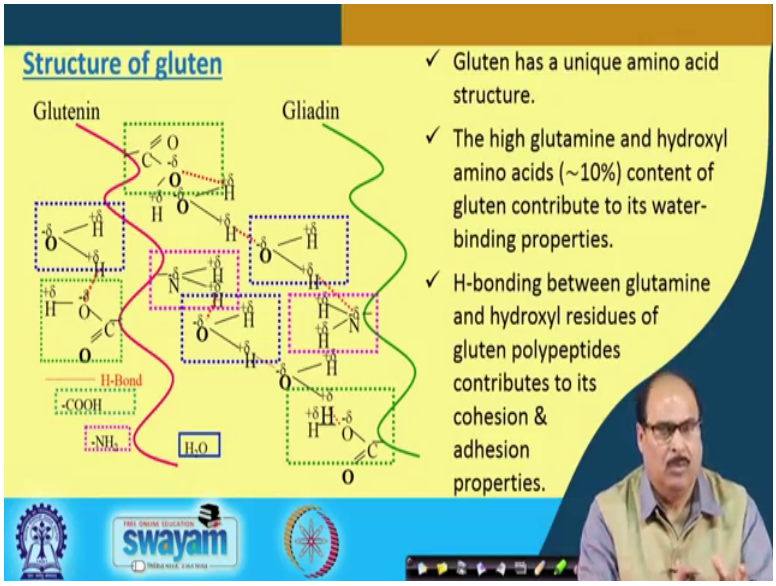
It also provides a chewy and satisfying texture to the product. The bread making quality of the wheat flour depends on both, the quantity of these glutenin and gliadin present and in general the quantity of the wheat protein as well as quality of the wheat protein. The gluten proteins contribute around 80 to 85 percent of the total wheat proteins and they are the major storage protein of wheat.

(Refer Slide Time: 03:12)



So, as I told you the functionally distinct groups of gluten proteins are the monomeric gliadines and polymeric glutenins and these are largely insoluble in water or in dilute salt solutions. The gliadin fraction has been reported to contribute to the viscous property and extensibility of wheat doughs. Whereas, the glutenin factor has been considered or it has been known to give or a have a prominent role in providing elasticity or in providing strengthening of the dough.

(Refer Slide Time: 03:55)



So, in this picture, we have shown you, that is the structure of gluten right. There is a this gluten both gliadinin portion, gliadin portion and glutenin process. They have unique amino acid composition, amino acid structure and they contain about a comparatively high content of hydroxyl amino acids and glutamines. And this high hydroxyl amino acids contains a gluten contributes to its water binding properties.

Hydrogen bonding, you can see here in these two gliadinin fraction and glutenin factors, they are interacted with the hydrogen bond and network coherent structure as I told you, all right. So, this hydrogen bonding between glutamine and hydroxyl residues have the gluten, polypeptide contributes to its cohesion and adhesion properties. And this is very, in fact, that how much water will be there and even mechanical force applied that is the needing parameters etcetera that, they are necessary, proper kneading and proper amount of water are important for the proper development of gluten.

In fact, ideal characteristics in the ideal case for a good development of bread at least, the gluten should have the glutenin and gliadin properly mixed in 1 is to 1 proportion. And that can be controlled by proper kneading conditions and other factors.

(Refer Slide Time: 05:36)

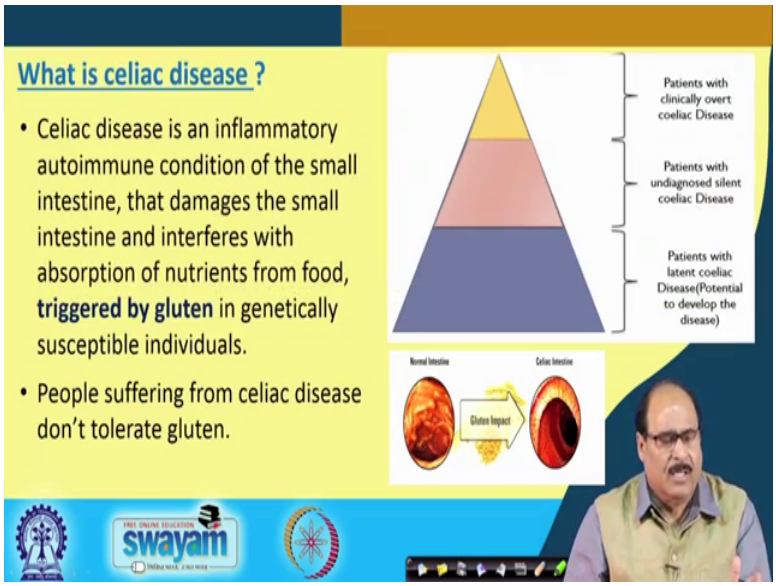
So, you have now that is what is gluten. In fact, it is a very very important constituent or component and which makes the wheat flour or wheat a unique and very very important material for the preparation of bakery products. That is it is the gluten which gives the

visco-elastic properties, dough handling characteristics, dough water absorption and all those, that is it becomes a suitable from it.

So, now why do we need gluten free products? There are various wheat products which are liked by the consumers and they have very high acceptability. And they are prepared even in their homes and throughout the world. Large population of the world they consume wheat products. But, up late now, data is available that the gluten has some that important role particularly, it results into some sort of diseases or malfunctions of the system in the body. And that celiac disease one is a one very very common auto disease which is because of the autoimmune response of individual to the gluten.

