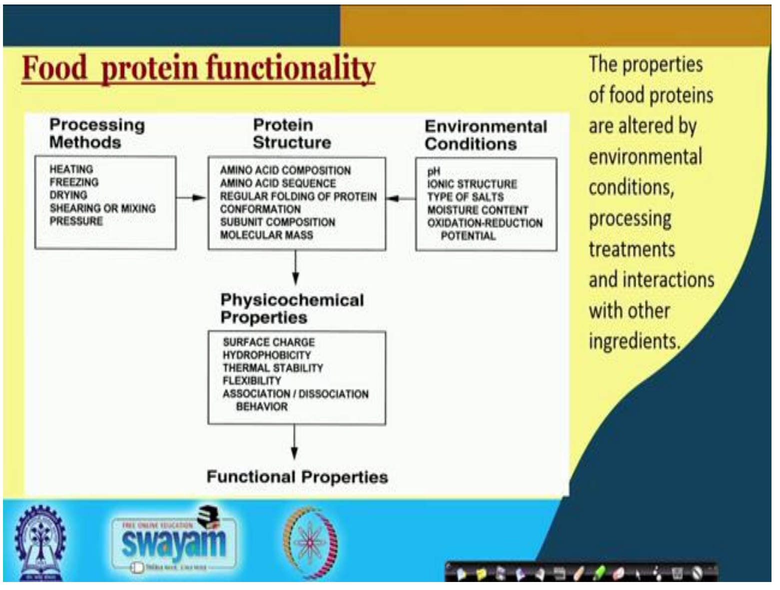
Novel Technologies for Food Processing and Shelf Life Extension
Prof. Hari Niwas Mishra
Department of Agricultural & Food Engineering
Indian Institute of Technology, Kharagpur

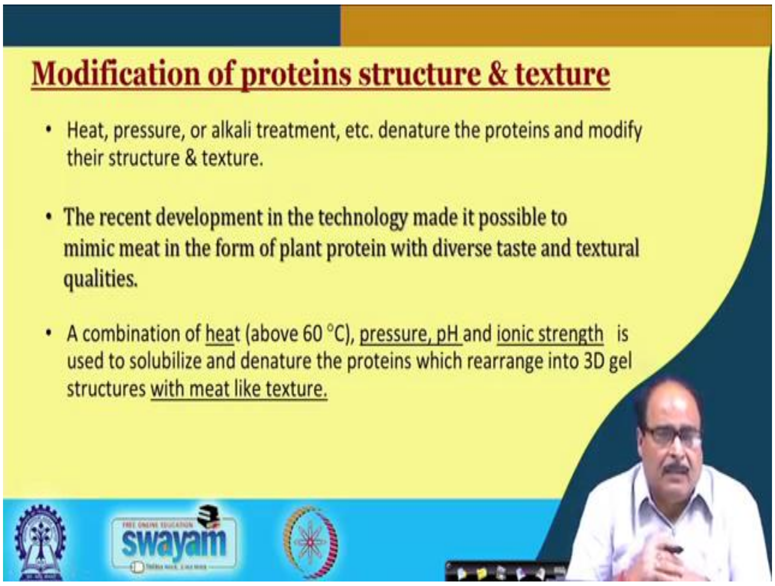
Lecture – 25
Textured Vegetable Protein

In this lecture, the textured vegetable proteins, different methods for their manufacture as well as their applications, and the product quality characteristics are elaborated.



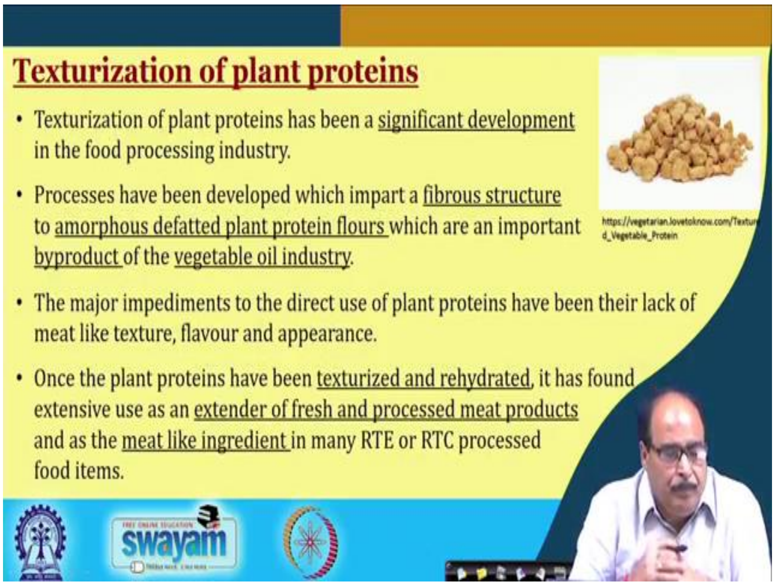
The properties of food proteins are altered by environmental conditions, process treatments and the interactions with other ingredients. Processing methods are generally heating, freezing, drying, shearing or mixing, pressure etc.; environmental conditions such as pH, ionic, structure, type of salts, moisture content, oxidation-reduction potential and so on. All these conditions have important influences on protein structure.

