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DESIGN AND DEVELOPMENT OF RAGI MILLET MAKING MACHINE

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ABSTRACT
Ragi is used most commonly as south Indian food. The ragi ball is most important part of the food for most of the people. Ragi is potentially the best source of calcium and a good source of protein as well. The ragi dough can be made effectively by eliminating the dough matter. In this project, the ragi ball is made by combining beaters/agitator and screw extruder. The beaters helps in continuous mixing of the ragi dough at proportionate quantity. The extruder is used to fill the die with ragi dough so as to get the shape of the die (spherical). Continuous heating is done so as to maintain the desired characteristics of the ball. The density of the dough at the start of the heat and that of the ball must be checked always so as to maintain the same quality all the time. Due to the intense manual handling and care involved in preparing the ragi ball, most of the people have discontinued ragi ball as a part of their meals. If care is not taken while preparing the ragi ball uneven cooking of the ragi flour happens which results in bad taste and unsuitable for consumption. An attempt to eliminate the complications involved in making a ragi ball has been made by developing a machine which makes ragi ball. The developed machine must be able to meet the desired requirements and maintain uniform taste all the time.

INTRODUCTION
Eleusinecoracana is an annual plant widely grown as a cereal in the arid areas of Africa and Asia. It is commonly known as finger millet, African finger millet, red millet, caracan millet, koracan, and Ragi. It is very adaptable to higher elevations and is grown in the Himalaya up to 2,300 meters in elevation. Finger millet has been cultivated in India from as far back as 400 years ago. Now the Indian states of Karnataka, Andhra Pradesh, Tamil Nadu, Bihar and few others states produce Ragi. Karnataka is the top producer of Ragi and has 58% share in India's export of this crop. Post-harvest management of Ragi is unproblematic; the seeds are seldom attacked by insects or moulds and combined with a longer shelf life make the finger millet an important crop in risk-avoidance strategies for poorer farming communities. The price variations across states are not very high; hence, the commodity has much better price stability. Despite so many advantages the Ragi has not grown to be a major crop in our country due to its designation as a low-value inferior crop alongside other millets.

Benefits of Ragi as a Food

- Ragi contains amino acids such as Lecithin and Methionine which help in bringing down the cholesterol levels by eliminating the excess fat from your liver.
- Ragi plant is an excellent source of natural iron which is must for human body if suffering from anaemia.
- Ragi ball contains fiber which is good for constipation.
- One of the health benefits of Ragi ball is that it keeps your thyroid in check. It is best for those who are suffering from Hypothyroid.
- Health benefits of Ragi ball are; it makes the bones strong as it has high amount of Calcium and Vitamin D.
- Ragi ball reduces the risk of diabetes mellitus and gastrointestinal tract disorders.

PREPARATION OF RAGI BALL

Finger millet is normally consumed in the form of flour-based foods such as roti (unleavened pancake), mudde (stiff porridge/dumpling) and ambli (thin porridge). The simple procedure to make Ragi stiff porridge (ball) is as follows:

- Take required amount of ragi flour, measure it and keep it ready in a jar.
- Heat the water in a sauce pan until it boils.
- Add a pinch of salt to the boiling water.
- Now add the ragi flour to the boiling water.
- Let the Ragi flour cook on a low-medium heat for 5-7 minutes.
- Turn off the heat & mix the Ragi flour. You could do whisking action to mix it thoroughly, with the help of stick Ensure there are no lumps.
- Scoop the cooked dough onto a plate. Work with the dough when it is hot.
- Use your hands to knead the dough for about 10-20 seconds, in between dip your hand in cold water to carry out this process comfortably. Shape the dough like a ball.

REVIEW OF LITERATURE

Dough is a thick, malleable, sometimes elastic paste made out of any cereals (grains), leguminous or chestnut crops. Dough is typically made by mixing flour with a small amount of water and/or other liquid, and sometimes includes yeast or other leavening agents as well as other ingredients such as various fats or flavours. Techniques used in dough production depend on the type of dough and final product. For yeast-based and sponge (such as sourdough) breads, a common production technique is the dough is mixed, kneaded, and then left to rise. Kneading is the process of working dough to produce smooth, elastic dough by developing gluten. This process is both temperature and time-dependent; temperatures that are either too hot or too cold will cause the yeast to not develop, and rising times that are either too short or too long will affect the final product. Ragi dough is usually prepared at medium temperatures, using semi- solid mixture of Ragi flour and hot water. Care should be taken so that flour is mixed well with hot water without leaving any lumps in the dough.