That is the there are maybe certain individuals, when they consume gluten, because of the gluten there is some disorder develops in those individual. Similarly, certain individuals may have gluten intolerance, sensitivities or allergic immuno immune response to the allergens are AD HD and autism. This is the problem of digesting protein found gluten and casein causes an opiate-like effect on the brain that is autism. And even there may be some other autoimmune development issues including thyroid issues due to the consumption of diet containing gluten.

(Refer Slide Time: 07:56)



So, the celiac disease as I told you, it is an inflammatory autoimmune condition of the small intestine. That damages the small intestine and interferes with the absorption of nutrients from food. And this autoimmune condition or inflammatory condition of the

small intestine is basically triggered by gluten in genetically susceptible individuals. And people suffering from celiac disease in fact, do not tolerate gluten. And the medical report says that, to for such individual who are susceptible to gluten, who cannot tolerate gluten or which are reported to have celiac disease or such other fellows. For them, they have to completely avoid gluten in their diet.

(Refer Slide Time: 08:57)

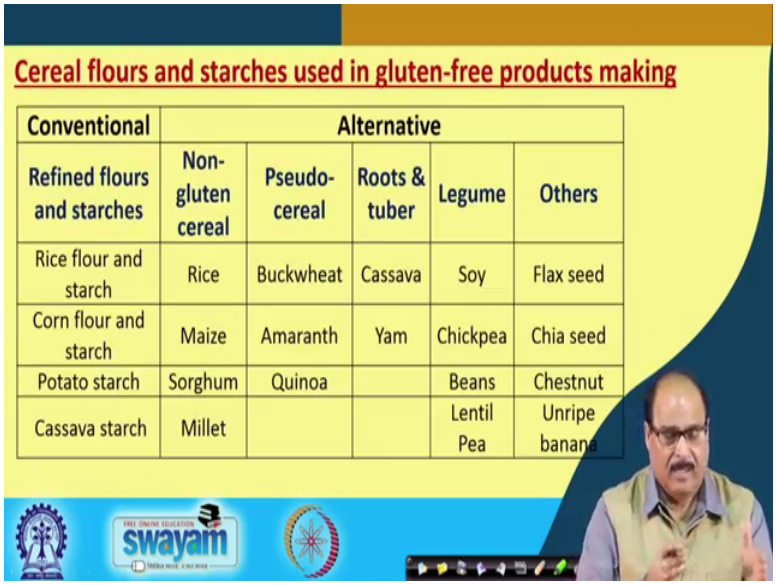
And that is where the gluten free products are needed. That is for such individual who have problem this gluten consumption. That is, the products containing gluten consumption, celiac disease etcetera. So, for them gluten free products are needed. So, gluten free formulations are developed generally using maize and rice flours often combined with corn, potatoes or cassava starches along with the proteins and hydrocolloids for binding agent. Because, is one, that is the product to, from the non-gluten containing raw material has been the one major ingredient for conversion of the to gluten free product.

But, there it has a important because the visco-elastic properties or such other properties cohesiveness the other properties of the material all right. That is which is contributed by the gluten into the wheat products that lacks in the non-gluten containing raw material. So, by adding certain additives, hydrocolloids etcetera or by using appropriate processes or having the proper selections of the material etcetera these gluten free products so are developed. That is a these products, that is the which the in certain ingredients

hydrocolloids etcetera which can mimic the properties which are provided by the gluten that becomes very very important ok. So, gluten free products generally they have lower fiber and micronutrients in comparison to its wheat-containing counterparts.

Because, it is usually made from refined flour and or starches that are not generally in this that fortifies. A number of nutrient dense alternative raw materials, in combination with conventional GF flours and starches, increase variety and improve nutritional quality of the GF bread right.

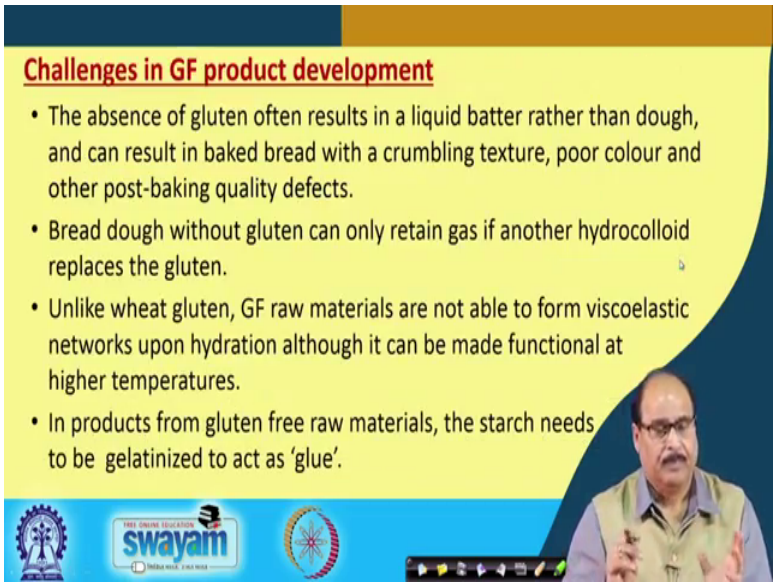
(Refer Slide Time: 11:11)



In this slide just I have tried to give you that materials that is cereal flours and starches which can be used for the preparation of gluten free products. Like conventional flours, like refined flours and starches of rice, corn, flour or corn starch, potato starch, cassava starch etcetera are alternative non-gluten containing raw materials. Like non-gluten cereals like rice, maize, sorghum, millet.

Pseudo-cereal such as buckwheat, amaranth, quinoa or roots and tubers that is cassava and yam. Legumes like soya, chickpea, beans, lentil pea or other grains like flax seed, chia seeds, chest nut, unripe banana etcetera these can be used for preparation of gluten free products.