So, with the varying conditions of processing methods and environmental conditions, protein structures get changed and this change in the protein structure influences its physical properties, functional properties and many other factors.



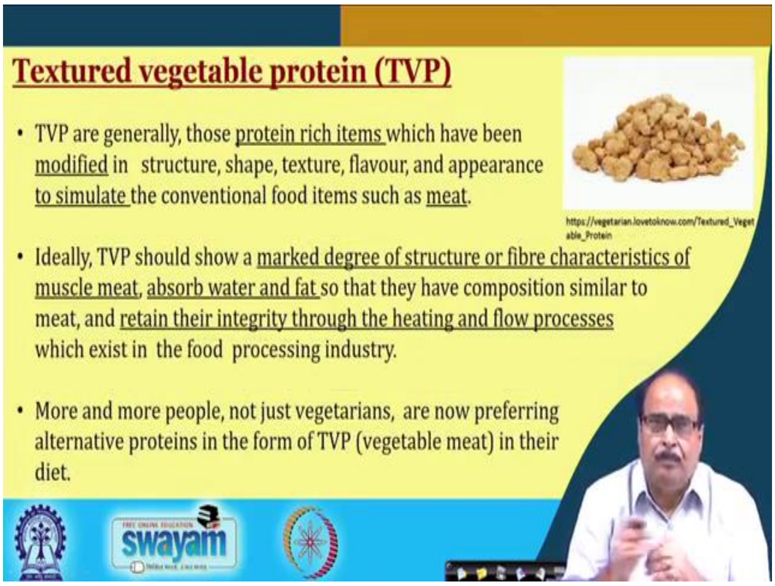
So, in most of these processes, it is basically the heat, pressure, or alkali treatment, etc. which are involved and these factors result in the denaturation of proteins and this denaturation process modifies the structure and texture of the protein.

The recent developments in the technology have made it possible to mimic meat in the form of plant proteins with diverse taste and textural qualities. A combination of heat generally above 60 °C, pressure, pH and ionic strength is used to solubilize and denature food proteins. Under these conditions, proteins rearrange themselves into 3D gel structures and which gives the meat like texture and other properties.

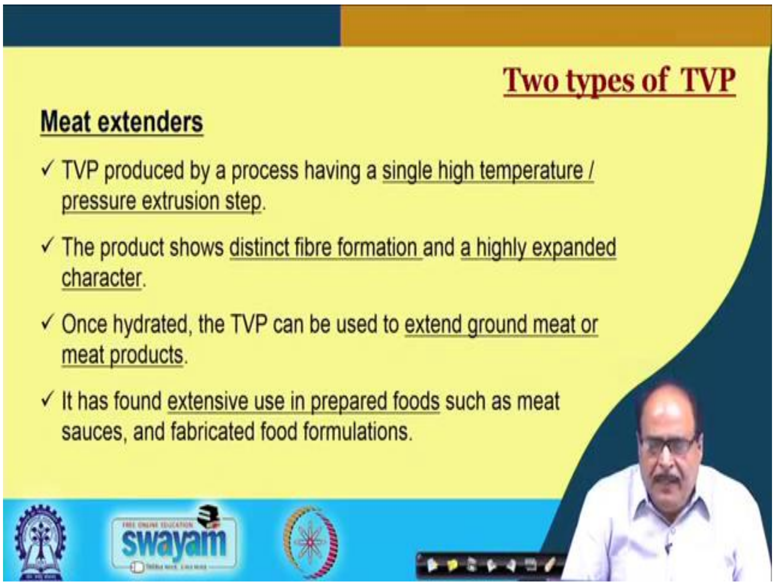


Texturization of plant protein has been really a very significant development in the food processing industry. Processes have been developed which impart a fibrous structure to amorphous defatted plant protein flours. In fact, these defatted plant protein flours are important by products of the vegetable oil milling industries.

