



NEW INITIATIVES FOR FOOD PROCESSING

Extruded Snacks From Millets – The Grain of The Future

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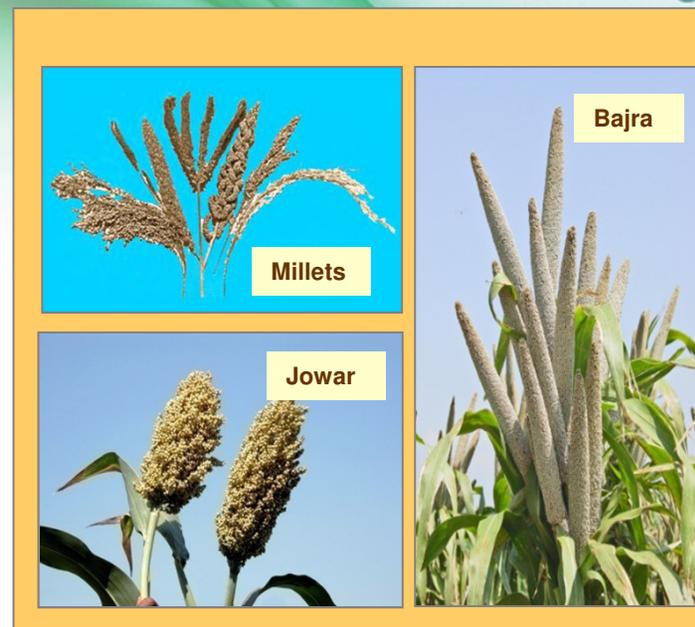
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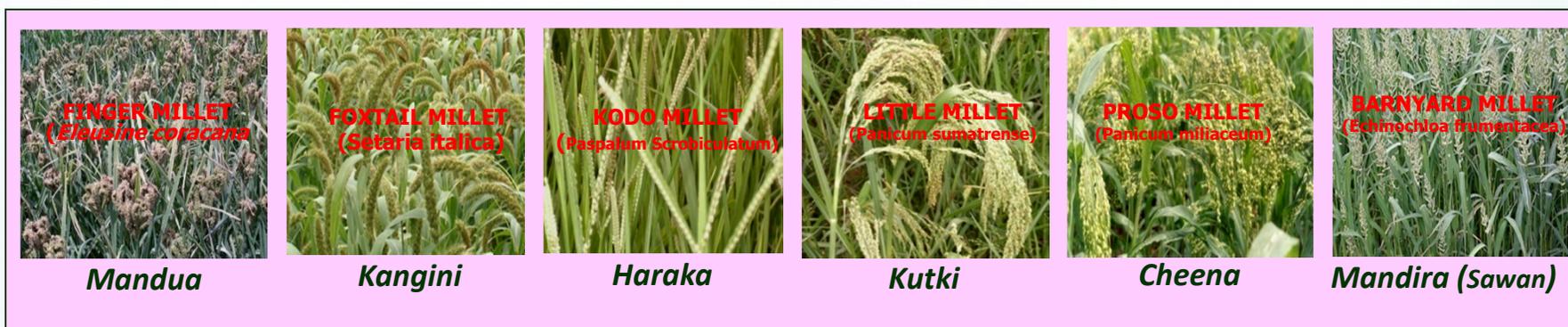
In the climate change scenario... Millets will be the winners of ever green revolution”....



- Since they are Versatile: highly adaptable- **Climate change compliance**
- Can withstand vagaries of weather and produce high biomass
- They are C4 crops – have higher efficiency in absorbing and utilizing CO₂
- Hybrids yield 30-50% more than varieties