(Refer Slide Time: 12:07)



So, as I told you, there are challenges in the preparation of gluten free product development because, the absence of gluten often results in a liquid batter. Rice is conventionally, traditionally used for preparation of the gluten free products, even bread I will tell you little later that we have worked on also that is, you prepared bread using rice flour.

But, from the rice it is not possible to prepare a dough similar in consistency and visco-elastic property as we get from the wheat dough, because in the wheat gluten is there which contributes to this property. But, from rice we normally get a batter and this batter that can result in baked bread with a crumbling texture, poor colour and there may be other post-baking defects.

Bread dough without gluten can only retain gas if another hydrocolloid replaces the gluten. because that is very important. Gluten provides the unique texture, it has a proper gas retention characteristic during fermentation or process or leavening process. The carbon dioxide gas which is produced in the general bread baking process that finally, during baking process a part of that gas is retained in the structure which gives the bread its unique crumb and other texture, another characteristic.

But, in the gluten free raw materials, the absence of glutens poses a challenge to the setup. So, there should be some agent either hydrocolloid etcetera should be added in the

formulation or the rice starch or such other starches. Their characteristics should be suitably changed so that they can hold some of the gas.

So, are their gas retaining properties, water absorption characteristics are significantly improved unlike wheat gluten, gluten free raw materials are not able to form visco-elastic network upon hydration. Although, it can be made functional at a higher temperature in products from gluten free raw materials the starch to provide or to improve its properties to contribute to the properties of the product, that is starch need to be gelatinized to act as a glue.

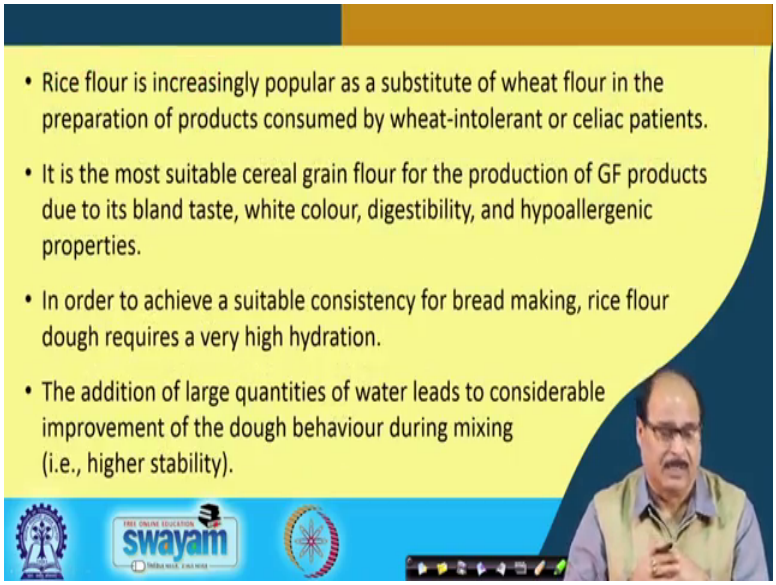
(Refer Slide Time: 14:46)

So, the gluten free bread that will be the development of good quality gluten free bread is a serious task. Therefore, many researchers have investigated the substitution of gluten by ingredients which are able to mimic its functional properties. The majority of the commercially available gluten free breads as I told you, they are inferior in the quality to their gluten-containing counterparts. Although, it has been a challenge that researchers are working that to improve the quality and mimic, that is the prepare gluten free bread quality and characteristics as close as possible to the wheat bread.

That is the gluten free bread have a relatively shorter shelf life. The crumb is wet after baking; it sticks together and quickly becomes dry. So, crumbliness is a problem. It becomes a rough, it becomes crumbly, disintegrates. So, in the gluten free bread these are

some of the issues which need to be taken care of by appropriate processing and appropriate use of the hydrocolloids etcetera.

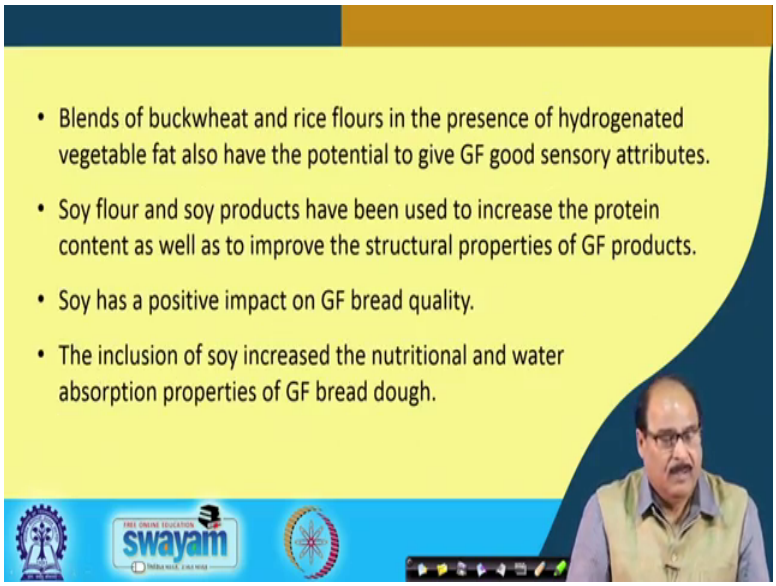
(Refer Slide Time: 16:05)



As I told you, rice flour is increasingly becoming popular as a substitute for wheat flour in the preparation of products which are consumed by wheat intolerant or celiac patients. It is the most suitable cereal grain flour for the production of GF products due to its bland taste, white colour, its digestibility and hyper allergenic properties.