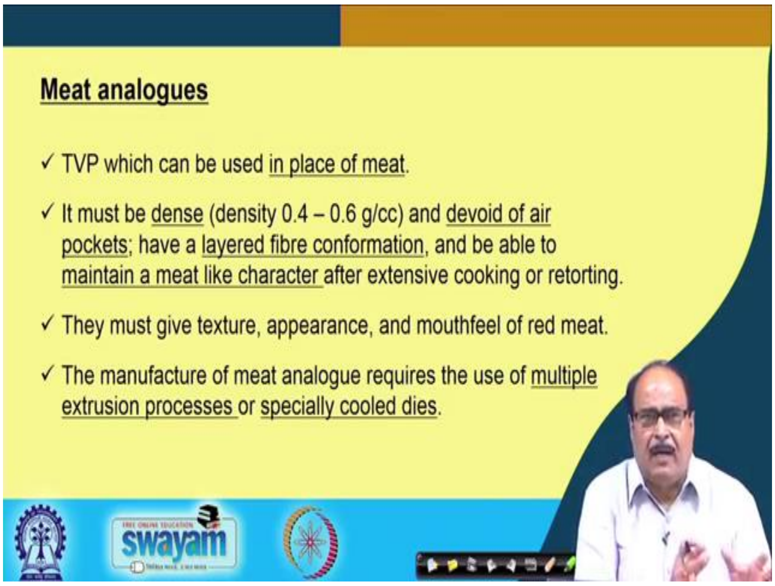
The major impediments to the direct use of these plant protein flours have been their lack of meat like texture, flavour and appearance. After the plant proteins have been texturized and rehydrated, it has found extensive use as an extender of fresh and processed meat product and as the meat like ingredients in many ready to eat or ready to cook processed food items.



Texture vegetable proteins (TVPs) are generally those protein rich items which have been modified in structure, shape, texture, flavour and appearance to simulate the conventional food items such as meat. So, ideally the TVP should show a marked degree of structure or fibre characteristics of the muscle meat. It should absorb water and fat appropriately so that they have the composition similar to meat and more importantly, it should retain their integrity through the heating and flow processes which exist in the food processing industries. Nowadays throughout the world, more and more people not just vegetarians, are preferring alternative proteins in the form of TVP in their diet. In fact, textured vegetable proteins are also known as vegetable meat and these become very good products for the vegetarian people or other people who want to enjoy the texture of the animal protein or meat like product from the vegetable sources.



So, these TVPs can be categorized into two types; one is the meat extenders and other is meat analogues. The meat extenders are the TVPs produced by a process having a single high temperature or pressure extrusion system. The product shows a distinct fibre formation and has a highly expanded character. Once these TVPs are hydrated, they can be used to extend ground meat or meat products means that they can be used to replace the natural meat or as an ingredient etc. These TVPs have found extensive use in prepared foods such as meat sauces and different fabricated food formulations.



The other category of the TVP which is the meat analogues are actually used in place of meat in routine cooking operation or for general cooking purpose. It must be dense i.e. their density is normally is up to 0.4 to 0.6 g/cc and they should be devoid of air pockets.

They should have a layered fibre confirmation and should be able to maintain a meat like character after extensive cooking or retorting. So, they should resemble in every aspect to meat like products, they must give texture, appearance and mouth feel of the red meat. The manufacture of meat analogues requires the use of multiple extrusion processes or specially cooled dies.

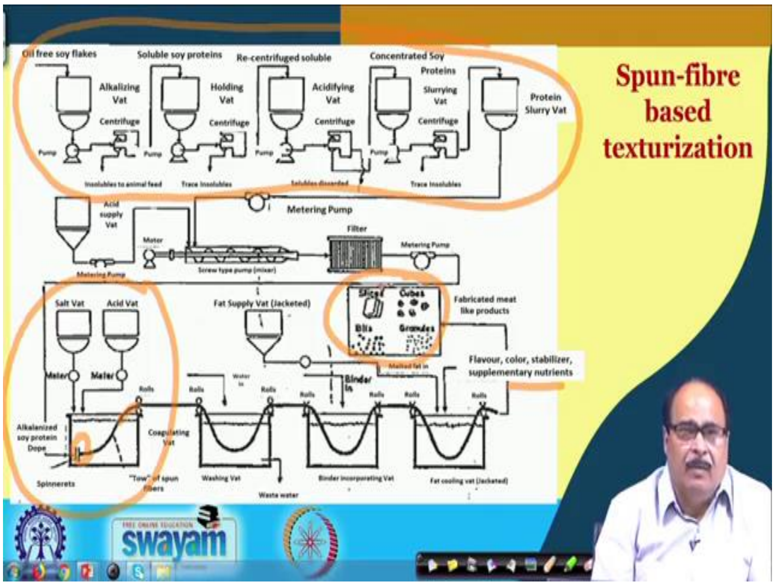
Generally the approaches to vegetable protein texturization can be categorized into two: One approach tries to assemble a homogeneous structure comprising a certain amount of protein fibres within a matrix of binding material. In fibre spinning technology, the fibres are produced by a spinning process which is similar to the one used for the production of synthetic fibres for the textile industry.

In the second approach, the vegetable proteins are converted into a hydratable, laminar, chewy mass that do not have fibres. So, in this, there are two methods which can be used like steam texturization and extrusion texturization. In the steam texturization, there is another method press texturization can also be used and finally, extrusion texturization process. So, these are different methods which can be used for texturization of plant proteins.

