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2. Millet Based Industrial Products

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Abstract:

Millets are a group of small-seeded grasses that are primarily cultivated in semi-arid regions of the world. These grains have been used for centuries as a staple food source in many countries, particularly in Africa and Asia. However, in recent years, millets have gained attention for their potential as a source of industrial products due to their unique nutritional and physical properties. In this chapter, we will explore some of the industrial products that can be made from millets. Advances in post-harvest processing and value addition technologies have made it possible to process and prepare value added products acceptable to both rural and urban consumers. Millets and sorghum have huge potential for wider use. With finger millet this potential is much harnessed. The other millets particularly minor millets remain un-researched and their potential untapped in diversified ways. Processing and utilization of millets in product development have promising prospects with regard to nutrition, quality and health benefits and can be an alternative to cereals but its full scope and utilization is yet to be established.

Keywords:

Millets, processing, puffing, fermentation and millet bioplastic.

2.1 Introduction:

Little grains that are heterogeneously grouped under the umbrella word "millet" are referred to as "coarse cereals" together with maize and sorghum. Although millets are not very important in the west, they are a staple in the diets of people in Asia and Africa. Their hardiness, tolerance of adverse weather, and ability to be cultivated with few inputs in low-

rainfall areas give them agricultural relevance. Bajra or pearl millet (*Pennisetum americanum*), ragi or finger millets (*Eleusine coracana*), navane or foxtail millet (*Setaria sitalica*), samai or little millet (*Panicum miliare*), sharaka or kodo millet (*Paspalum scrobiculatum*), spanivaragu or proso millet (*Panicum miliaceum*), banti sor barnyard millet (*Echinochloa frumentacea*) are the important millets cultivated largely in the Asian and African countries.

Millet-based industrial products are goods that are manufactured using millet as the primary ingredient or raw material. Millet is a type of cereal grain that is commonly grown and consumed in many parts of the world, particularly in Africa and Asia. Millet can be processed and transformed into a wide range of industrial products, including food products, animal feed, biofuels, and other industrial materials.

Examples of millet-based industrial products include millet flour, which can be used to make various baked goods such as bread, biscuits, and cakes; millet-based snack foods such as puffed millet, millet-based breakfast cereals, millet-based baby food, and millet-based animal feed. Millet can also be used to produce biofuels such as ethanol and other industrial materials like insulation and paper.

2.2 Historical Background of Millet as A Source of Industrial Products:

Millet has been used as a source of food for thousands of years, particularly in Africa and Asia. However, its use as an industrial crop is a more recent development.

During the 19th century, millet was first used in Europe and North America for the production of birdseed, due to its high protein content and small size. In the early 20th century, millet began to be used for other industrial applications, such as the production of starch, alcohol, and paper.

During World War II, millet was used as a substitute for wheat and other grains that were in short supply. It was also used to produce fuel, due to its high cellulose content. In the years following the war, research continued on the use of millet as an industrial crop, and new applications were discovered. For example, millet straw was found to be a useful source of fiber for the production of paper and other products.

Today, millet is used for a variety of industrial applications, including the production of ethanol, bioplastics, and animal feed. Its use as an industrial crop is expected to continue to grow, as researchers discover new applications for this versatile grain.

2.3 Millet-Based Industrial Products:

Millet based industrial products include:

A. Millet Flour Millet flour is a versatile ingredient that can be used in a variety of products, such as bread, pasta, and baked goods. It is also gluten-free, making it a suitable alternative for people with celiac disease or gluten sensitivity.

B. Millet Starch Millet starch is a fine white powder that can be used as a thickening agent in soups, sauces, and gravies. It is also used in the production of noodles, puddings, and other food products.
C. Millet Protein Millet protein is a high-quality protein that contains all the essential amino acids needed by the human body. It can be used in the production of protein powders, protein bars, and other nutritional supplements.
D. Millet Syrup Millet syrup is a natural sweetener that can be used as a healthier alternative to sugar. It has a low glycemic index and is rich in minerals and antioxidants.
E. Millet Fiber Millet fiber is a dietary fiber that can be used as a functional ingredient in food products. It has been shown to have prebiotic effects, helping to promote the growth of beneficial gut bacteria.