Because of this, it is taken as or considered as a good raw material for preparation of gluten free product. In order to achieve a suitable consistency of bread making, rice flour dough requires a comparatively higher or rather very high hydration it needs more. As I told you that is it is converted to be in a sort of batter and the addition of large quantities of water leads to considerable improvement in the dough behavior during mixing. That is, high it provides higher stability to the dough behavior or dough batter which is obtained.

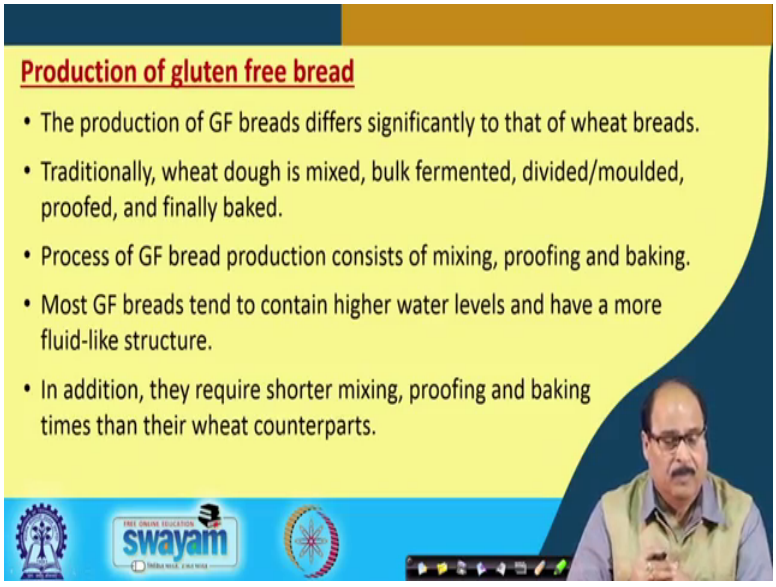
(Refer Slide Time: 17:21)



Even blends of buckwheat and rice flours in the presence of hydrogenated vegetable fat have also been found to good material. They give good gluten free bread, having good sensory attributes.

Soya flour and soya products have been used to increase the protein content as well as to improve the structural properties of gluten free products. Soya has a positive impact on gluten free bread quality. The inclusion of soya bean or soya flours increases the nutritional value and water absorption characteristics of the gluten free bread doughs.

(Refer Slide Time: 18:08)

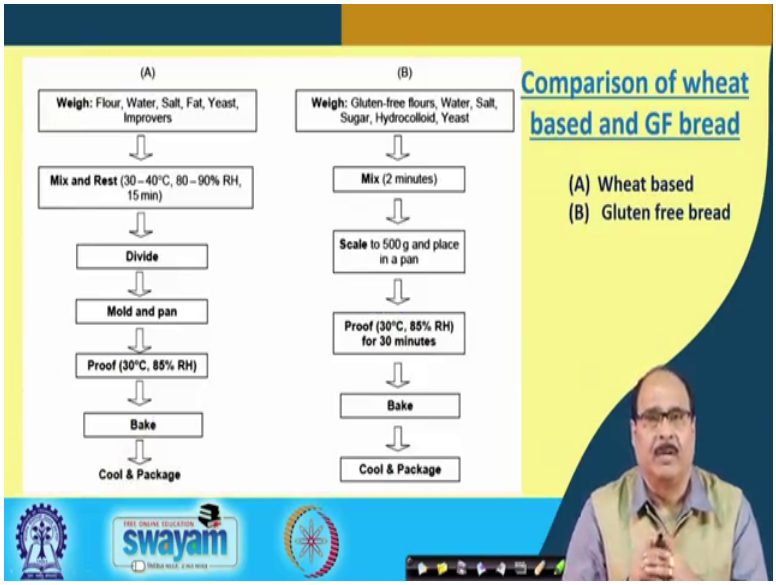


Regarding the production of gluten free bread, there is a mix that is the production of gluten free bread differs significantly from that of the wheat bread. That is the process of production right.

Wheat bread traditionally, it is made that is, the wheat flour is taken of appropriate protein content. Water is added, it is mixed properly, dough is made of proper consistency and the dough and in the formulation of course, yeast another ingredients are added salt and all those things. So, the during fermentation, that is the yeast acts and carbon dioxide gas is liberated and there is a leavening rising of the dough. And after fermentation or proofing, the dough is divided or molded of proper size and then, it finally baked.

But all these steps are not necessary because we do not get a good quality dough here. Maybe that molding etcetera, or dividing or some of the, even fermentation, some of the processes may require to be changed and their conditions might require to be changed. So, process of GF bread production consists of mainly mixing, proofing and baking. Most of the gluten free breads tend to contain a high water levels and have a more fluid-like a structure. In addition, they require shorter mixing, proofing and baking times than their normal wheat counterparts.

(Refer Slide Time: 19:49)