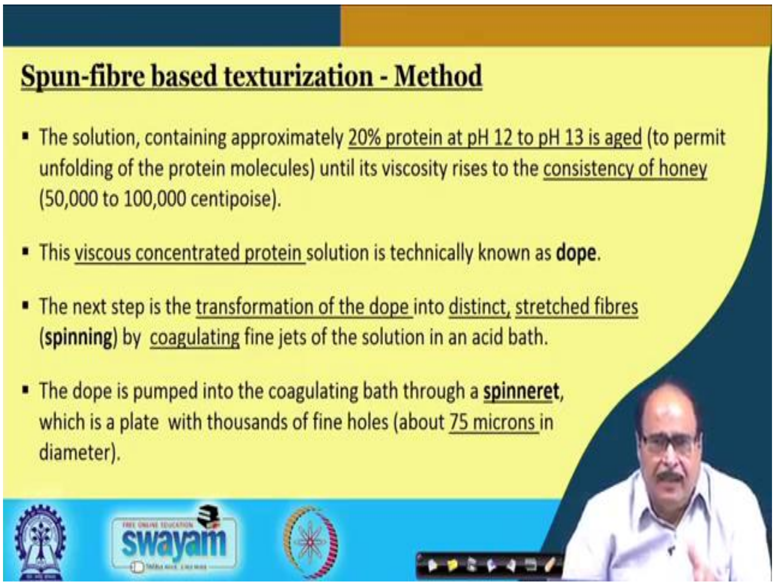
In the fibre spinning technology, a relatively pure vegetable protein which is called spinning dope is pumped through a spinneret. This spinneret contains thousands of tiny holes, may be of 75 micron. When the dope is forced through these spinnerets, it comes in the form of minor threads and these threads are allowed into acid coagulation bath where these proteins get coagulated.

The bundles of fibre produced in this manner are stretched, washed, coloured, flavoured and bound into aggregates to produce a simulated meat like item. The fibre bundles produced as above are passed through a special type of heated forming extruder where they are aligned, compressed and bound unto a chunk like mass which have the property analogous to meet. After formation the spun fibres are cut into convenient length, mixed and impregnated with fat and other heat coagulable binders like egg albumin, etc.

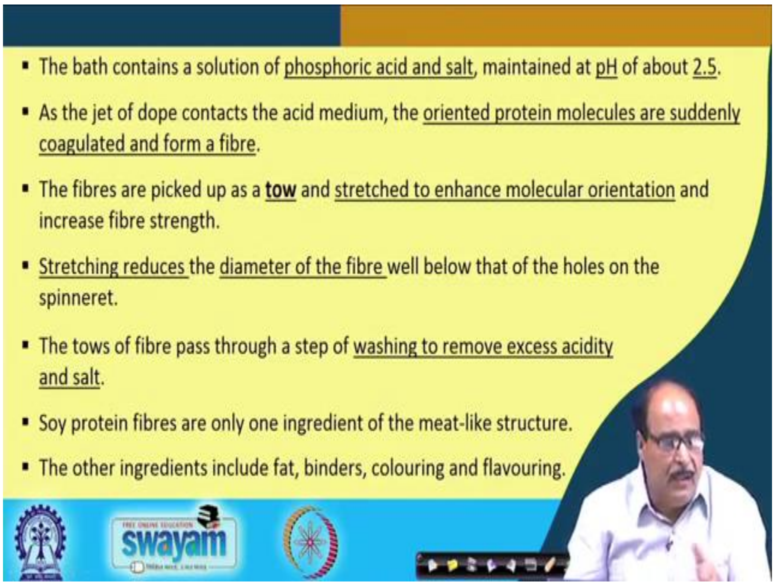
This spun fibre technology or fibre spinning technology produces a comparatively high quality meat analogue because here pure vegetable protein is used as a raw material. But it is of comparatively highly cost since the extraction or purification of the protein itself involve certain cost. Further, the low yield and disposal of the waste steams are some of the drawbacks of these technology. Otherwise, it becomes a very good process for manufacture of good quality protein products.