Small millets





Sorghum Vs Millets- Current production scenario -TE 2011

Sorghum

Area- 7.97 million ha

Kharif: 3.31 Rabi: 4.39

Production- 7.29 million t

Kharif: 3.25 Rabi: 4.04

Productivity- 948 kg/ha

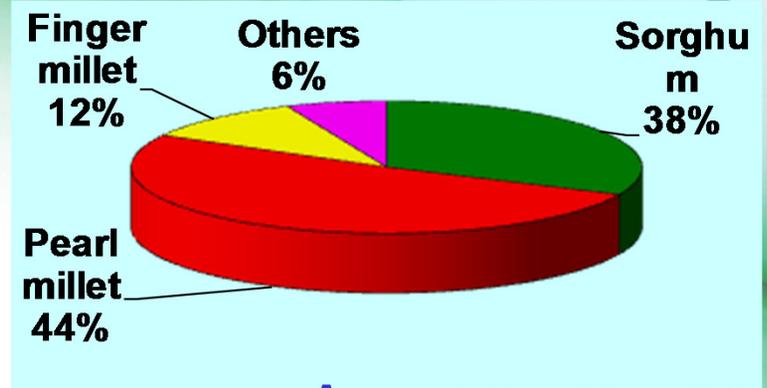
Kharif: 978 Rabi: 948

Millets

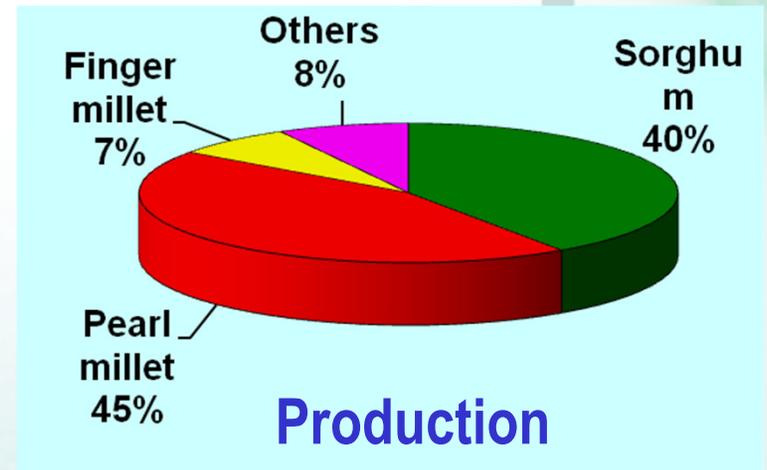
Area- 20.2 million ha.

Production- 17.57 million t

Productivity- 869 kg/ha.



Area



Production



Gaps in millet production, utilization & marketing



- Drudgeries in processing methods-consumption patterns
- Neglected policy front
- Nutritional merits of millets are not exploited for commercialization
- Inconsistent quantity and quality -Safety and quality assurance
- Low marketed surplus- due to low remuneration to the farmers~ supply chain issues
- Changes in income, urbanization etc- Changing consumers tastes and preferences



Millets- highly nutritious & Healthy



(All values for 1000 gms)

| Food rains | Nutrients per kilogram | | | | | | | | | |
|-----------------|------------------------|----------|-------|----------|--------------|------|----------|----------|------------|------------|
| | Protein | Minerals | Fibre | Cal-cium | Phos-phorous | Iron | Carotene | Thiamine | Riboflavin | Folic acid |
| | (gms) | (gms) | (gms) | (mg) | (mg) | (mg) | (µg) | (mg) | (mg) | (µg) |
| Sorghum | 104 | 16 | 16 | 250 | 2200 | 41 | 470 | 3.7 | 1.3 | 200 |
| Pearl millet | 116 | 23 | 12 | 420 | 2960 | 80 | 1320 | 3.3 | 2.5 | 455 |
| Italian millet | 123 | 33 | 80 | 310 | 2900 | 28 | 320 | 4.7 | 2 | 150 |
| Finger millet | 73 | 27 | 36 | 3440 | 2830 | 39 | 420 | 4.2 | 1.9 | 183 |
| Little millet | 125 | 19 | 22 | 140 | 2060 | 8 | 0 | 2 | 1.8 | - |
| Kodo millet | 77 | 15 | 76 | 170 | 2200 | 93 | 0 | 3 | 0.9 | 90 |
| Rice* | 64 | 7 | 2 | 90 | 1430 | 10 | - | 2.1 | 0.5 | 110 |
| Wheat (whole)** | 118 | 15 | 12 | 410 | 3060 | 53 | 640 | 4.5 | 1.7 | 366 |

Source: Nutritive value of Indian foods (1996), National Institute of Nutrition, ICMR, Hyderabad.

*Rice - parboiled and milled.