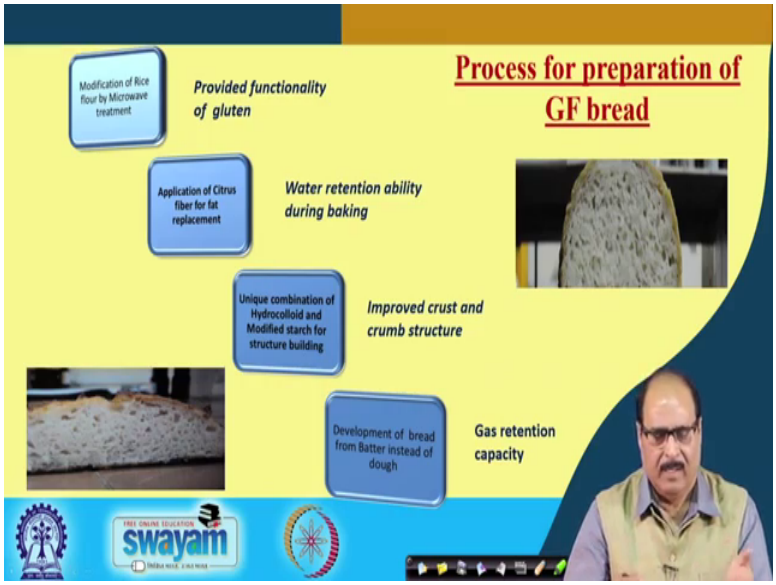


So, in this process in fact, it is a comparison of the wheat based bread as well as a non-wheat or gluten free bread containing not. So, for the wheat flour bread as I told you,

flour, water, salt, fat, yeast and some improvers, they are added, mixed properly. And they are given a rest at 30 to 40 degrees Celsius, 80 to 90 percent relativity for about 15, 20 minutes so that is the rising or the development. And finally, it is divided or molded into pan and finally proved, that is second fermentation at 30 degrees Celsius 85 percent relative humidity. And finally, it is baked at appropriate temperature and cooled and packaged. In the case of gluten free flour bread preparation, that is the materials are taken as for the formulation, that is like gluten free flour, rice flour, etcetera, water, salt, sugar and hydrocolloids here. There was improver here, hydrocolloids and yeast.

So, here mixing is normally very short mixing, about 2 minutes and after mixing, that is the formulation is taken. It is a 500 gram or 800 gram or 1000 in the scale to formulation, put in a pan and this pan is put in the room at 30 degree Celsius temperature and 85 percent relative humidity is maintained and for 30 minutes. So, for some the yeast to act and finally, it is baked and the bread obtained and cooled and packaged.

(Refer Slide Time: 21:27)



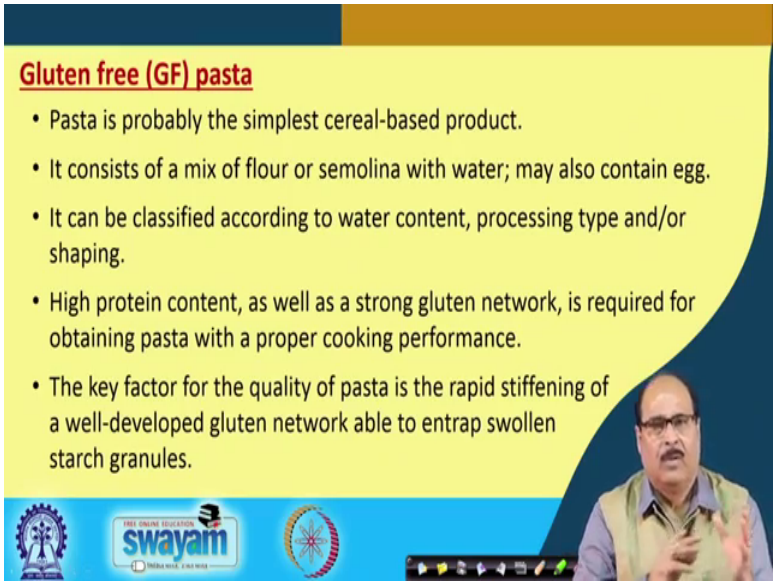
And this is In fact, at IIT Kharagpur in our laboratory, we have developed gluten free bread using rice as a raw material. And which in the pictures you see, the pictures of the bread, these are the bread samples of the bread prepared in our laboratory using rice. So, what do we take? We take rice flour and this rice flour is given some microwave treatment to modify its starch and other components are little bit modified. So, the first it is a patented process. So, I may not disclose the major things, but general I will give you.

That, what are the different steps that is, the modification or the rice, starch characteristics by microwave treatment.

And then, in that addition of some citric fiber that is citric fiber is used as a fat replacer and it improved the water retention ability during of the dough batter during baking. And this microwave treatment of the rice flour provides improvement in the functionality of the material and starch are gluten like behavior it gives. Then, unique combination of hydrocolloids and modified starch for structure binding. That is the, now, this modified starch are partially gelatinized rice flour and normal rice flour they are mixed and some hydrocolloids are also added, citric fiber. So, a formulation we prepared and this here, this combination gives the improved crust and crumb structure.

And finally, it is baked at under usual conditions like those of the normal bread so development of bread from the batter. In this case, let me tell you that here we got batter not the bread, but this from the batter we have prepared this bread which you can see in the picture. So, it has a good gas retaining capacity community.

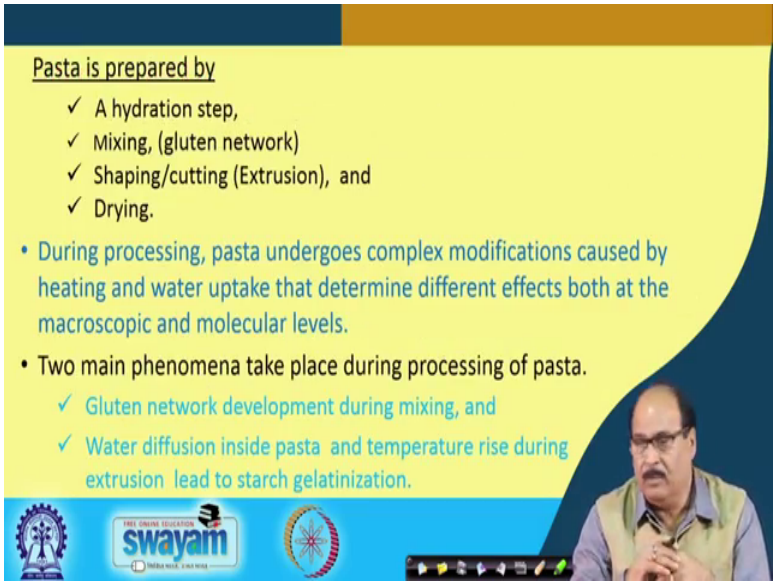
(Refer Slide Time: 23:36)



Now, the next important product is that gluten free pasta. Pasta is a, probably the simplest cereal based product. It is becoming increasingly popular among the masses even in our country. Younger people like pasta better than the bread and other chapattis is that convincingly made with products.