Millet Bioplastics Millet bioplastics are biodegradable plastics that can be made from millet starch. They have the potential to replace traditional plastics in many applications, reducing the environmental impact of plastic waste.

2.3.1 Bread (Ragi & Bajra):

Normal white bread is made of wheat flour, which is deficient in many nutrients. Nutrient supplementation can be done by incorporating millets such as Ragi/Bajara to increase the nutritional value of the bread. This finely ground ragi/bajara flour is blended with wheat flour and the dough is prepared. Further, the dough is fermented, divided, proved, baked, sliced, and packed. The technology can be utilized in the rural sector at the cottage/family scale units to make composite bread containing millets such as Ragi/Bajara, which are rich in many macro and micro nutrients.

Whole-grain bread, Ezekiel bread, and rye bread are among the most healthful options for bread. Bread made from whole or sprouted grains contains essential nutrients, including protein, vitamins, minerals, and fiber. Others, such as processed white bread, contain very few nutrients. Composite flour has been used commercially in bread in several countries, but it is usually accepted only when there is a shortage of wheat flour.

However, newer trends in diversification of bakery products have created great scope for composite bread containing millets such as Ragi/Bajara. White bread has approximately the same carbohydrate and protein content as whole meal bread, contains soluble and insoluble dietary fiber, and a good percentage of nutrients4.

2.3.2 Millet Cookies:

Cookie is a small flat, baked product, commonly called biscuit. Cookie usually prepared from wheat flour, eggs, sugar and fat, sometimes toppings with raisins, oats or chocolate chips. Generally, wheat is one of the cereals used extensively throughout the world for the preparation of cookie. But cookie from non-wheat cereals like rice, jowar, maize or millet is uncommon. Recently, millets are gaining importance because they can offer several nutraceuticals, and also being rich in protein, minerals and vitamins. Its protein has a beneficial influence on the metabolism of cholesterol. Cereal or millet cookie is made from a fine flour of millet with leavening and shortenings.

2.3.3 Millet Snack:

Snacks are made from ragi flour to develop ready-to-eat snack products. Products are suitable as a low-fat snack which provides a good shelf-life without sacrificing the attractive texture and taste of a crispy snack. Product can be consumed as any time snack. Products are cost-effective and can also be considered as a health food (low fat-high fiber). In addition, fried chips also can be manufactured in same process lines.

A. Flaked Jowar RTE Low Fat Sweet & Savoury Snacks:

The jowar or sorghum snack is a ready-to-eat (RTE) product with either sweet or salt spicy in taste. It is suitable as a low-fat snack because the step of frying in oil fat has been omitted to provide a good shelf-life without sacrificing the attractive taste and texture of eating a crispy snack. The unit operation involved in the process is grading, roasting, flavoring, coating, drying and packing.

Figure 2.1: Flaked Jowar RTE Low Fat Sweet & Savoury Snacks

2.3.4 Millet Vermicelli:

Noodles or vermicelli are popular ready-to-cook products, normally prepared from wheat worldwide. There is growing interest on noodles from millets due to their nutraceutical content and the health benefits. Hence, noodles based on ragi (finger millet) and pulse flour was prepared. The product will be of low in cost and can be considered as health food (low fat and high fibre).

The noodles/vermicelli prepared exhibit good cooking and textural properties and may be used in any type of pasta dish--soups, stews etc. The noodles prepared can be used to make a variety of food and snack products like chaw-chaw, fried noodles. The noodles can be deep fat fried to a crispy snack, cooked in water and seasoned to soft snack, or boiled in milk and sugar to make a sweet dish.