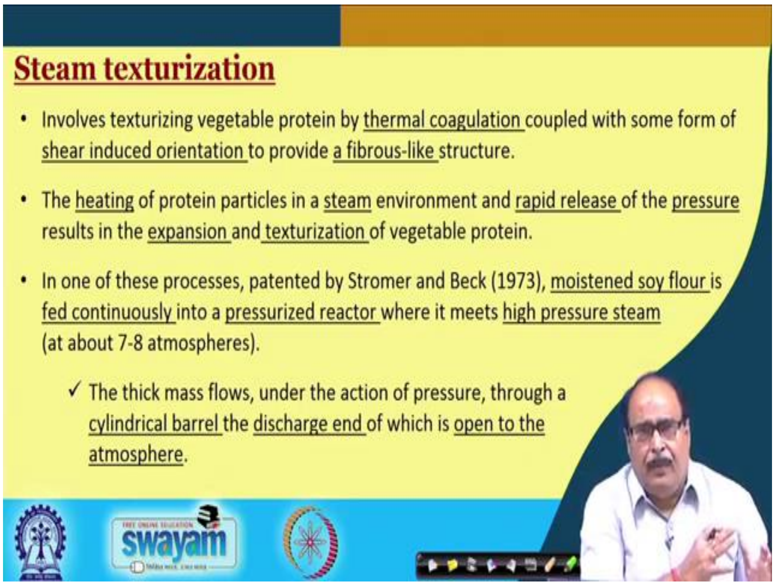
A schematic representation of the spun fibre based protein texturization process is shown in this diagram. The top section involves basically the preparation of the protein, i.e. extraction of the protein using appropriate methods like solubilization and its extraction. The proteins which are obtained are aged and made into a viscous honey like material and which generally called a dope. Now, solution of protein dope is passed through the spinneret from where it comes in the form of thread and falls into the acid coagulation bath. Here, the protein gets coagulated and forms fibres. Then, it is sent to the washing section for removing any adhering acid or excessive salts. After that, it is passed through the stretching section where the diameter of the fibres is further reduced even less than that of the opening of the spinneret hole. Then, it is passed through another vat containing various binders, colours, flavours, heat coagulable binders like egg albumin, etc. And then, sent again through the rollers where there is flavor, colour stabilizer, supplementary nutrients etc. finally, it is cut to the appropriate size. Different types of fabricated meat like products can be obtained.



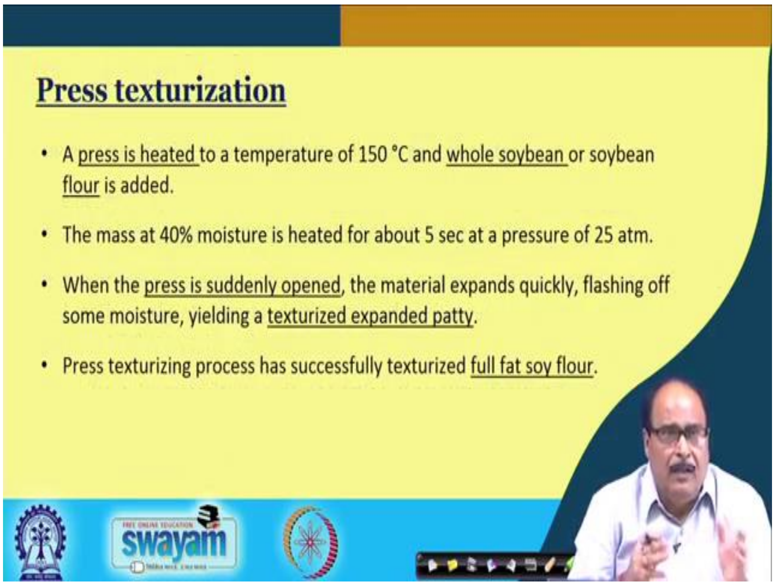
Spun-fibre based texturization – Method: The protein solution which contains approximately 20% protein at pH around 12 to 13 is aged. Once its viscosity reaches to that of the honey i.e. around 50000 to 100000 centipoise, the dope is passed through the spinneret with holes of about 75 µ.



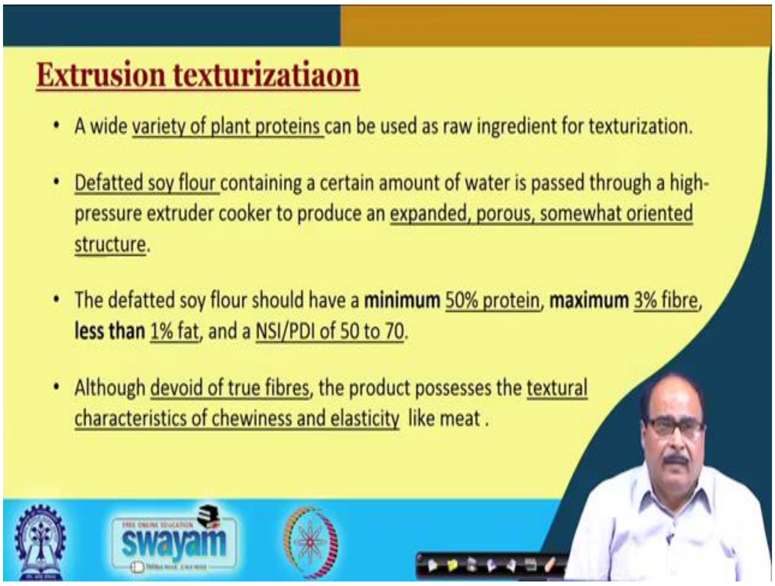
The same process is explained in this slide which could be understood.



The next step is the stream texturization. This process involves texturising vegetable protein by thermal coagulation coupled with some form of shear induced orientation to provide a fibrous like structure. The heating of protein particles in a steam environment and rapid release of pressure result in the expansion and texturization of vegetable protein. In one of these processes like steam texturization processes which has been patented by some researchers, the moistened soy flour is fed continuously into a pressurized reactor where it meets high pressure steam at around 7 to 8 atm. The thick mass then flows under the action of the pressure through a cylindrical barrel at the discharge end of the barrel which is open to the atmosphere.



