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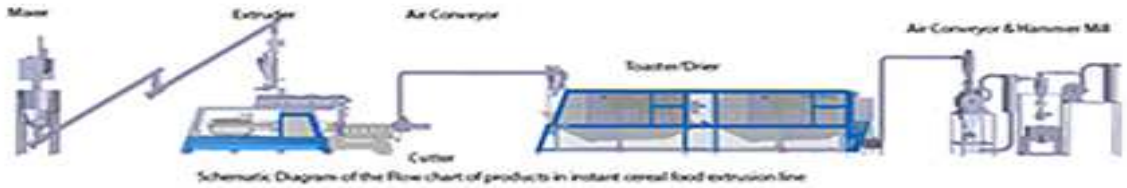
Extrusion Process for Preparation of Instant Cereal Beverage Powders based on Corn and Soybean

INTRODUCTION

Precooked or instant food can used as quick food both for babies as well as adults

Full fat precooked soy flour ingredients can be fortified with other for nutritious meal

Pre-cooked flours are fast dissolving or instant cereal-based preparations that, when rehydrated (with water or milk), provide a soup, mush, cream or dough. They are widely used as cereal-based baby foods (for children above four months) and, in many countries, they are used as ingredients in regional recipes. They are easy to store, to transport and to prepare and are balanced nutritionally.



Precooked flours production line flow diagram

The present urban social condition is competitive, the way of life is urgent and urban citizens are faced with chronic traffic problems. Hence their need for food which can be easily prepared and convenient for consumption is ever increasing. In the aspect of food industry, more technologies for food product research and development are needed to satisfy needs of consumers. Apart from being convenient to prepare and easy for consumption, these food products should also have sufficiently high nutrition, to result in good quality of life for the consumers. For adults, pre-cooked flours often use soy because of their high protein content or corn to make regional dishes. These products can be served in soups or porridges, and vegetables, cheese and other ingredients can be added to prepare more elaborate dishes.

Various cereals can be used to process pre-cooked flours: rice, corn, wheat, barley, oats, tapioca, manioc, etc. Local cereals or root vegetables can also be used. Recipes can include other ingredients such as milk powder, sugars, minerals and vitamins, as well as salt and flavours. For children, rice flour is often used in pre-cooked flours because it is easily digested, well balanced and low in allergens.

For many years now, cooking extrusion technology has been used in the production of numerous instant cereal products, including cereals for feeding small children. The usefulness of extrusion technology as an cooking process has been proved beyond any doubt. Extrusion technology is not only economically beneficial in the production of instant cereals; it also allows for continuous production processes while ensuring a high retention of the product’s nutritional values and excellent microbiological characteristics. Extrusion process is known to inhibit harmful biological activity of raw soybean as well as improve its digestibility for human consumption. And ingredients that need to be added during processing, if they cannot withstand the shear developed in the extrusion process, then the same can be blended post extrusion to preserve the nutrients.

Instant foods are especially suited for school age children who are often faced with traffic problems, causing them not to have time for breakfast before going to school. And not having breakfast reduces the sugar level in the blood, resulting in reduction of learning, and working efficiency in working age people. With this reason, instant beverage powders are another choice for

consumers who need convenience and quickness in food preparation for family members. They are also health food for consumers in all gender and age groups. Soybean and and corn are processed into instant beverage powders which can be prepared in short length of time by dissolving in water. The products are suitable for those who have no time for food preparation.

In the aspect of instant food processing from cereals which can dissolve well in water, the traditional process is to make the food hot, cooked and dried by drum drier. Flaked product is obtained, and the product is then ground and sifted through a mesh with required size. After extrusion, cooking technology was introduced in the food industry, diverse production processes and various instant food products from cereals were developed (Hauck, 1980), including instant beverage powders. This is because extrusion system (Harper, 1981) has the ability to make cereals gelatinize and form expanded products with the property of good water absorption. Moreover, it is also beneficial in the aspects of its high productivity, energy efficient and production step reduction. Concerning foreign research works related to instant beverage powder production, most of raw materials used are in the form of liquid or high viscosity liquid. Therefore they tend to be made hot and dried by using spray drier (Holsinger et al ., 1974; Guy and Vetterl 1975; King, 1985). But if the main raw materials used were cereals and in characteristics of powders, the process used tend to be one of the two systems (Anderson et al 1971) which one is the drum drying system, making them hot and then dry by using roller machine, and the another is extrusion cooking system, making them hot and reduce moisture within the extruder, such as in the research work “Instant Beverage Mixes” (Bookwalter et al., 1971) which used cereals as raw materials, and they are made hot and cooked by using single screw extruder. Screw Extruder can be regarded as Bio-Reactor. Cooking at elevated temperatures inside extruder not only kills germs, products thus cooked have cold-swell properties and good water absorption. This process makes it possible to transform natural starches into nutritious and digestible starches.