Food extrusion is a process in which a food material is forced to flow, under one or more varieties of conditions of mixing ,heating and shear, through a die which is designed to form and/or puff dry the ingredients. A food extruder is a device that expedites the shaping and restructuring process for food ingredients. Extrusion is a highly versatile unit operation that can be applied to a variety of food processes. Extruders are used to cook, form, mix, texturize, and shape food products under conditions that favour quality retention, high productivity, and low cost.

Extrusion technology, well-known in the plastics industry, has now become a widely used technology in the agri-food processing industry, where it is referred to as extrusion-cooking. It has been employed for the production of engineered food and special feed. With the help of shear energy, exerted by the rotating screw, and additional heating of the barrel, the food material is heated to its melting point or plasticating point. In this changed rheological status, the food is conveyed under high pressure through a die or a series of dies and the product expands to its final shape. These results in very different physical and chemical properties of the extrudates compared to those of the raw materials used. Food extruders (extrusion-cookers) belong to the family of HTST (high temperature short time)-equipment, capable of performing cooking tasks under high pressure. This is advantageous for vulnerable food and feed. As exposure to high temperatures for a short time will restrict unwanted de-neuration effects on proteins, amino acids, vitamins, starches and enzymes. Physical technological aspects like heat transfer, mass transfer, momentum transfer, residence time and residence time distribution have a strong impact on the food and feed properties during extrusion-cooking and influence the final product quality.

An extrusion-cooker is a process reactor, in which the designer has created the prerequisites with the presence of a certain screw lay-out, the use of mixing elements, the clearances in the gaps, the installed motor power, barrel heating and cooking capacity, to control a food and feed reaction. Proper use of these factors allow to stimulate transformation of processed materials due to heating, for example, the de-naturation of proteins in the presence of water and the rupture of starches, both affected by the combined effects of heat and shear. These reactions can also be provoked by the presence of a distinct biochemical or chemical component like an enzyme or pH controlling agent. When we consider the cooking extruder to be more than just a simple plasticising unit, a thorough investigation of the different physical technological aspects is more than desirable. Currently, extrusion-cooking as a method is used for the manufacture of many foodstuffs, ranging from the simplest expanded snacks to highly-processed meat analogues.

The functions of an extruder are given below

- Agglomeration: Ingredients can be compacted and agglomerated into discrete pieces with an extruder.
- Degassing: Ingredients that contain gas pockets can be degassed by extrusion processing.
- Dehydration: During normal extrusion processing, a moisture loss of4-5% can occur.

- Expansion: Product density (i.e., floating and sinking) can be controlled by extruder operation conditions and configuration.
- Gelatinization: Extrusion cooking improves starch gelatinization.
- Grinding: Ingredients can be ground in the extruder barrel during processing.
- Homogenization: Extruder can homogenize by restructuring unattractive ingredients into more acceptable forms.
- Mixing: A variety of screws are available which can cause the desired amount of mixing action in the extruder barrel.
- Pasteurization and sterilization: Ingredients can be pasteurized or sterilized using extrusion technology for different applications.
- Protein de-naturation: Animal and plant protein can be denatured by extrusion cooking.
- Shaping: An extruder can make any desired shape of product by changing a die at the end of the extruder barrel.
- Shearing: A special configuration within the extruder barrel can create the desired shearing action for a particular product.
- Texturealteration: The physical and chemical textures can be altered in the extrusion system.
- Thermal cooking: The desired cooking effect can be achieved in the extruder.
- Unitizing: Different ingredient lines can be combined into one product to produce special characteristics by using an extruder.

Advantages of Extrusion

The principal advantages of extrusion technology compared to traditional food and feed processing methods with modifications include the following:

- Adaptability: The production of an medium variety of products is feasible by changing the minor ingredients and the operation conditions of the extruder. The extrusion process is remarkably adaptable in accommodating consumer demand for new products.
- Product characteristics: A variety of shapes, textures, colors, and appearances can be produced, which is not easily feasible using other production methods.
- Energy efficiency: Extruders operate with relatively low moisture while cooking food products, so therefore, less re-drying is required.
- Low cost: Extrusion has a lower processing cost than other cooking and forming processes. Savings of raw material (19%), labor (14%), and capital investment (44%) when using the extrusion process have been reported by Darlington (1987). Extrusion processing also requires less space per unit of operation than traditional cooking systems.
- New foods: Extrusion can modify animal and vegetable proteins, starches, and other food materials to produce a variety of new and unique snack food products.

