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Integration of Millets in Fortified Foods

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Preface

Notwithstanding the unprecedented success of the Green Revolution in rendering the nation food self-sufficient and food-secure, achieving household and individual level food security is still a daunting task. India is home to one-fourth of the world's malnourished and over 40 percent of Indian children below five years of age are under-weight. Thus, alleviation of the stubbornly entrenched high hunger and poverty must be foremost priority of the country.

In an agriculturally important country like India, agriculture-led growth is pivotal for overcoming hunger and poverty. And, food-based nutrition is the most important way to fight undernutrition, especially in the vast rainfed arid and semi-arid resource-poor settings. Millets, possessing superior nutritional attributes and adaptability to drought and low-input conditions, are thus a boon for agro-ecological and socio-economic regimes of rainfed areas. Moreover, millets as the main feed and fodder resource, greatly complement the livestock industry in such ecologies.

It is gratifying that in recent years the Government of India has initiated programmes to promote millets as nutricereals. The National Academy of Agricultural Sciences (NAAS), towards strengthening this initiative, organised a Brainstorming Session to analyse the current status of production, processing and utilization of millets in fortified foods, especially the blends with dairy products to promote functional foods. As detailed in this document, the Session has recommended certain policy options and actions for enhanced production, processing and consumption of millets and millet products. It is hoped that the recommendations will be effectively implemented at different levels to augment the national nutritional and income security, especially of resource-poor people inhabiting rainfed areas.

The Academy greatly appreciates the efforts of Dr A.K. Srivastava in convening the event. Grateful thanks are due to the expert scientists for their active participation in the Brainstorming Session.

(R.B. Singh)
President, NAAS

Integration of Millets in Fortified Foods

PREAMBLE

Despite the Green Revolution and the acclaimed national level food security, ensuring household and individual level food and nutritional security is still a daunting task. India is home to about 240 million undernourished people, one-fourth of the world's. As per the Global Hunger Index (GHI), 2011, in the list of 81 countries, with a GHI of 23.7 against the world average of 14.6 India ranked 67th, posing an alarming situation [1]. The high GHI is the result of high levels of child underweight. A recent UNICEF report reveals that India accounts for 42% of world' underweight children under five years of age [2]. According to an estimate, more than 51 and 74% women and children are anemic respectively. Likewise, 57% suffer from sub-clinical Vitamin A deficiency.

Food-based nutrition is the most important way to fight hidden hunger, under nutrition and ill health, particularly when nearly half of the population (about 600 million people) spends more than 50 percent of the income on food. Nearly 70 percent of the hungry and poor live in rural areas and majority of them belong to small and marginal farming households. Moreover, majority of the rural resource-poor are concentrated in rainfed areas. Under such settings of arid and semi-arid traits receiving low to scanty rainfall (200-600 mm), where fine cereals like rice and wheat cannot be grown profitably, millets which can withstand drought like conditions can be grown successfully [3]. For instance, in the Deccan and Rajasthan, millets comprise the bulk of the locally produced food, feed and fodder. Millets are often grown on marginal, sub marginal and skeletal soils that are less than 15 cm deep with limited use of fertilizers supplemented with biofertilizers and farmyard manures. Thus, they do not burden the state with demands for irrigation or power or too much of synthetic fertilizers or associated subsidies. Hence, for the vast dryland areas, millets are a boon.

Moreover, millets are nutritionally, especially in micronutrient content superior to the commonly consumed cereals. Along with millets, livestock population and milk production are in rainfed arid and semi-arid areas, and the two commodities are highly complementary in socio-economic and ecological terms. For instance, pearl millet in rainfed areas provides the main source of nutritious staple food grain, high-energy feed grain (for milch and draft animals, as well as for poultry, fish, and other mono-gastric livestock), and green and dry fodder for ruminant livestock.

With the above backdrop, the National Academy of Agricultural Sciences (NAAS) organized a Brainstorming Session to analyze the status and scope of integrating millets in fortified foods towards enhancing nutritional security in the country.

PRODUCTION SCENARIO

Between 1955-56 and 2008-09, millet production increased from 14.1 million tons to 18.6 million tons, whereas the average yield increased from 387 kg/ha to about 1000 kg/ha and the area decreased from 36.4 m.ha. to 18.6 m.ha [3]. Fifty percent of the area and 52 percent of the production was attributed to pearl millet, grown predominantly in Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana which accounted for more than 90% of pearl millet acreage in the country. Sorghum or Jowar is the second most important millet cultivated in India on an area of 8.05 m.ha, with a production of 7.33 m.t. and productivity of 911 kg/ha. Ragi is cultivated approximately on 1.38 million ha with a production of 2.04 million tons and productivity of 1477 kg/ha [3]. The remaining small millets are grown on an area of 0.9 million ha with a production of 0.4 million tons and a very low productivity of 491 kg/ha [3].