The product obtained from Extruder is then ground and flavored and improved nutritive value by mixing with other food materials such as milk powder. This product can be dissolved in hot water and ready for consumption.

MATERIALS AND METHODS

Single screw extruder for full fat Soy flour, corn + wheat, etc.

Twin screw extruder for instant food and precooked flours.

How are precooked flours produced ?

A single screw extruder or twin screw extruder could be used for processing the premixed dry ingredients like wheat, soy, corn cereals, etc. These ingredients are mixed or blended using suitable blender, which are then transported using mechanical or pneumatic conveyors to the extruder for further processing. Inside the extruder, a screw (or twin screws) rotate at high speed inside the stationery barrel. The screw has special profile and made up of several segments which have specific function like feed screws, mixing, cooking and transporting elements to cook the hydrated flours into plastic mass which extrudes out of die in form of rope or ribbon which loses some moisture in process, and gets cut into small lengths at extruder cutter. The required cooking inside the extruder is achieved due to elevated temperatures and pressures on the material which are result of mechanical work and extra heat supplied around the barrel jackets. The extra moisture gets evaporated inside the Drier which consists of moving conveyor belts in hot air chamber. After the moisture gets evaporated to value of less than 5%, the pellets or cut ribbons are finely ground on hammer mill through fine meshes and ready for packing as precooked flour. Other ingredients like malt, milk powder, etc. may be added as required.

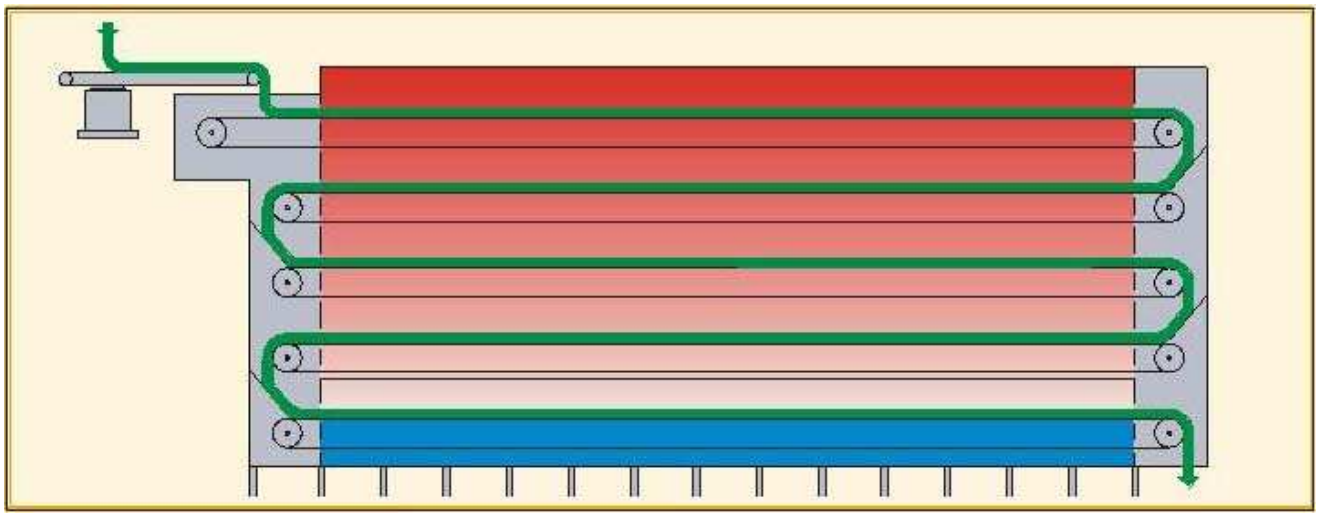
Cereals or cereal mixtures are fed into the single-screw extruder using volumetric feeder. A medium shear Extruder is best suited for such processing. It is better if a preconditioner is employed on Extruder which sprays water uniformly over the dry ingredients as they move inside the preconditioner paddles towards the extruder feed. Preconditioning can also use live steam to precook the ingredients before entering the extruder. In addition, Water, injected

directly into extruder, is mixed with the powder, thus forming a “paste” The flour paste is subjected to thermo-mechanical treatment in the extruder, at a controlled speed in keeping with thermally controlled parameters. The composition and the speed of the screw are important factors in the thermo-mechanical process. Accurate temperature control is achieved through an internal cooling system in each barrel module according to the temperature profile selected by the operator.
Residence time is also controlled in the configuration of the machine through the number of barrel modules, calibration of the die and product flow and screw speed of 300-350 RPM. This means that an ideal transformed starchy base is produced thus proving an easily rehydrated product with the suitable viscosity. The hot paste (> 100 ° C) is forced through the extrusion die: the pressure difference between the inlet and the outlet determines the features of the expanded product. The configuration of extrusion parameters means that the cooking characteristics and texture of the product are precisely controlled. The product is cut at the die exit, and undergoes further drying before grinding, resulting in optimized elements that facilitate future rehydration to make the consumable product.