Since, both ragi and soy are good source of minerals (rich in Ca, K and Zn) and nutraceutical (polyphenols, dietary fibre) the protein rich ragi vermicelli will offer several health benefits to the consumer.

2.3.5 Multigrain Pasta:

Pasta is known as one of the most ancient nourishment and as a very versatile dish, both from nutritive and gastronomic points of view. Nutritionist considers pasta as highly digestible. It also provides significant quantities of complex carbohydrates, protein, B-vitamins and iron and is low in sodium, amino acids and total fat. Recent developments in pasta products include attempts to improve the nutritional properties of pasta by the addition of supplements from various natural sources. The use of pasta products is more wide spread in the world because pasta products are simpler to make and quick to serve, if dried can be conveniently stored for a relatively long period of time without deterioration. The developed multigrain pasta formulation (based on millets, durum semolina and permitted additives) could be used to supplement the nutritional requirements of growing children and adults. The multigrain pasta has increased fiber and mineral content by 4-5% compared to normal pasta. It can be consumed along with tastemaker as a breakfast cereal/snack.

2.3.6 Multi Grain Sweet Mix (Halva):

Ragi/Sorghum/wheat, and rice, pulse and nuts based ready to cook mix for preparation of halva. Process involves grain size reduction, hydrothermal and thermal treatment and blending with ingredients.

2.3.7 Muffins (Ragi & Bajra):

A nutritious millet with 344 mg of calcium, 288 mg of phosphorus, 3.9 mg iron and 11.5 g dietary fiber. The Phytates, polyphenols and tannins contribute to antioxidant activity & important for health, aging and metabolic diseases. Gluten free muffins for normal people and celiac disease patients 1.5 times more dietary fiber, double the amount of phosphorus, 17 times higher calcium than wheat flour muffins.

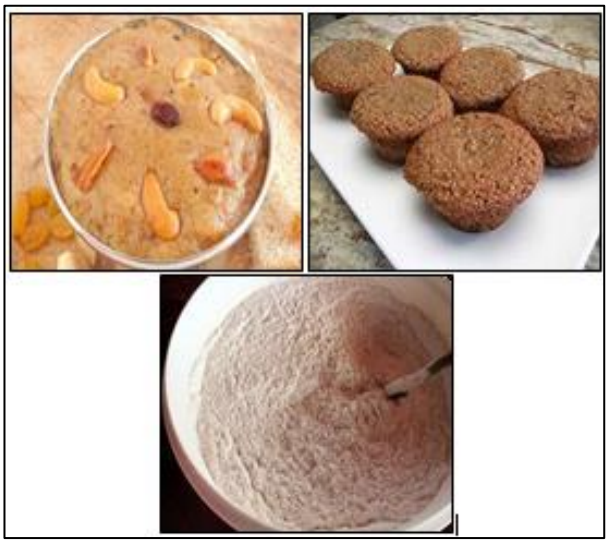

Figure 2.2: Muffins (Ragi & Bajra)

2.3.8 Nutritious Millet Flour:

The prominent small millets are foxtail, finger, little, proso, barnyard and kodo millet. All these grains, except for finger millet, contain a non-edible husk as a distinct part, which needs dehusking, similar to paddy, before consumption. Unlike the major cereals, the milling machineries for dehusking and polishing of small millets are not fully developed. In this connection, preparation of husk free flour from small millets using roller mill was developed. In this process, the husked millet grains are directly milled using roller milling technology. In addition, the same mill is used to produce the semolina (sooji & rava) from the different dehusked millets and multi-millet semolina prepared. This semolina can be used as alternative to wheat semolina for the preparation of upma, halva and other traditional food products.