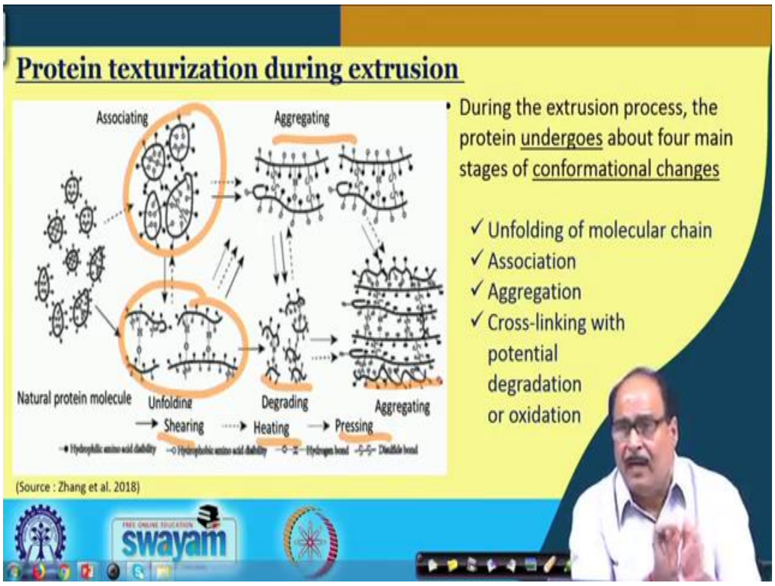
In the press texturization, the press is heated to a temperature of around 150 °C and whole soybean or whole soya flour is added into the press. The mass taken at 40% moisture content is heated for about 5 sec at a pressure of about 25 atm. When the press is suddenly opened by trigger mechanism, the material expands quickly flashing off some of the moisture which yields a texturized expanded patty. And this pressed texturization particularly is suitable for texturizing full fat soya flour.



Other next process which is mostly used by the industry for the preparation of textured vegetable protein products is the extrusion texturization. Although there is potential of using a wide variety of plant proteins in this process like defatted groundnut protein, defatted sunflower protein, sesame defatted sesame protein or other proteins, but at present the soy flour is used more commonly.

So, the defatted soy flour containing a certain amount of water is passed through a high pressure extruder cooker to produce an expanded, porous and somewhat oriented structure. The defatted soy flour should have a minimum 50 % protein, a maximum 3 % fibre, less than 1 % fat and a NSI (nitrogen solubility index) or PDI (protein dispersibility index) of around 50 to 70.

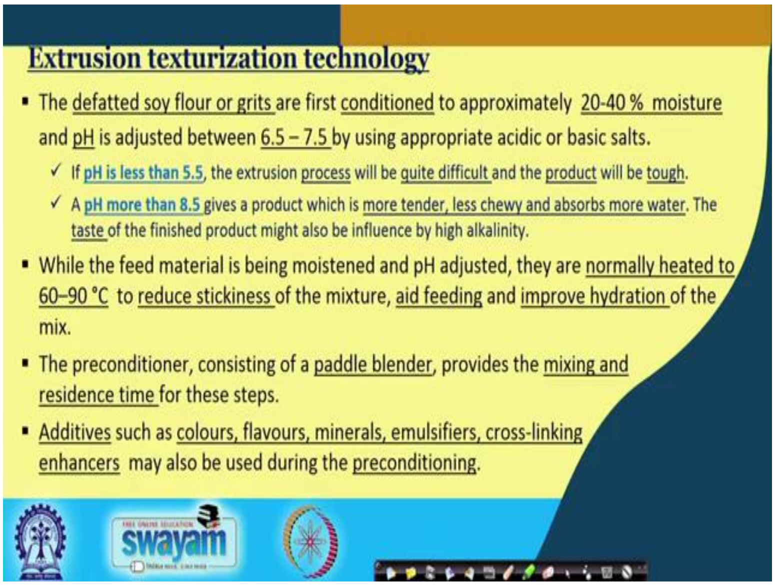
Although, these products which result from the extrusion process are devoid of true fibres but they possess the textural characteristics particularly chewiness, elasticity etc. like that of the natural meat.



In this figure, shown the process of protein texturization during the extrusion process.

