# STATUS REPORT OF NUTRIENT ANALYSIS, VALUE ADDITION AND PRODUCT DEVELOPMENT OF FINGER MILLETS AND OTHER SMALL MILLETS IN INDIA

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Climate changes, water scarcity, increasing world population, rising food prices and other socioeconomic impacts

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A great threat to agriculture and food security

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Challenge of producing, processing, and utilizing other potential food sources to end hunger and poverty.

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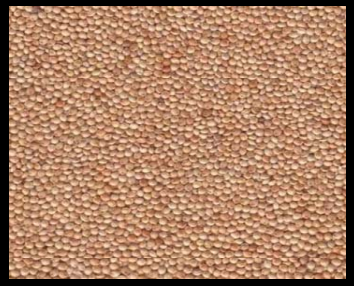
Millet grain is a probable solution

- Pearl millet (*Pennisetum glaucum)*,
- Finger millet *(Eleusine coracana)*,
- Kodo millet (*Paspalum setaceum)*,
- Proso millet *(Penicum miliaceum)*,
- Foxtail millet (*Setaria italica)*,
- Little millet *(Panicum sumatrense)*,
- Barnyard millet (*Echinochloa utilis)*

- They are known as *coarse cereals* beside maize (*Zea mays)*, sorghum *(Sorghum bicolor)*, oats *(Avena sativa)* and barley *(Hordeum vulgare).*

Foxtail



Little

Proso

Kodo

Barnyard

# Table: Nutritive value of millet grains

| Food | Protein[a] (g) | Fat (g) | Ash (g) | Crude fiber (g) | Carhohydrate (g) | Energy (kcal) | Ca (mg) | Fe (mg) | Thiamin (mg) | Riboflavin (mg) | Niacin (mg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rice (brown) | 7.9 | 2.7 | 1.3 | 1.0 | 76.0 | 362 | 33 | 1.8 | 0.41 | 0.04 | 4.3 |
| Wheat | 11.6 | 2.0 | 1.6 | 2.0 | 71.0 | 348 | 30 | 3.5 | 0.41 | 0.10 | 5.1 |
| Maize | 9.2 | 4.6 | 1.2 | 2.8 | 73.0 | 358 | 26 | 2.7 | 0.38 | 0.20 | 3.6 |
| Sorghum | 10.4 | 3.1 | 1.6 | 2.0 | 70.7 | 329 | 25 | 5.4 | 0.38 | 0.15 | 4.3 |
| Pearl millet | 11.8 | 4.8 | 2.2 | 2.3 | 67.0 | 363 | 42 | 11.0 | 0.38 | 0.21 | 2.8 |
| Finger millet | 7.7 | 1.5 | 2.6 | 3.6 | 72.6 | 336 | 350 | 3.9 | 0.42 | 0.19 | 1.1 |
| Foxtail millet | 11.2 | 4.0 | 3.3 | 6.7 | 63.2 | 351 | 31 | 2.8 | 0.59 | 0.11 | 3.2 |
| Common millet | 12.5 | 3.5 | 3.1 | 5.2 | 63.8 | 364 | 8 | 2.9 | 0.41 | 0.28 | 4.5 |
| Little millet | 9.7 | 5.2 | 5.4 | 7.6 | 60.9 | 329 | 17 | 9.3 | 0.30 | 0.09 | 3.2 |
| Barnyard millet | 11.0 | 3.9 | 4.5 | 13.6 | 55.0 | 300 | 22 | 18.6 | 0.33 | 0.10 | 4.2 |
| Kodo millet | 9.8 | 3.6 | 3.3 | 5.2 | 66.6 | 353 | 35 | 1.7 | 0.15 | 0.09 | 2.0 |

# Traditional methods to enhance bioavailability of micronutrients

Thermal processing

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Mechanical processing

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Soaking

↓

Fermentation

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Germination/malting

Increase the physicochemical accessibility of micronutrients,
Decrease the content of antinutrients, such as phytates,
Increase the content of compounds that improve bioavailability.

# Traditional and Bioprocess Technologies

## Germination or malting

- Biochemical modifications
- ↑ nutritional quality
- ↑ nutrient content
- ↑ digestibility
- ↑ iron and other minerals availability

# Utilization of malt

- Several healthy and nutritional food products
- Infant formula
- Complementary food products
- Composite flours or food blends

# Industrial application

- Need for the application of malting at an industrial scale
- Use of novel germinators enhanced by a control system of germination conditions to provide high-quality malt products that can be easy to handle and consumed by larger populations

- Promote millet utilization

# Fermentation (enzymatic hydrolyzation)

*Fermentation is widely used in Africa (food preservation)*

- Chemical compositions modified
- Decreases the levels of antinutrients in food grains
  - Trypsin and amylase inhibitor activities
  - Phytic acid content.
- Increase in protein availability, *in vitro* protein digestibility *(IVPD)*, and nutritive value.
- Lysine, tryptophan, and vitamin B2 contents increased
- Vitamin A and flavaonoid contents and paste viscosity were reduced.