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- High productivity and automated control: An extruder provides continuous high-throughput processing and can be fully automated.
- High product quality: Since extrusion is a high-temperature/short time (HT/ST) heating process, it minimizes degradation of food nutrients while it improves the digestibility of proteins (by denaturing) and starches (by gelatinizing). Extrusion cooking at high temperatures also destroys ant nutritional compounds.
- No effluent: This is a very important advantage for the food and feed industries, since new environmental regulations are stringent and costly. Extrusion produces little or no waste streams.
- Process scale-up: Data obtained from the pilot plant can be used to scale up the extrusion system for production.

DESIGN AND DEVELOPMENT

The primary objective of solid mixing requires intimate intermingling of the materials to be mixed. To meet this requirement, the flour is placed in a vessel of known quantity which allows the material to be moved and stirred in a desired pattern. As there is no one mixer design that universally satisfies all mixing requirements, and a customized mixer design was developed for initial trials. Some of the factors that needs to be considered while designing mixer are given below.

1. Type of agitator(mixer) and position
2. Geometry of the tank/ Hooper (size, shape)
3. Rotation of the rotor (speed, rate of discharge)
4. Length of mixing
5. Imposed physical conditions (pressure, temperature)

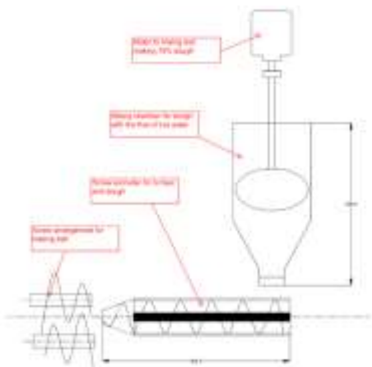

Fig: Conceptual Design

The design of single-screw extrusion is relatively not that simple. The role of the screw is to convey, compress, melt and plasticize the material and to force it under pressure through small die holes at the end of the barrel. The material must be made to flow at a proper flow rate without sticking to the surface of the screw. In food extrusion sticking can be avoided by reducing the frictional force applied against the barrel wall. The principle is more friction, the less spinning of the material and easier movement of material.

Single-screw food extruders are used to process relatively easy materials characterized by a high friction co-efficient, such as maize or rice grits. The main disadvantage of single-screw extruders is poor mixing of the material. Hence the mixing is done before feeding. Also, single-screw extruders show a limited efficiency, when multi-component mixtures of raw materials are used. Smooth positive movement of the material in a single-screw food extruder depends on the actual drag flow, caused by the screw geometry and its rotation. In order to maintain the correct working point of the extrusion process it is necessary that technological development regime, that is, to maintain the relevant working parameters of the machine, determined experimentally, or data acquired them during their operations. The proper preparation of raw materials, especially their grinding and moisturizing is important. A number of factors that are considered in routine extruder operations are, homogenous distribution of moisture content and particle size distribution of raw material which prevent abnormal working of the extruder (shooting or blocking) and will ensure the desired quality of the extrudates.

Reduced moisture content of raw materials influences the pressure of extrusion but does not have an essential impact on the extruders performance (i.e., increase in the viscosity of the material). Intensive cooling of the barrel (e.g., with cold water) contributes to a lower temperature and increases the friction inside the material. It must be co-related with the quality requirements of the extrudate. Temperature drop in the material raises its viscosity and contributes positively to the extruder's performance. The blocking of a few die-holes results in a sudden increase in pressure and leads to a powerful back flow. The smallest holes in the die, cause a higher resistance during the extrusion of the material; since small openings increase pressure and reduce the extruder's output as the back flow is higher. By applying a plasticizing screw of greater L/D ratio, it is possible to generate more extrusion pressure due to a longer fully filled screw, which leads to a better plasticizing of the material and a reduced back flow. The loss of a small clearance between the barrel surface and the screw flights (in practice 0.1–0.2 mm) hampers the movement of the material, reduces friction and pressure and causes poor operation of the machine and stops the flow, which means poor product or no product at all.