Processing diversification - **Extrusion** can be employed gainfully for creation of demand when other interventions are integrated in a **value chain mode**

Extrusion



The word “Extrusion” refers to a process by which a product is forced through a die opening of the desired cross section.

Or

- A process which combines several unit operations including mixing, cooking, kneading, shearing, shaping and forming.
- Today, their processing functions may include conveying, mixing shearing, separation, heating or cooling, shaping, co-extrusion, venting volatiles and moisture, flavor generation, encapsulation and sterilization.

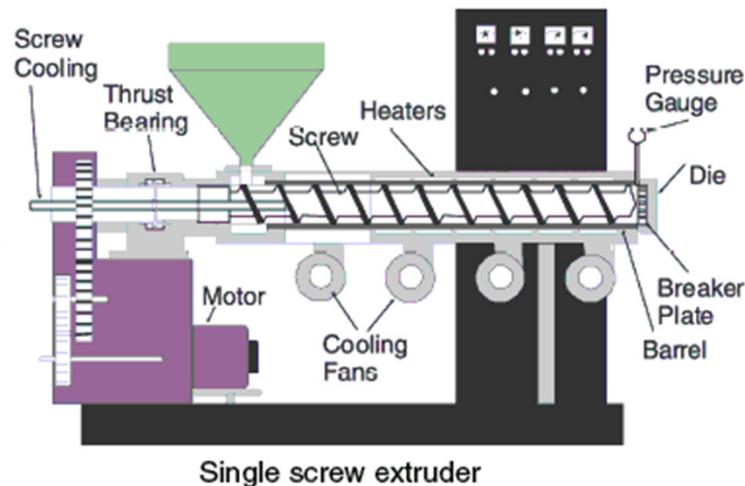
Classification of Extrudates

- Extruders are classified into two types according to operation:
Hot and cold extruders .
- Based on type of construction extruders are classified into:
Single screw and twin screw extruder

Single-Screw Extruder



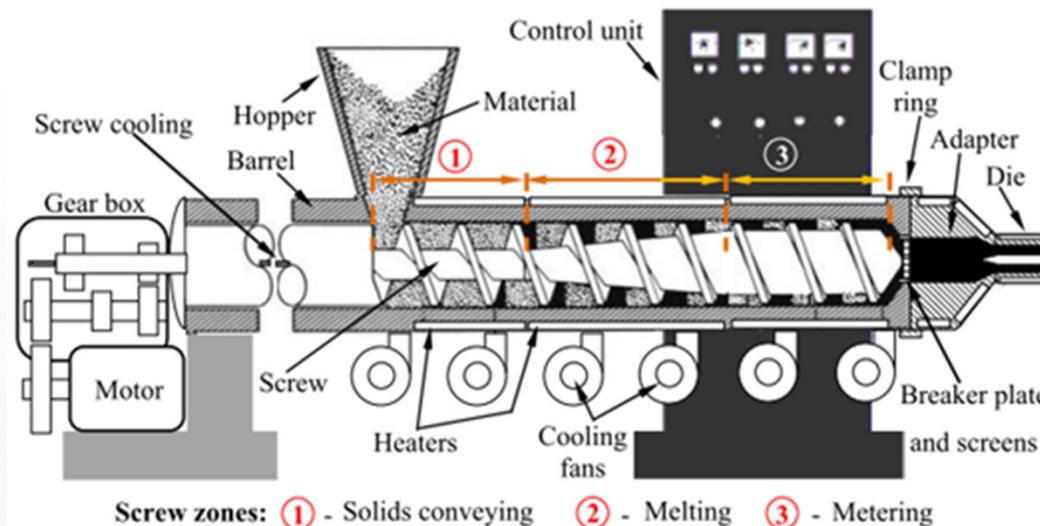
- A typical single-screw extruder consists of a live bin, feeding screw, preconditioning cylinder, extruder barrel, die and knife.
- As single-screw extruders have relatively poor mixing ability, they are usually supplied with premixed material which often has been preconditioned with added steam and water
- Generally, preconditioning prior to extrusion enhances extrusion processes which benefit from higher moisture content and longer equilibration time.
- Product quality can be improved greatly by preconditioning the raw ingredients.