# Contd……

- Mixed-culture fermentation of pearl millet flour with *Saccharomyces diastaticus*, *Saccharomyces cerevisiae*, *Lactobacillus brevis*, and *Lactobacillus fermentum* caused an improvement in its biological utilization in rats.

- Lactobacilli and yeast was more effective in increasing the protein as well as starch digestibility as compared to pure culture fermentation.

*The enhanced proteolytic activity during fermentation is generally associated with improved protein digestibility, which increases amino nitrogen by partial breakdown of proteins to peptides and amino acids.*

## Contd……

- Fermentation and enzymatic hydrolysis are promising techniques
- Application of these techniques for the preparation of millet food products on a commercial scale is limited.
- Therefore, industrial application of these methods, using modern equipment and optimized conditions, is needed for the preparation of high-quality and safe millet food products at commercial scale.

  - Fermented drinks,
  - Millet fractions rich in functional components that can be used for therapeutic purposes and food of large populations.

# Popping or puffing

Expanded cereals and grain legumes to prepare ready to-eat products.

- Crude fat and crude fiber contents of popped foxtail millet were significantly lower than raw millet, while the carbohydrate and energy values were significantly higher.

# Soaking and cooking

*Can be used as pretreatments under optimized conditions*

- To reduce the antinutritional contents in millet grains
- To enhance nutrient bioavailability and nutritional quality of millet food products.

# Dehulling

- Reduces some nutrient contents such as fiber and minerals
- Improves edible and sensory properties
- Increases the appearance of their food products
- Use of finger millet are confined to flour based products
- Hydrothermal treatment of millet hardened the endosperm texture and enabled its decortication.

# Milling

- Millet grains are usually milled by a nonmotorized grain mill.
- A manual grain mill that has been attached to a gas or electric motor by a pulley system can also be used.
- Milling and heat treatment during *chapati* (an unleavened bread)making lowered polyphenols and phytic acid and improved the protein digestibility and starch digestibility to a significant extent.

## Conversion into pure-millet food products

- Ready-to-eat food products from pure millet grains.
- White proso and foxtail millets - flaked whole grain ready-to eat breakfast cereal.

**It was not possible to stretch pure-millet dough into noodles**

- Deficiency of gluten which is very important to give a dough with elastic and extensible properties, makes them unsuitable for the preparation of easy-to-handle pure-millet solid food products, particularly bakery or noodle products.

- However, they can be converted into liquid or semi liquid food products, such as beer and porridge and other traditional household foods.

# Contd…. .

Therefore, there is a need for innovative processing technologies to convert millet grains into liquid foods such as drinks of high nutritional quality and safety that can be consumed by large populations in rural and urban areas.

# Blending in composite flours & food products

- For improvement of the nutritive value of food and diet
- Biscuits were produced from millet flour and pigeon pea - 65 : 35
- Composite of finger millet and wheat flour (60 : 40) was best, particularly regarding biscuit quality
- Barnyard millet plus wheat composite flour was formulated and prepared by mixing 61.8 g/100 g barnyard millet, 31.4 g/100 g wheat, and 6.8 g/100 g gluten for bread.
- Millet was also used with amaranth and buckwheat in the manufacture of extruded breakfast cereal products as a replacement for wheat and maize flour.

## Contd…. .

- Incorporation of 30% finger millet into noodles
- Addition of vitamin C and mango for enhancement of mineral extractabilities

# Fortification and supplementation

- Supplementation of pearl millet flour with soybean protein steadily decreased IVPD.
- Supplementation significantly increased lysine 1.5- to 2.4-fold.
- Therefore, it can be concluded that supplementation of millet grains with natural food products to enhance their nutritive value can be promising and with high cost-effectiveness compared with fortification by chemical synthetic nutrients.

# Preservation Treatments

- Refrigeration, irradiation and hydrothermal treatment or a combination of more than one technique extend shelf-life of millet grains and their milling fractions as well as their food products.

- This can be attributed to inactivation effect of these treatments on endogenous enzymes and microorganisms.

- However, using of these techniques should be under optimized conditions to avoid unlikable changes in quality attributes of millet grains and their food products.