2.3.9 Ragi Flakes:

Finger millet or ragi (Eleusine coracana) is one of the important minor cereals. It is a nutritious grain and contains about 7% protein, 1.5% fat, and is a good source of calcium, dietary fiber and other protective nutrients. The health benefits of the millets are being recognized globally and non-traditional millet consumers are also looking for ready-to-use foods from the millet. Finger millet flakes are ready-to-use convenience products similar to rice, wheat and sorghum flakes. The flakes could be wetted with water and seasoned with spicy condiments, or sweetened for consumption as snacks. The thicker grade flakes may be deep fat fried or toasted to crispy textured products, and ready-to-eat snacks. The broken and pulverized flakes can be mixed with legumes and other ingredients to prepare traditional foods like bisibele bhath, idli and such other products. These flakes can also be used after toasting or blistering similar to corn flakes.

2.3.10 Millet Murukku Mix:

It is a ready mix for preparation of murukku, made from cereal flour either alone or blending with pulse flours. The blend after mixing with salt and spices is made into dough and deep fat fried to an attractive crispy snack. Even though the product is all time snack, it is commonly used as an evening snack along with tea/ coffee. Since, the product is an energy rich snack; it is an ideal snack for school children. The shelf-life of the mix is nearly 6 months with FFA content less than 10% when stored at ambient conditions.

Figure 2.3: Millet Murukku Mix

2.3.11 Millet Pappad:

It is a ready-to-fry crisp snack food adjunct. It is made from cooked dough containing cereal flour like ragi, rice, maize, sorghum, wheat flour or sago either alone or as blends with other pulse flours along with salt, khar and spices. It is deep fat fried to a attractive crispy wafer like product that is commonly used as an adjunct to a full meal.

2.3.12 Ragi Rusk:

A rusk is a hard, dry biscuit or twice-baked bread. It is sometimes used as a baby teething food. It is a popular baked product liked by all, especially children and working class, both in rural and urban sector. It is also a tea time snack which is yeast leavened containing 50% of 95% extraction ragi flour along with wheat flour. The crumb is pinkish brown color, pleasant flavor and crisp texture with a moisture content of about 4%.

2.4 Instant Beverage from Millet:

Beverages are a class of convenient foods, which are either in ready-to-drink form or in powder form, and can easily be reconstituted with milk or water before consumption. Beverages can be classified as specialty foods that provide energy and some of the essential nutrients like proteins, minerals and vitamins. These foods offer energy and nutrition to the consumers and help them to overcome fatigue and convalescence in the form of liquid food supplement.

2.4.1 Market Potential of Millet-Based Industrial Products:

- Millet is essential for creating a nutritious diet, hence the government and organisations in India encourage millet production. Millets are designated as Nutri-Cereals by the Government of India due to their nutritious content. To increase the area, output, and productivity of millets, the Department of Agriculture and Farmers Welfare (DA&FW) is also carrying out a sub-mission on nutri-cereals under the National Food Security Mission.
- The Food and Agricultural Organization (FAO) estimates that the production of millet on a global scale was 28.33 million metric tonnes in 2019 and 30.08 million metric tonnes in 2021. With a market share of 43.0% in 2021, India will continue to be the world's largest producer of sorghum (jowar), pearl millet (bajra), finger millet (ragi), and other minor millets. India's millet production climbed from 14.52 million tonnes in 2015–16 to 17.96 million metric tonnes in 2020–21, according to the Ministry of Agriculture and Farmers Welfare.
- The export of millet has increased as a result of the rising domestic production. A rise in millet exports from India to 159,332.16 metric tonnes in 2021–2022 from 147,501.08 metric tonnes in 2020–2021, as reported by the Director General for Commercial Intelligence & Statistics (DGCI & S), is expected to increase local millet output. In addition, the Indian government is encouraging the export of millet because of the growing demand on the international market.
- For instance, Agriculture and Processed Products Export Development Authority (APEDA) has planned 16 programs for the promotion of millets and millet products in

countries such as UAE, Indonesia, the United States, Japan, the United Kingdom, Germany, South Africa, Australia, Saudi Arabia, etc. to increase the millet exports of the country. Thus, the rising demand for millets in the global market and increased domestic production in India are anticipated to drive the market in the coming years.