Application of Single Screw Extruder



- The first major commercial application of the single-screw extruder in the food processing industry was conversion of semolina flour into pasta using solid screws.
- This low-shear, low-temperature-forming process first found commercial production in the 1920s and 1930s, and remains a standard process although equipment has improved (Huber, 2000).
- Several new developments in the single screw extruder have further increased its efficiency and versatility.
- Some of the products like Pasta and Vermicelli have been developed using sorghum based formulations and are well accepted .



Sorghum based Pasta and Vermicelli (Cold Extruder)



Twin-screw extruder



- Recent years have seen increasing requirements for new products with intricate shapes and small sizes that are beyond the capabilities of single-screw systems.
- The term 'twin-screw' applies to extruders with two screws of equal length placed inside the same barrel.
- Twin-screw extruders are more complicated than single screw extruders, but at the same time provide much more flexibility and better control.
- Twin screw extruders are generally categorized according to the direction of screw rotation and to the degree to which the screws intermesh:
 - 1 . Counter- rotating twin- screw extruders
 - 2 . Co-rotating twin-screw extruders.
- In the counter-rotating position the extruder screw rotates in the opposite direction, whereas in the co-rotating position the screw rotates in the same direction.

Expanded Snacks and Breakfast Cereal

Twin Screw Hot Extruder



Value-Added Applications for Extrusion in Sorghum



- Extrusion cooking is used worldwide for the production of expanded snack foods, modified starches ready to- eat cereals, baby foods, pasta and pet foods. (Toft, 1979).
- The extrusion cooking process is high temperature short time process in which moist, soft grain is fed into the extruder where the desired temperature and pressure are obtained over the required period of residence time.
- For cooking of the product generally external heat is not supplied, heat for cooking is achieved through shear and friction in the extruder

Pet foods



Baby foods



Cont....



- Millet is a starchy food with a 25:75 amylose to amylopectin ratio and is a fairly good source of lipids (3–6%), having about 50% of the lipids in the form of polyunsaturated fatty acids (Sridhar and Lakshminarayana, 1994).
- Although millet is known to contain amylase inhibitors, the carbohydrate digestibility of millet foods is not affected because of heat-labile nature of the inhibitors (Chandrasedker *et al.*, 1981).
- *Even though the nutritional qualities of millet have been well recorded (Hulse *et al.*, 1980), its utilization for food is confined to the traditional consumers in tribal populations, mainly due to non-availability of consumer friendly, ready-to-use or ready-to-eat products as are found for rice and wheat.*



Sorghum

- Recent research has focused on improving the digestibility of grain sorghum through extrusion processing, while retaining its nutritive and functional properties in sorghum-based foods such as tortillas, couscous, porridges and baked goods.
- Cross-linking of protein structures is thought to be one of the major factors that influence sorghum protein digestibility.
- Besides decortication, extrusion significantly reduces condensed tannins by breaking down its molecular weight and thereby increasing the cereals bioavailability.
- It appears from past work and literature study that food extrusion could be a viable option for enhancing sorghum protein digestibility by using controlled conditions of heat and moisture that would lower the formation of disulphide bonds in proteins (Mahasukhnothachat et al., 2010).

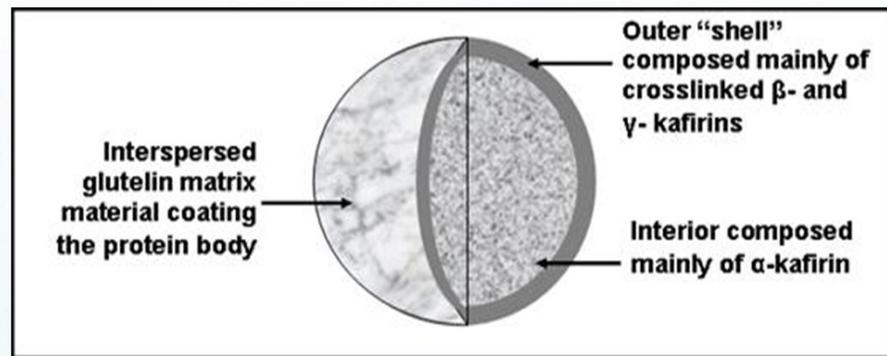


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- Extrusion processing generally decreased antioxidant activity when compared to conventionally cooked porridges (Duodo et al., 2002).
- Sorghum protein bodies forces to disintegrate the matrix and denature kafirin protein for enhanced bio-availability using extrusion technology.