# Edible coatings

- An edible coating (EC) is a thin layer of edible material formed as a coating on a food product.
- Some of its functions are to protect the product from mechanical damage, physical, chemical and microbiological activities. Coatings are based on proteins, lipids, polysaccharides or composites.
- Edible coatings can influence various changes in fresh and minimally processed foodstuff in some areas such as: antioxidant properties, colour, firmness, sensory quality, microbial growth inhibition, ethylene production and volatile compounds.
- Edible coatings can be used as a method of preservation of food products and improve the stability of lipids and lipid containing foods, thus preventing the loss of sensory and nutritional quality.

# Potential Health Benefits of Millet Grains and Their Fractions

- Epidemiological evidence from research studies has shown that diets rich in plant foods are protective against several degenerative diseases :
  - cancer,
  - cardiovascular ailments,
  - diabetes,
  - metabolic syndrome and
  - Parkinson's disease.

# Antioxidant contents and activities

- 50 phenolic compounds belonging to several classes:
  - phenolic acids and their derivatives,
  - dehydrodiferulates
  - dehydrotriferulates,
  - flavan-3-ol monomers and dimers,
  - flavonols,
  - flavones, and
  - flavanonols

Finger millet extracts had radical-scavenging activity > wheat, rice and other species of millet.

*(Xylo-oligosaccharides (XOs) mixture of finger millet exhibited relatively higher antioxidant activity than the XOs of rice, wheat, and maize by DPPH and ferric reducing antioxidant power assays)*

- Methanolic extracts of foxtail millet of whole flour and bran-rich fraction exhibited a significantly higher radical-scavenging activity (44.62% and 51.80%, respectively).

# Contd…. .

- Potential functional food and nutraceuticals:
  - dietary fiber,
  - protein,
  - minerals,
  - vitamins, and
  - antioxidants.

- More studies in animal models and with human subjects should be performed to verify their activity and health benefits.

# Millet for diabetics

- The intake of whole grain foods is suggested to be beneficial for the prevention and management of diabetes mellitus.
- Lower incidence of diabetes has been reported in millet-consuming populations.
- Phenolic compounds from millet grains also showed potential antidiabetic effects.
- Phenolic constituents in FMP such as gallic, protocatechuic, p-hydroxy benzoic, p-coumaric, vanillic, syringic, ferulic, trans-cinnamic acids and quercetin inhibited cataract eye lens effectively.
- Aqueous extracts of foxtail millet grains were found to have excellent antihyperglycemic activity.
- Millet grains and their milling fractions can be used in preparing various food products for diabetics.

## Table: Glycemic index (GI) of the coated foxtail millet

| Treatments | GI |
|---|---|
| **Uncoated** | 33 |
| **Gum acacia coated** | 32 |
| **Fenugreek coated** | 28 |
| **Curry leaf coated** | 30 |
| **Aloe vera coated** | 31 |

# Millet and cardiovascular disease

- Rats fed with a diet of native and treated starch from barnyard millet had the lowest blood glucose, serum cholesterol, and triglycerides compared with rice and other minor millets.

# Millet against cancers

- Populations consuming sorghum and millet have lower incidences of esophageal cancer than those consuming wheat or maize.

# Millet against celiac disease

- Celiac disease is an immune-mediated enteropathy triggered by the ingestion of gluten in genetically susceptible individuals. It is one of the most common lifelong disorders worldwide.

- A gluten-free diet - in place of wheat, barley, and rye-based foods, persons must consume foods made from gluten-free grains:
  - rice, corn
  - sorghum
  - millet
  - amaranth, buckwheat, quinoa,
  - wild rice, and oats.

- Since millets are gluten-free, they have considerable potential in foods and beverages that can be suitable for individuals suffering from celiac disease.

## Millet and aging

- There is potential usefulness of millets in the protection against aging.

## Antimicrobial activity

- Extracts of phenolic acids and other bioactive components have the potential to be used as natural alternatives in food preservation and for therapeutic purposes.

# Technology for Commercialization: CFTRI

## JOWAR AND RAGI FLAKES

Cleaning ➢Soaking ➢ Drying ➢ Roasting ➢ Polishing ➢ Flaking ➢ Drying and Packing

## BAKERY PRODUCTS

- Bread: (Brown, plain, sweet, milk, whole wheat, fruit, high fiber, ragi, bajra)
- Composite ragi rusk
- Ragi based biscuit

# CEREAL PRODUCTS

- Cereal flakes: rice, jowar
- Refined millet flour
- Vermicelli noodles: Rice, jowar, ragi, maize, bajra, navne and samai
- Decortication of ragi, malted ragi flour-enzyme rich
- Flaking of foxtail millet
- Flaked jowar
- Shelf stable jowar flour.