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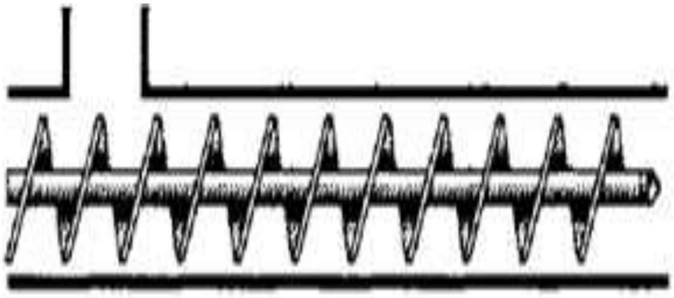

Fig: Constant pitch constant root diameter

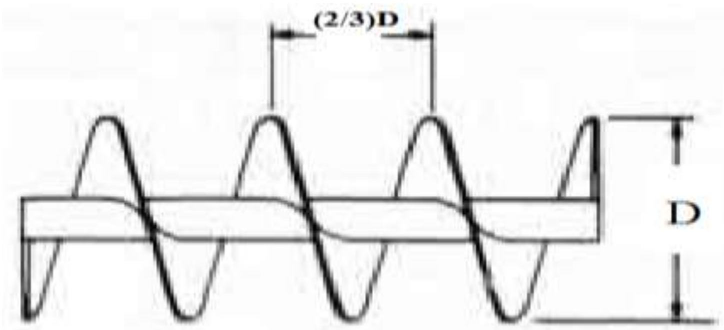

Fig: Screw profile

Table: Technical Details

Parameters	***Dimension (in mm)***
Diameter of Screw (D)	*68*
Pitch of Screw	*45*
Thickness of Screw	*1.6*
Length of Barrel (l)	*500*

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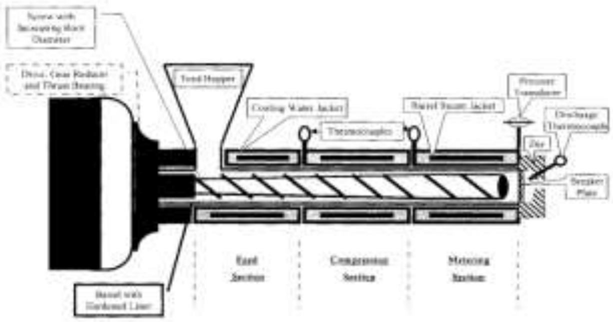

Fig: Single screw solid extruder

The classical drawing of a solid-screw extruder is shown in Figure, which can be used to explain the principles of how an extruder works. Note that the area of product volume is decreased from the feed to the discharge end of the screw by the thickening of the screw root, which results in shallower, fixed pitch flights. If not preconditioned, the dry ingredients are moistened and mixed early in the first feed section, and then they are compressed in the transition section, cooked in the metering section, discharged through a shaping die, and cut to desired lengths by a suitable rotating knife. Compression in the transition zone can be as high as 5:1.

Fig: Final Design 3D Model isometric view

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TESTING MODIFICATION AND RESULTS

1. Initially the ragi dough was prepared outside and was kneaded 40-50% with bit of water added to it so that it is easy to pass into the basin & internal screw feeder feed the dough characteristics was lost and the flow ability was not achieved.
2. The basin was heated into 100ºc degree more than water and powder added to it. Water will mix for some time with continuous heating. After the density of dough is close to 50% of the required density. The dough forced to enter screw feeder/ extruder. Then the dough in the feeder is heated so that the required density (ragi ball density) is maintained at the end of the screw feeder. The above described process gave satisfactory results. After measuring the density of ragi dough at the end of screw feeder.
3. This case is documented and considered has the 1st step of the testing baseline method. With reference to the case model baseline the dough mixture (semi fluid). Mixture of dough and water and temperature with different regions is modified and mixing zone extruder is considered to extract the equal sizing and batch production.

SCOPE FOR FEATURE

- By providing suitable grooves (longitudinal or spiral grooves) on the inside of the barrel. The grooves increase the grip-resistance and direct the flow of the forced material.
- The comparison between experimental data and numerical data for prototype and customized ragi ball machine for Indian seaniorio condition.
- Customized design of ragi machine with available material in market cost effectively.
- This ragi machine can be used widely in Indian commercial hotels, hostels, hospitals and uses food industries. Further step are to be taken to use new product development of the machine in large scale production.
- Still need to use the material with high precision and food quality material as per th food machine material slandered for better hygienic and performance of the machine.
- The scope of feature work gives is less time consumption, more efficiency, consistency and high power output of the machine.

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