Schematic of a sorghum protein body (de Mesa-Stonestreet, Alavi et al., 2010)



Finger millet (ragi)



- Finger millet also known as ragi in India is one of the important cereals occupies highest area under cultivation among the small millets
- Finger millet is comparable to rice with regard to protein (6-8%) and fat (1-2%) and is superior to rice and wheat with respect to mineral and micronutrient contents
- The composite vermicelli of acceptable quality could be made using finger millet out of medium coarse granulation in combination with milled wheat fractions.
- This millet is used in preparation of various extruded products, breakfast cereals and weaning foods.



Pearl millet (Bajra)



- Pearl millet is one of the most extensively cultivated cereals in the world, after rice, wheat, and sorghum, particularly in arid to semi-arid regions
- Pearl millet utilization in human food is not common due to lack of processing technologies and restricted food uses.
- Nowadays, consumers prefer well balanced and convenience foods like extrudates, breakfast cereals, pasta etc.
- So to avail pearl millet nutrients and utilize whey proteins; extrudates were prepared with incorporation of WPC in twin screw extruder.
- Pasta is also a popular food product that comprises of spaghetti, noodles, vermicelli etc.
- So, pearl millet based composite pasta having the functional advantage of barley flour and nutritional value of whey protein concentrate were developed.



Foxtail millet



- Foxtail millet (*Setaria italica*) is one of the important food crops in parts of the Indian subcontinent and African countries
- Processing millet to prepare ready-to-use and ready-to-eat products would enhance its food and economic value.
- Accordingly, popped, flaked, roller dried and extrusion cooked millets were prepared using foxtail millet and some of their functional properties were determined.

Little Millet:

- Little millet (*Panicum miliare*) is one such nutritious but neglected crops grown in both plains and hilly regions
- A study on extrusion of millets into ready to eat breakfast cereals and effect of secondary sweeteners was conducted by Ferriola and Stone (1998). Three white proso millet varieties and one foxtail millet were used to develop these products.
- Hence, two separate processing technologies were followed to process the millet in the form of RTE and RTC flakes. The RTE flake was a product which was processed by combinations of partial gelatinization, flaking, extruding and toasting. It could be consumed like any other commercial breakfast cereal or extended for various uses.



Nutrient content of Millets



| Commodity | Protein (g) | CHO (g) | Fat (g) | Fibre (g) | Minerals (g) | Ca (mg) | P (mg) |
|-----------------|-------------|---------|---------|-----------|--------------|---------|--------|
| Sorghum | 10.4 | 72.6 | 1.9 | 1.6 | 1.6 | 25 | 228 |
| Pearl millet | 11.6 | 67.5 | 5.0 | 1.2 | 2.3 | 42 | 296 |
| Finger millet | 7.3 | 72.0 | 1.3 | 3.6 | 2.7 | 344 | 283 |
| Proso millet | 12.5 | 70.4 | 1.1 | 2.2 | 1.9 | 14 | 206 |
| Foxtail millet | 12.3 | 60.9 | 4.3 | 8.0 | 3.3 | 31 | 290 |
| Kodo millet | 8.3 | 65.9 | 1.4 | 9.0 | 2.6 | 27 | 188 |
| Little millet | 8.7 | 75.7 | 5.3 | 8.6 | 1.7 | 17 | 220 |
| Barnyard millet | 11.6 | 74.3 | 5.8 | 14.7 | 4.7 | 14 | 121 |

Nutritional value of Extruded Millets



Protein

- Protein digestibility value of extrudates is higher than non extruded products.
- This might be due to the denaturation of proteins and inactivation of anti- nutritional factors that impair digestion.

Starch

- Extrusion cooking is somewhat unique because gelatinization occurs at lower Moisture levels (12-22%).

Dietary fibre

- At mild or moderate conditions, extrusion cooking does not significantly change dietary fibre but it solubilises some fibre components.
- At more, severe conditions the dietary fibre content tends to increase, mainly owing to increase in soluble dietary fibre and enzyme resistant starch fractions.