# PRODUCTS DEVELOPED IN UAS, BANGALORE

CHAKLI (MURUKU)

VERMICELLI

BISCUITS

RUSK

MILLET MALT

MILLET NUTRI MIX

MILLET PAPAD

POPPED MILLET POWDER

Chakkali

Murukku

Biscuits

Cakes

Rusk

# Extruded products from millets

Pasta

Macaroni

Kurkure

Vermecelli

# Edible coated foxtail millet samples

CURRY LEAF

FENUGREEK SEED

UNCOATED

GUM ACACIA

ALOE VERA

# Ready-to-cook palav mixes from edible coated foxtail millet

RICE

UNCOATED

FENUGREEK COATED

CURRY LEAF COATED

GUM ACACIA

ALOE VERA

## Ready to cook payasa mix from edible coated foxtail millet

RICE

UNCOATED

GREEN TEA

GRAPES

TULSI

BHT

# Ready to cook vermicelli upuma mix from edible coated foxtail millet

RICE

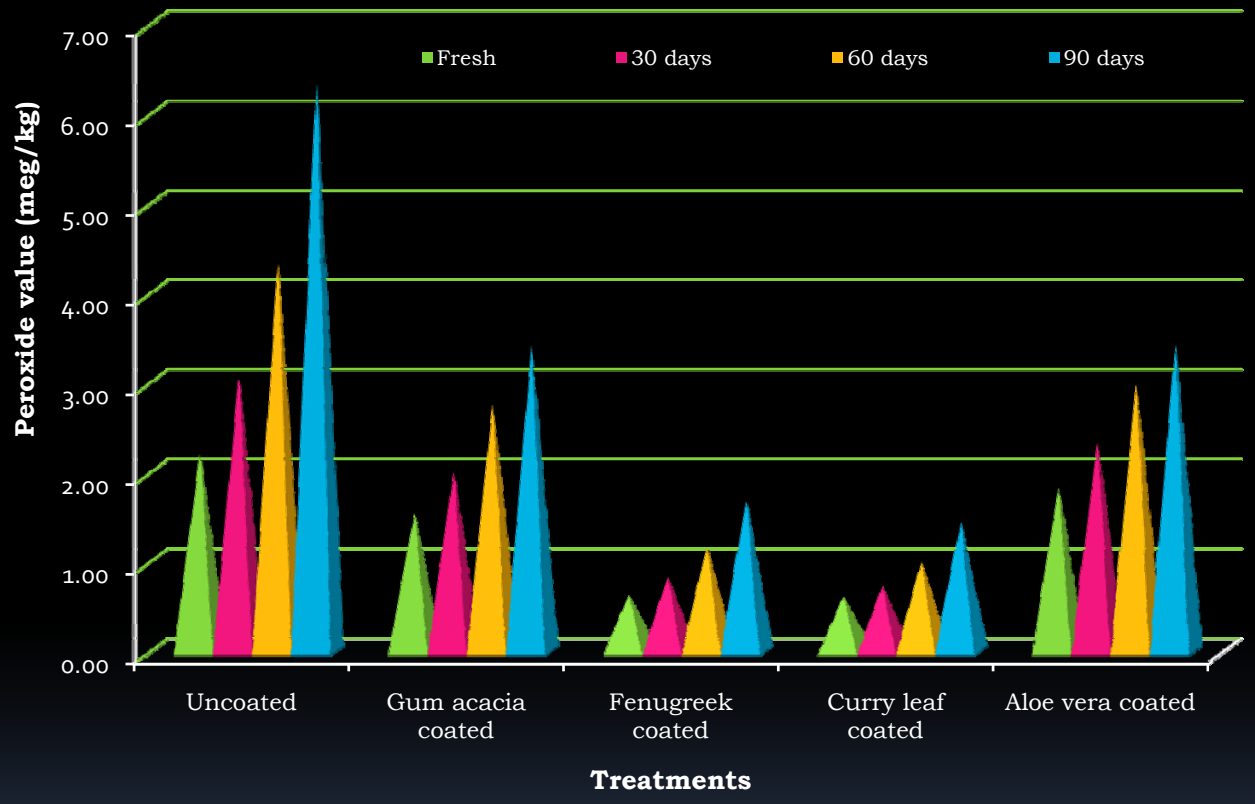
UNCOATED

GREEN TEA

TULSI

GRAPES

BHT




## Shelf life of edible coated foxtail millet

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# THANK YOU