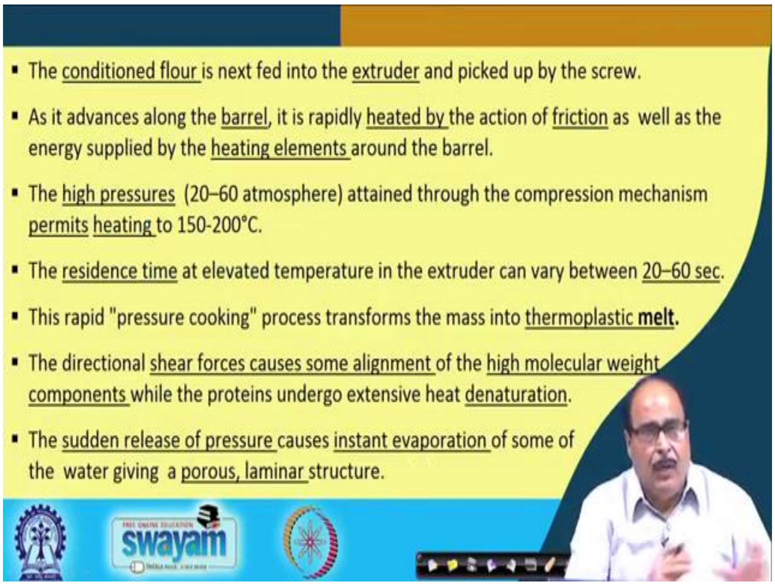
During extrusion process, the protein undergoes several conformational changes like shearing action, heating, pressing etc. depending upon the processing conditions. There may be unfolding of the natural structure, secondary or quaternary structure or conformational changes of the protein. There may be unfolding of the molecular chain association, aggregation or even cross linking with potential degradation of oxidation etcetera.

In fact, by varying the extruder system conditions, extruder process parameters and other material conditions like extruder process parameter, L/D ratio or specific mechanical energy etc. a variety of textured vegetable products with varying characteristics can be obtained.



Extrusion texturization technology: The defatted soy flour and grits are conditioned approximately to 20-40 % moisture and the pH is adjusted between 6.5 and to 7.5 using appropriate acidic or basic salts. If pH is less than 5.5, the extrusion process will be quite difficult and the product will be tough. If the pH is more than 8.5, the product will be more tender, less chewy and absorb more water. Even alkaline taste may also be introduced into the product; the product may taste little bitter because of the high alkalinity in the material. So, these flours or grits are conditioned and pH adjusted, they are being heated to around 60-90 °C to reduce their stickiness, aid in the feeding process, and improve hydration of the mix.

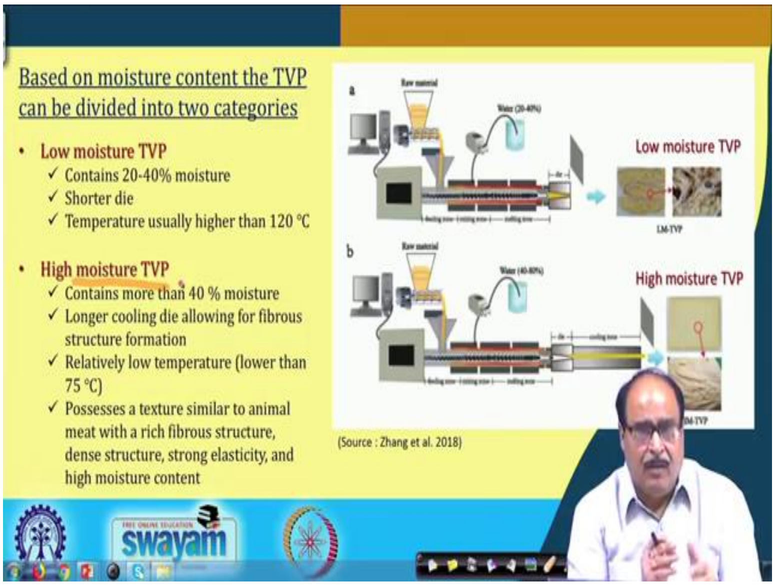
And generally for this purpose a preconditioner consisting of a paddle blender is used which provides the desired mixing and residence time. At this stage, even several additives like colours, flavours, minerals, emulsifiers, cross linking enhancers like elemental sulphur etc. maybe used to improve the product characteristics.



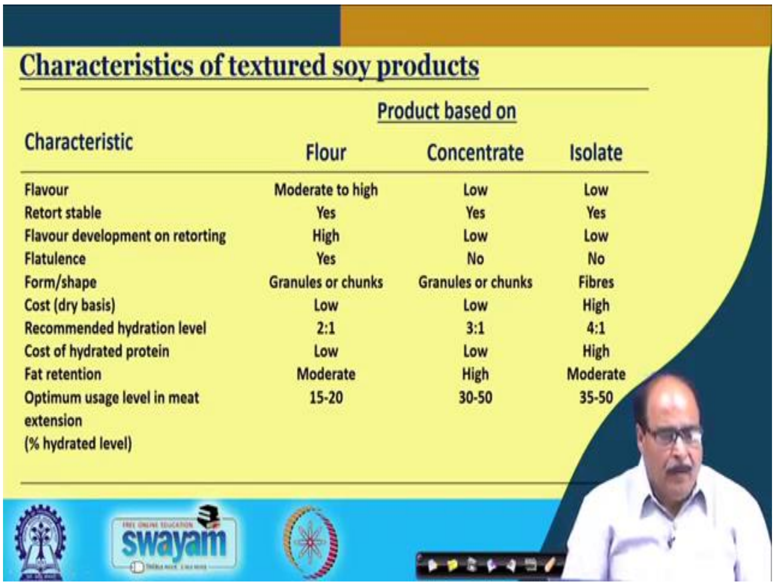
After the preconditioning, the precondition flour is fed into the extruder and picked up by the screw barrel. As it advances forward in the barrel, it is rapidly heated by the action of the friction as well as energy supplied by the heating elements around the barrel.