Pasta consists of a mix of flours or semolina with water, it may also contain egg. It can be classified according to the water content, processing type and or shaping. That is, different shapes, different types, different raw materials are used for the preparation of pasta and accordingly, the pasta are classified. High protein content, as well as a strong gluten network, is required for obtaining pasta with good consistency, with proper cooking performance. The key factor for the quality of the pasta is the rapid stiffening of the well developed gluten network which is able to entrap swollen starch granules.

(Refer Slide Time: 25:07)



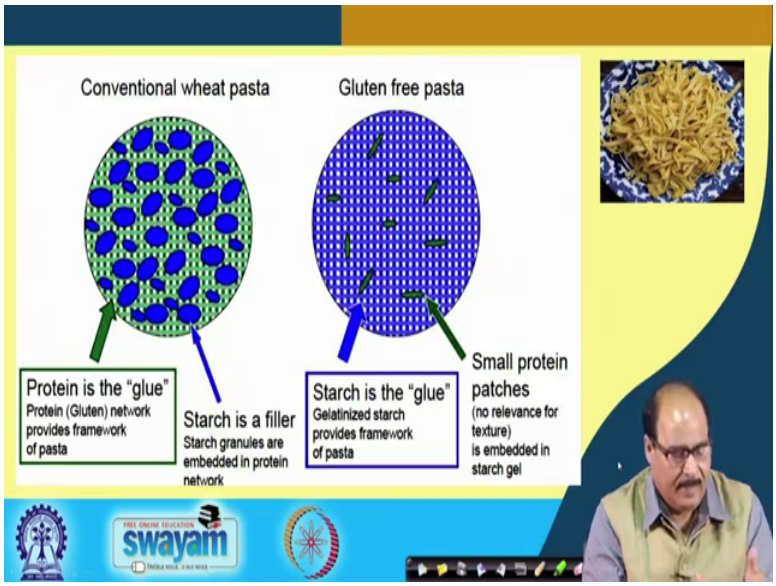
Pasta is prepared by, I told you that is, there are 4 steps. First is the hydration step, where the flour is mixed with water there is and this mixing. So, the hydration and then mixing, the mixing helps in the development of the gluten network in the similar way as you have seen in the case of bread. Then, really the next is the shaping and cutting and for this basically, the extrusion process is used or extruders between (Refer Time: 25:42) extruders are better or even single screw extruders also can be done. But, twin screw extruders or even pasta extruders are also available. So, even low temperature extruder, high temperature extruder, these become extrusion conditions. They have effect on the quality of the pasta ok.

And then finally, after it is given shape, the next step is the drying; so, during processing, particularly during mixing, extrusion, drying, etcetera. The pasta undergoes complex modifications during mixing and shaping. These are the two important steps in the

processing, where the modifications caused by heating as well as water uptake and these changes in the protein and structure and protein structure and starch and all the materials. It determines the different effects both, at the microscopic level as well as at the molecular level.

So, two main phenomena's take place during processing of pasta as I told you, that is the one is the gluten network development during mixing and then water diffusion inside pasta and temperature rise during extrusion. The temperature rise during extrusion lead to the gelatinization of starch and which gives the desirable strength and other cooking improved, desired cooking characteristics to the pasta.

(Refer Slide Time: 27:19)



So, you can see here, that is a here 2 pictures are there. That is conventional wheat pasta and gluten free pasta. So, in the conventional wheat pasta, where the gluten is there wheat gluten is the glue it provides the characteristic elasticity and other characteristics.

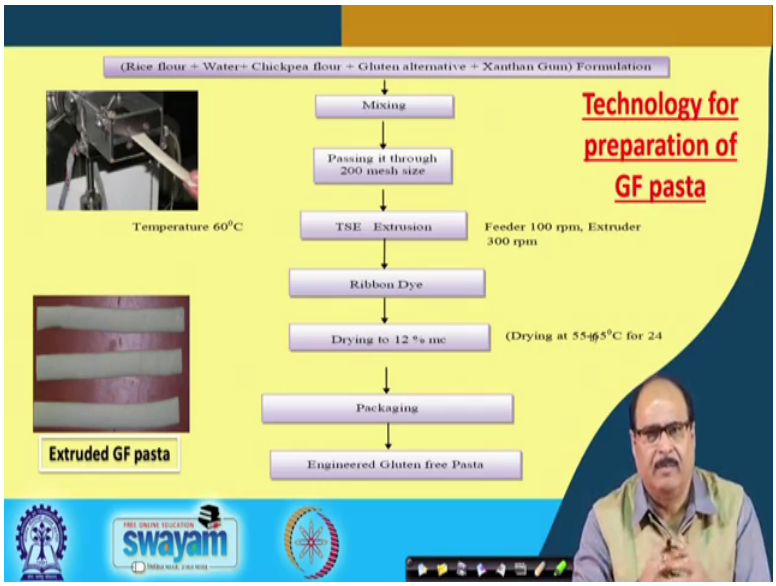
And the protein glue network provides the framework of pasta. And in this, starch is a filler, there is this is smaller are the starch. This is they are embedded in the gluten network or protein network and it is the similar to that in the case of wheat bread also similar type of the things. As I told you, that is gluten protein network there gliadin, glutenin, etcetera right. And starch and other, we even added yeast and salt and other components which are added, they get embedded in the water molecules.