2.4.2 Technology for Millet Value Addition:

Decortication/Dehulling: By virtue of a very hard seed coat, the first and foremost step in millet processing is dehusking or decortication. Traditionally, millets are decorticated through manual pounding. Traditional millstones) utilized for dehusking and grinding of millets grain are usually comprised of a small stone that is held in the hand and a larger flat stone that is placed on the ground.

The friction between these grinding stones results in Dehulling and grinding of millet grains. In general, 4–5 passes are required through this method to get the completely dehusked seeds. The traditional method of Dehulling is laborious and time-consuming with low Dehulling yield (50%).

Milling: The major limiting factors for the utilization of millets as ready-to-use value-added products are the coarse grains, hard seed coat, pigmented seeds, acidic or bitter taste, and poor shelf life of the processed products. Therefore, proper milling technologies are required for the value addition and commercialization of millet-based products. Various processing techniques like pearling, debranning, and chemical treatment of millets are reported to overcome some of these limitations to improve consumer acceptability.

Composite Flour: Blending of millet grains with widely utilized cereals like wheat and maize and some nutritious pulses is one possible way to enhance their widespread utilization. Many functional food products of wheat like cakes, pasta, macaroni, vermicelli, noodles, spaghetti, and flakes are widely consumed in developed and developing countries. In general, the major ingredient of these products is refined wheat flour or semolina.

Flaked Millets: Various processing treatments mainly the thermal treatment of grains induces the physicochemical and structural changes in starch–protein matrix which ultimately leads to the expansion of the grains to produce a puffed product. High treatment short time (HTST) is a common and convenient method to make expanded flakes and other popped products.

2.4.3 Pasta, Noodles, and Other Products Making Machines:

Noodles and pasta are the widely consumed food products among all the age groups in both developed and developing countries. Compared to other products noodles and pasta have a longer shelf life and economic significance. A variety of noodles and pasta are prepared from millets. It includes noodles solely made from finger millet flour, noodles made from finger millet and wheat flour in a ratio of 1:1 and finger millet mixed with wheat and soy flour in the ratio of 5:4:1. Fortified small millets noodles are prepared by supplementing with lysine to overcome the deficiency of amino acid on heat treatment.

2.4.4 Extruded Products:

Cooking procedure which is utilized for the post-harvest processing of starchy and protein-rich materials at high temperature for short timing is known as extrusion cooking. Extrusion cooking enhances the protein digestibility, quality, and versatility of the processed food items It is performed by direct application of heat through a steam injection or indirectly through a jacket by the dissipation of mechanical energy through shearing occurring within the blend. The ready-to-cook extruded products of millets by mixing pearl millet and finger millet flour are reported to have nutrient content, color, texture, and cooking quality and sensory properties in the acceptable range.

2.4.5 Fermented Products:

In general, millets are a good source of protein but the protein quality in terms of essential amino acid profile is low (Jaybhaye et al. 2014). Interestingly, probiotic fermentation and germination of millets are known to enhance the protein digestibility and content of lysine, thiamine, niacin, sugars, protein fractions, soluble fibers, and in vitro availability of micronutrients.

2.5 Conclusion:

Millet-based industrial products have great potential in the market due to their high nutritional value and health benefits. Millets are rich sources of various nutrients, including B vitamins, calcium, iron, potassium, magnesium, and zinc, and are gluten-free with a low glycemic index, making them suitable for people with allergies/intolerance to wheat, diabetic, or trying to lose weight. Millet-based industrial products include activated carbon, biscuits, amylase, proteases, and lignolytic enzymes, bioethanol, and animal feed. Millets are also used to produce flour, flakes, cookies, and other food products. The market potential of millet-based industrial products is increasing, given the growing awareness among the population regarding the health benefits of millets. Millets-based products such as flour, flakes, cookies, etc. are increasingly visible in the consumer market. The promotion of millet-based products is aimed at enhancing their visibility and total acceptance in both rural and urban populations, creating a sustainable ecosystem for growers and processors.

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