And the pressure normally 20-60 atm attained through the compression mechanism permits the heating of the material to around 150 to 200 °C. Under the high pressure and high temperature condition, it is very flexible but the residence time at this elevated temperature in the extruder can vary from 20 to 60 sec depending upon the material characteristics as well as the characteristics desired in the end products.

The directional shear forces cause some alignment of the high molecular weight components whereas, the proteins undergo extensive heat denaturation. When it comes out of the extruder die because of the sudden release of the pressure, there is an instant vaporization of some of the moisture and which gives a porous and laminar texturized structure; the material is flexible enough to take the shape of the die.



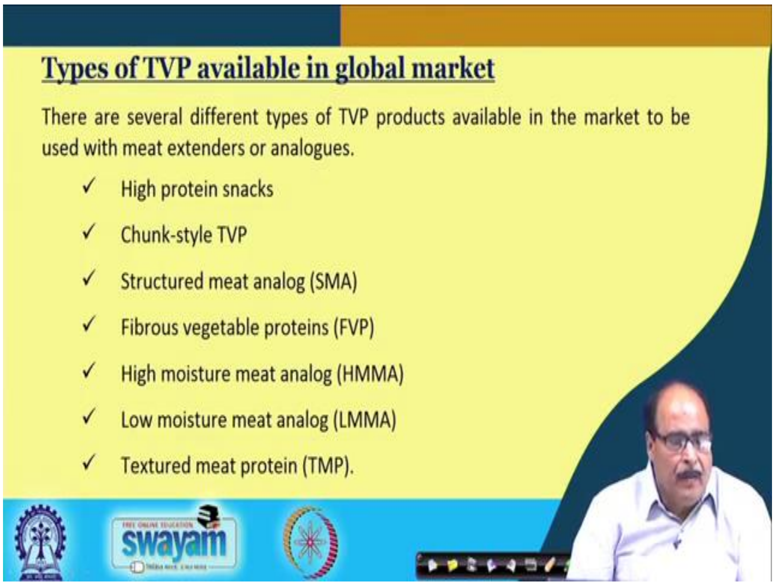
So, based on the moisture content of the textured vegetable protein, they can be of two categories; one is the low moisture TVP, the other may be a high moisture TVP. The low moisture TVP contain generally 20-40 % moisture, shorter die is used and temperature usually higher than 160 °C. Whereas, the high moisture TVPs contain more than 40 % moisture, larger cooling die, relatively low temperature (lower than 75 °C) and possesses a texture similar to animal meat with a rich fibrous structure, dense structure, strong elasticity and high moisture content.



Characteristics of textured soy products

Characteristic	Product based on: Flour	Concentrate	Isolate
Flavour	Moderate to high	Low	Low
Retort stable	Yes	Yes	Yes
Flavour development on retorting	High	Low	Low
Flatulence	Yes	No	No
Form/shape	Granules or chunks	Granules or chunks	Fibres
Cost (dry basis)	Low	Low	High
Recommended hydration level	2:1	3:1	4:1
Cost of hydrated protein	Low	Low	High
Fat retention	Moderate	High	Moderate
Optimum usage level in meat extension (% hydrated level)	15-20	30-50	35-50

The characteristics of different textured soy product are tabulated. When the flour, concentrate or isolate is used as a raw material, how the flavor, stability and flatulence, form, shape, cost and other characteristics of the product vary. It can be understood by reading.



Different types of TVPs which are available in the global market include high protein snacks, chunk-style TVP, structured meat analogues, fibrous vegetable, proteins high moisture meat analogues, low moisture meat analogues, texture meat proteins and so on.

Different types of products are available in the market; there may be chunks type, granular, larger thread like material, sheet like material and so on. So, these textured vegetable proteins like high moisture textured snacks, high moisture meat analogue or chunks and mixed style of extenders and meat analogue they are all produced by using varying materials and process parameters. They also have some natural bioactive components or health ingredients.

These novel products have a vast commercial and industrialization potential. If in addition to the soy flour, other protein flours like groundnuts, peanut, sesame, sunflower, etc. are used and processes are developed for their texturization, it will be an important addition. It will improve the conditions or even economics of the oil milling industry and, the benefit will be both to the consumers as well as to the industry.