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Lipids

- A feed with low fat level is desirable for extrusion cooking. The extrusion process minimizes lipid oxidation, thus increasing the nutritional and sensory quality of food products.

Vitamins

- The retention of vitamins in extrusion cooking decreases with increasing temperature, screw speed and energy input.
- It also decreases with decreasing moisture, feed rate and die diameter.

Minerals

- Extrusion cooking enhances apparent absorption of most minerals.
- This increased absorption can be by the positive effect of extrusion in the reduction of antinutritional factors like phytates and tannins.
- Extrusion cooking increases the amount of iron available for absorption, in all most all the cases. However this is not studied in detail further research in this area is necessary.

Effects of extrusion cooking on nutritional quality are ambiguous



Beneficial effects include

- Destruction of antinutritional factors,
- Gelatinization of starch,
- Increased soluble dietary fibre
- Reduction of lipid oxidation.
- Lowers viscosity of the products

Disadvantages

- Maillard reactions between protein and sugars reduce the nutritional value of the protein, depending on the raw material types, their composition and process conditions.
- Heat-labile vitamins may be lost to varying extents.
- Changes in proteins and amino acid profile, carbohydrates, dietary fibre, vitamins, mineral content and some non-nutrient healthful components of food may be either beneficial or deleterious.
- Mild extrusion conditions (high moisture content, low residence time, low temperature) improve the nutritional quality,
- While high extrusion temperatures (P200 °C), low moisture contents (<15%) and/or improper formulation (e.g. presence of high-reactive sugars) can impair nutritional quality adversely.
- To obtain a nutritionally balanced extruded product, careful control of process parameters is essential.

Advantages of Extrusion Processing



Extrusion cooking has gained in popularity over the last two decades for a number of reasons:

- **Versatility:** a wide range of products, many of which cannot be produced easily by any other process, is possible by changing the ingredients, extruder operating conditions and dies.
- **Cost:** extrusion has lower processing costs and higher productivity than other cooking and forming processes
- **Productivity:** extruders can operate continuously with high throughput
- **Product quality:** extrusion cooking involves high temperatures applied for a short time, retaining many heat sensitive components of a food
- **Environmentally-friendly:** as a low-moisture process, extrusion cooking does not produce significant process effluents, reducing water treatment costs and levels of environmental pollution.

Specific advantages of extrusion in millets

- Extrusion in millets helps in overcoming lower shelf life
- Problem of low digestibility can be tackled through extrusion
- The inconvenience in preparation of millet based recipes can be eliminated by providing ready to eat and ready to cook snacks.
- Through extrusion a range of products can be made which are children friendly. Thus, roping in children for healthy and nutritious diet.
- Ready made market is available for extruded products which can Be diversified for millets.
- It could also be an alternate snack food item to be distributed to under-nourished population under different government programmes.



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- Extrusion improves protein digestibility via denaturation, which exposes enzyme-access sites. Most proteins such as enzymes and enzyme inhibitors lose activity due to denaturation.
- Since most extruded foods are not high in protein, nutritional evaluations of extruded feeds, weaning foods and other specialized products have been emphasized.
- Vitamin losses in extruded foods vary according to the type of food, the moisture content, the temperature of processing and the holding time.
- Generally, losses are minimal in cold extrusion. The HTST conditions in extrusion cooking, and the rapid cooling as the product emerges from the die, cause relatively small losses of most vitamins and essential amino acids.
- Generally foods containing less than ten per cent lipids are extruded because greater quantities of lipids reduce slip within the extruder barrel, making extrusion difficult, particularly for expanded products and shearing operations.

Conclusion

- Sorghum/Millet's grain's flexibility in food systems and high consumer acceptability, it makes significant contributions to the nutritional value of diets of populations at risk.
- Food manufacturing firms and product development companies have been constantly looking at newer scientific methods in evaluating processed foods and sorghum/Millet is now a center stage for most producers .
- Sorghum/Millet is now transitioning from being a feed based commodity to a food based necessity
- Hence, the scope to innovate and develop extrudates with millets will be of paramount interest to people involved in agricultural research, food manufactures and consumers in developing countries.
- It could also be an alternate snack food item to be distributed to under-nourished population under different government programmes.



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Thank You!