Whereas, in the case of gluten free pasta you can see, here starch provides the glue. And protein and other smaller proteins and some other products, they are in the network frame. So, accordingly, that it becomes important that is due to by extrusion and or by other appropriate hydrocolloids etcetera may be added. So, that these glue property of the starch are suitably changed or suitably modified to provide the needed functionality. That is, a small protein such as here ok. So, they are small protein patches. They are embedded of course they are not very very significant in this case. So, it is the important thing is that in this case starch is the glue.

(Refer Slide Time: 29:11)

So, flour used for gluten free pasta, the same type of flour which are used for gluten free bread making. They can also be used for gluten free pasta. A rice flour is increasingly being used, but other cereals etcetera can be used. But, the important thing in this similar manner, here also the characteristics need to be changed.

(Refer Slide Time: 29:34)



This is a process flowchart for the preparation of gluten free pasta which has been developed in my laboratory at IIT Kharagpur right. So, in this what we do? We take rice flour, water, chickpea flour and that is some hydrocolloids, gluten alternatives, xanthan gum etcetera.

So, this formulation has been standardized. We have tried different combinations and permutations and these ingredients as per the formulation they are mixed properly. And then it is of course, passed through 200 mesh size to ensure the uniformity of the mix. And then, these material then they are passed through twin screw extruder, where the twin screw extruder, feeder speed is maintained at 100 rpm. And extruder runs at feeder barrel runs at 300 rpm and the temperature inside the extruder is maintained 60 degrees Celsius.

So, the ribbon type die we have used, although there are different. It can be different types of dies or different types of cutter can be used to get the desired types and size of the GF pasta right. So, the finally, this is the picture of the ribbon type gluten free pasta which we get. And this pasta is then dried at a temperature of about 55 to 65 degrees Celsius for overnight may be 24 hours or so, alright; to dry the pasta to your moisture content of 12 percent, final 10 to 12 percent final moisture content. And of the giving, you are getting desired characteristics.

As a prime factor, low temperature drying, low temperature long time drying for pasta is recommended. Then, after their packaging, suitable packaging and for this packaging, the material should be that packaging materials such etcetera, should be of appropriate quality. So, that it does not reabsorbs moisture etcetera during storing. So, that is the technology for the preparation of gluten free pasta developed in our.

(Refer Slide Time: 31:58)

So, these are, there are now, novel technologies for preparation of gluten free pasta like these products which I have told you or which we have seen so far. That is, the in most of the cases the non-gluten containing raw materials are used for the preparation of gluten free product. But, the best thing might be that to modify the protein content of that is glutenin and gliadin and the glutenin network etceteras of the wheat flour itself. In fact, lot of research is going on in this direction.

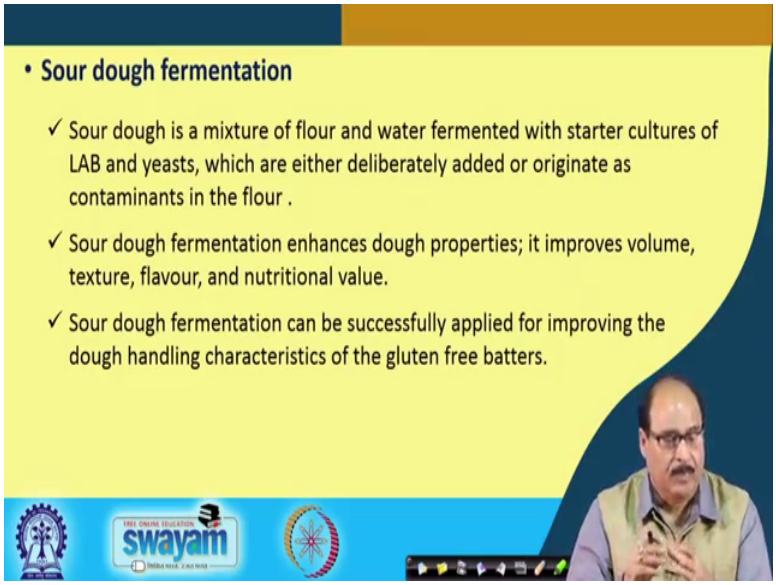
So, enzymatic approach can be followed like, having the that is enzymes action of prolyl endopeptidases etcetera PEPs enzymes which can clip, which can grab the peptide linkages that peptide bonds are the proline and glutamine residues in the gliadin and glutenin. And then, this becomes that is the toxicity are the problems.

That is the, because human gastrointestinal protease, they are unable to degrade these proteins to that amino acid level. So, if it can be done that is the by using enzymatic approach to break these bonds, break the peptides. So, that they are a effect of causing toxicity of diseases etcetera that can be eliminated. However, this may be a good

approach, but when these peptides are broken, how these flours, how these amino acids etcetera, how these peptides are behaving, how they are behaving in the giving the visco-elastic properties and other characteristics of the gluten that needs to be seen, established.

In fact, cereal germination can also degrade immune stimulatory gluten peptides and thereby diminish the toxic effects. Lactobacilli are known to possess a complex protease system, which can hydrolyze various proline residues of the gluten. So, these enzymatic approaches, bacterial action, bacterial enzymes, etcetera or germination etcetera, they reported to be good step or they can help in reducing the toxic effect or allerginess or such other effects of the gluten. But, what will be its effect on visco-elastic and other characteristics of the dough and in the bakery products, it needs to be seen.