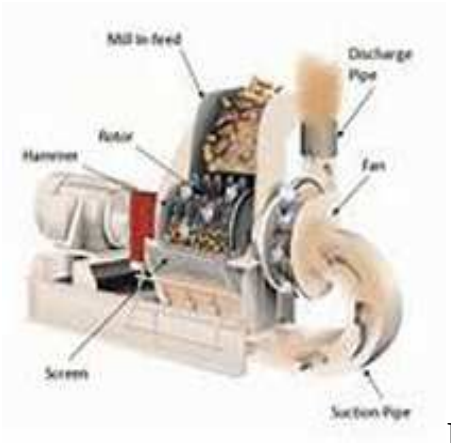
It is well known to use a screw type extruder in which a cereal flour, admixed with water to adjust the water content to 12-30 percent by weight, is uniformly cooked and extruded as a continuous "rope" which is then sliced into pellets. On leaving the extruder die, the extruded product expands by a factor of about 3 and has a water content of about 12 to 20% by weight. This product is then sliced, partially dried, and ground in a mill with a 2.4 mm round hole screen. The ground cereal product can then be dry mixed with supplementary thermosensitive ingredients. The latter are added post extrusion, since it cannot take high shear treatment as normally experienced in such cooking extruders. The dry mixture is then granulated by any suitable agglomeration process, the resulting wet granular material being finally dried to a water content of about 4% to 7% by weight and packaged.
It has been found that there is a very close relationship between the viscosity of the final product and the density of the extruded product, and the lower the density, the higher is the viscosity. Further, a moist product with 20-30% moisture inside the extruder will not result in adequate expansion after emerging from die due to high moisture content in materials. So, compressed gas is injected just before the die into the moist product to aid in expansion of product from die and affect the density of product.

In this way, the compressed gas, which is contained in the blend, tends to provide an additional puffing effect upon release from the die, the puffing effect being proportional to the gas content of the extruded product. It can be suggested that the added gas could provide nucleation sites for water vapour formation.
There is thus provided a very simple means of regulating the puffing effect and, thereby, the density of the extruded product wherein the smaller the amount of gas injected, the denser is the extruded product.
Furthermore, when the compressed gas is expelled from the extruded product, upon release from the die, it sweeps away sulphur-containing compounds from the extruded product.
The compressed gas may be air, nitrogen or carbon dioxide, or a mixture of these gases.

Preparation of raw materials
Corn grit (13 and 33 mesh) were . Corn grit (23 mesh), getting from corn grit (13 mesh) which was ground and sieved for screening to the required size.
Isolated soy protein (Profam 974), full fat soy flour and flavorings
The trial extruder comprised of 7 parts of barrel ending with a 24.5 mm thick die plate with one circular die hole (diameter 3.0 mm).
The mixture of raw materials were fed into the extruder with a volumetric twin screw feeder and water was pumped to the ingredients to achieve required moisture content. Temperature of barrel 1-7 and 9 was 30, 35, 65, 135, 155, 175, 130 and 125 C respectively. The other operating condition were adjusted at screw speed 350 rpm, feed rate 319-375 g/min, water rate 19-26 g/min, feed moisture 15-17% and melting temperature 152-155 C. After extrusion, the extruded samples were dried in the electric oven at 80 C for 10 min and grounded by Mill (mesh size 0.6 mm) to obtain instant cereal powders. Finally, the instant cereal powders (50%) was mixed with sugar (25%), skim milk powder (10%), creamer (14.4%), malt flavor (0.2%) and milk cream flavor (0.4%) to produce the instant cereal beverage powders.