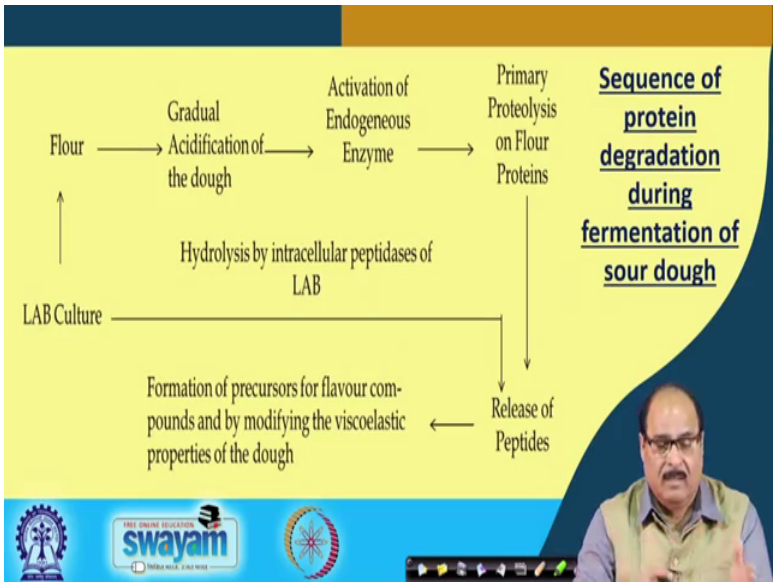
(Refer Slide Time: 34:44)



The second approach, another approach may be sour dough fermentation. Sour dough is a mixture of flour and water fermented with starter culture of lactic acid bacteria and yeast, which are either deliberately added or they originate as a contaminant in the flour.

So, sour dough fermentation enhances dough property. It improves volumes, texture, flavor and nutritional values etcetera. Sour dough fermentation can be successfully applied for improving the dough handling characteristics of the gluten free batters.

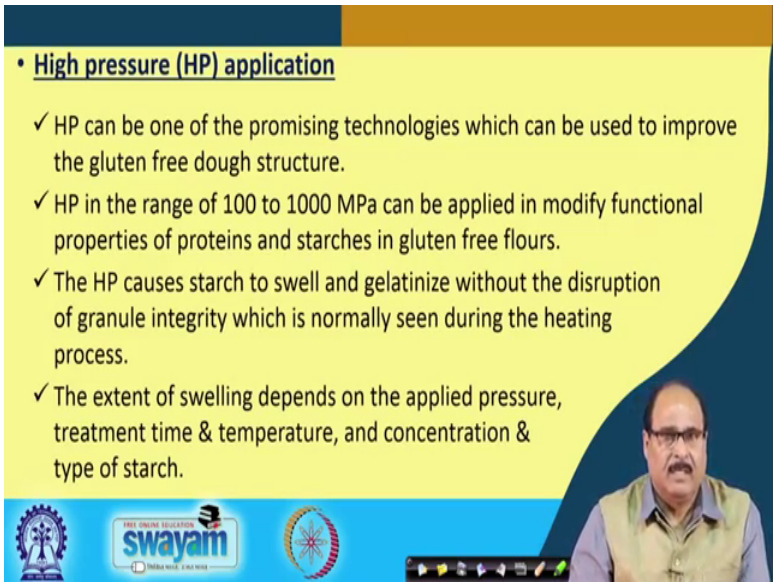
(Refer Slide Time: 35:28)



In this, there is just a schematic sequence of the protein degradation during fermentation by sour dough, sour dough process. That is, lactic acid bacterial culture can be added to the flour and this culture enzymes containing this culture, they act as the flour. And there is a gradual acidification of the dough.

Activation of the indigenous enzymes, it finally results into the proteolysis of the or breakdown of the flour proteins and release of peptides. Lactic acid bacteria also directly can hydrolyze that intracellular peptidases, alright? And they release the peptide and with ultimately finally, it may result into the formation of precursors of flavor compounds and by modifying the visco-elastic properties of the dough.

(Refer Slide Time: 36:24)



So, apart from this, enzymatic approach, sour dough fermentation, the high pressure application of high pressure may be another potential way for improving the functionalities of the starch and other components. Or they can lead to the formation of the; in the formation of the gluten free products.

That high pressure can be one of the promising technologies. In high pressure, in the range of 100 to 1000 Mega Pascal can be applied to modify functional properties of proteins and starches in gluten free flours. The high pressure causes starch to swell and gelatinize without the disruption of granule integrity, which is normally seen during the heating processes. So, the extent of swelling depends upon the applied pressure, treatment time and temperature and concentration and type of the starch.

So, these are the some of the approaches by which either the wheat this protein and their functionality can be improved or their toxic effect or other such effects of the wheat gluten can be lowered down. Or the functionality of the non gluten containing raw material are they are starch and proteins can be modified to mimic the properties exhibited by the gluten in the wheat flours. So, these are the approaches that these materials can be used to developed gluten free products. And either by continue using non-gluten containing raw material or by suitably modifying the characteristics of the wheat protein so that there its toxicity or air density is reduced.

But, one thing is very clear that the literature report says, that is the persons who are gluten intolerant for them a gluten free diet is a must. So, therefore, for such people and the number of celiac disease or gluten intolerant people are reported to be increasing day by day. Even in our country, in India also number of celiacs persons reported are the significant. Maybe I think about 3 in every 1000 are reported to be celiac in our country. So, for such people, the gluten free product are becoming product are there, very important.

Thank you very much.