Schematic diagram of multi-pass belt drier used in instant food production line



Hammer Mill or Crusher used for fine grinding of cut & dried pellets

Chemical and physical properties examination The final products, instant cereal beverage powders were examined chemical and physical properties as below. Moisture and protein content (A.O.A.C. 1990).
Bulk density (Akpapunum and Markakis, 1981). The loose bulk density of product was determined by transferring 50 g product into a 250 ml graduated glass cylinder and measuring the volume of the products off the scale. The packed bulk density was determined in a similar way, but the volume was measured after tapping the cylinder until the products settled (about 2 min). Both loose and packed bulk density were calculated as: Bulk density (g/ml) = mass of sample/ Volume occupied by sample Reconstitution index

(Ihekoronye and Oladunjoye, 1988). The reconstitution index was determined by mixing 7.5 g of products with 50 ml. of warm water (50 C) for 90 sec and measuring the sediment formed in a graduated cylinder, 10 min after the mixing. Water absorption index and Water solubility index (Anderson et al ., 1969 and Damardjati and Luh, 1987). A 2.5 g of the ground sample was suspended in 30 ml of water in a 50 ml tared centrifuge tube. The sample was stirred intermittently over a 30 min period and centrifuged at 3000 ¥ g for 10 min. The supernatant was poured carefully into a tared evaporating dish. The remaining gel was weighed and the WAI was calculated as follows: Water absorption index (WAI) =Weight of gel - Weight of ground dry sample Weight of ground dry sample: The supernatant liquid from the WAI study was vacuum dried at 70C until constant weight was reached. The amount of dried solid (%) recovered from evaporating the supernatant was expressed as water solubility index. Viscosity. The viscosity of dispersions containing 7.5 g of product in 50 ml of water was measured by Brookfield Digital Viscometer, model RVDV-III (Operating conditions:- U-L Adaptor, ULA Spindle, 16 ml sample, 25 r C and 10 rpm).

Sensory evaluation

The final products, instant cereal beverage powders at each size of corn grit and each composition between corn grit and isolated soy protein were conducted with trained panels (18) in balanced incomplete block experimental design (t=9, k=4, r=8, b=18, l =3) who have experienced with food product development by using 9-point hedonic scale (1-extremely dislike to 9-extremely like) to determine the preference in color, odor, flavor, texture and overall acceptant of products. Nutrition labeling and protein quality The nutritive value of the most appropriate instant cereal beverage powder was evaluated in the forms of nutrition labeling and pattern of essential amino acids. The nutrition labeling based on the Announcement of the Public Health Ministry No.182, 1998. Additionally, the protein quality was assessed by comparing essential amino acids of this product with standard pattern of essential amino acids set by joint FAO/WHO committee.

RESULTS AND DISCUSSION Chemical composition and particle size of raw materials using for instant cereal powders from extrusion process The principal raw materials using for production of instant cereal powders from extrusion process in this research work was corn grit. This is because apart from being an important agricultural raw material with cheap price and sufficient production quantity for domestic consumption, corn also has properties suitable for extrusion process. Because it can expand well and gives good corn flavor

retained after extrusion (Moore, 1993). The raw material used together with corn was soybean which improve extruded product for higher nutritive value in case of protein content and pattern of essential amino acids than product made from only one type of cereal.
Moreover, the heat from extrusion process also reduced trypsin inhibitor which is a toxic substance in soybean not required by the body (Konstance et Al ., 1998). Types of soybean using in this research were in the form of isolated soy protein and full fat soy flour. Usage of isolated soy protein gave benefits in the aspects of increasing protein quantity, without the disadvantage of bean smell in the product. While apart from being raw material with high nutritional value concerning protein.
Chemical composition and particle size of raw materials.

Raw materials	Chemical composition (%) Average Moisture	Fat	Protein	Ash	Dietary fiber 1/	particle size (mesh)
Corn grit (Large)	11.95	1.43	6.26	0.40	3.89	13
Corn grit (Medium)	11.67	1.30	6.46	0.45	2.42	23
Corn grit (Small)	11.80	1.64	6.36	0.54	2.88	33
Isolated soy protein	3.46	3.02	86.75	4.94	4.60	> 100
Full fat soy flour	2.65	22.10	40.14	5.06	17.20	> 100

Source :
1/ Food and Nutrition Technical Services, Institute of Nutrition, Mahidol University.
2/ Protein Specialties Division, Archer Daniels Midland Company, USA.
3/ Sahaviriya Pure Science Co., Ltd.

Full fat soy flour is also source of dietary fiber. Furthermore, usage of oil from full fat soy flour together with vegetable oil which added to the raw materials about 1-2 percent, was also beneficial in the aspect of food material lubrication, helping the food product to expand well and consistently, and have good texture (Boonyasirikool and Charunuch, 1999) apart from avoiding sticking inside the extruder surfaces.

In a nutshell, instant food and precooked flours not only can serve as multi vitamin and nutrient food intake for babies as well as adults, by incorporating two or more cereals and other ingredients, however the precooking also offers a ready to eat food that cooks fast.

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