Efforts have been initiated under the ambit of All India Coordinated Small millets Improvement Project to conserve the germplasm and for varietal improvement of these millets. Many new varieties of finger millet, foxtail millet, *kodo* millet, *proso* millet, little millet and barnyard millet with specific traits have been released. The adoption of these improved varieties by the farmers and dissemination of improved crop husbandry practices in millet crops is an uphill task and would require concerted efforts of agricultural and extension workers as famers have been diverting millets areas to more remunerative crops such as cotton, fruits & vegetables.

However, in recent years the importance of millets in ensuring the food and nutritional security in India and across the globe, especially in the Third World nations has been emphasized. In order to sustain this initiative, apart from yield and performance improvement, the R&D efforts need to be directed towards further enhancing the nutritional make up of millet crops. At present, the available millet varieties have not been investigated extensively for their post harvest characteristics and suitability for value addition. Proactive programmes in this direction through inter-disciplinary approaches should be initiated. The introduction of improved cultivars that have been developed with specific traits and found suitable for processing will provide an alternative to farmers for crop diversification and also offer them better price in market.

Millets – The Nutri-Cereals

While cereals such as wheat and rice are the major source of calories, proteins and micronutrients in our diet, the consumption of these commodities in the refined form has deprived us of valuable micronutrients and fibers in our diet. Millet crops are relatively rich in proteins and minerals (Table 1) and are superior in amino acid balance in comparison to conventional cereal crops (Table 2), besides vitamins and fibre [4].

Table 1. Proximate composition of millets, coarse cereals and fine cereals (per 100 g)

Commodity	Protein (g)	Carbohydrates (g)	Fat (g)	Crude fibre (g)	Mineral matter (g)	Calcium (mg)	Phosphorus (mg)
Sorghum	10.4	72.6	1.9	1.6	1.6	25	222
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
Barley	11.5	69.6	1.3	3.9	1.2	26	215
Maize	11.5	66.2	3.6	2.7	1.5	20	348
Wheat	11.8	71.2	1.5	1.2	1.5	41	306
Rice	6.8	78.2	0.5	0.2	0.6	10	160

Table 2. Essential amino acid content of millets (g/100g)

Commodity	Isoleucine	Leucine	Lysine	Methionine	Cystine	Phenyle alanine	Tyrosine	Threonine	Tryptophan	Valine	Histidine
Sorghum	3.9	13.3	2.0	1.4	1.4	4.9	2.7	3.1	1.1	5.0	2.1
Pearl millet	4.1	9.6	3.4	2.5	1.8	4.8	3.3	3.1	2.0	5.5	2.5
Finger millet	4.4	9.5	2.9	3.1	2.2	5.2	3.6	3.8	1.6	6.6	2.2
Proso millet	8.1	12.2	3.0	2.6	1.0	4.9	4.0	3.0	0.8	6.5	1.9
Foxtail millet	7.6	16.7	2.2	2.8	1.6	6.7	2.2	2.7	1.0	6.9	2.1
Kodo millet	3.0	6.7	3.0	1.5	2.6	6.0	3.5	3.2	0.8	3.8	1.5

Contd...

Commodity	Isoleucine	Leucine	Lysine	Methionine	Cystine	Phenyle alanine	Tyrosine	Threonine	Tryptophan	Valine	Histidine
Barnyard millet	8.8	16.6	2.9	1.9	2.8	2.2	2.4	2.2	1.0	6.4	1.9
Barley	3.5	9.8	2.6	1.6	1.6	5.1	3.6	3.5	1.4	5.8	2.1
Maize	3.7	12.5	2.7	1.9	1.6	4.9	3.8	3.6	0.7	4.9	2.7
Wheat	3.3	6.7	2.8	1.5	2.2	4.5	3.0	2.8	1.5	4.4	2.3
Rice	3.8	8.2	3.8	2.3	1.4	5.2	3.9	4.1	1.4	5.5	2.4

Nutritional significance of millets lies in the richness in micronutrients like calcium, iron, phosphorus, zinc, and sulphur containing amino acids. The protein content in millets like *Jowar* (10.4), *Bajra* (11.6), Proso millet (12.5), foxtail millet (12.5) and barnyard millet (11.6) is comparable with wheat (11.8) and much higher than rice (6.8). Though the finger millet contains lesser protein (7.3), it is rich in mineral matter and calcium in comparison to wheat and rice. All the millets contain more fibre than fine cereals. Particularly, the small millets, namely, barnyard millet (14.7), *Kodo* millet (9) little millet (8.6) and foxtail millet (8.0) are the richest in fibre in comparison to wheat (1.2) and rice (0.2).

The functionality of starch in millets is comparable to other cereals. The higher proportion of non-starchy polysaccharides, dietary fiber and low glycemic index render millets as ideal ingredients in many food formulations meant for specific target groups. The alkaline nature of millets also makes them suitable for the population suffering with acidosis and peptic ulcer. Certain anti-nutrients present in millets like tannin, phenolic and phytate are now being designated as 'phytochemicals' because of their remarkable higher antioxidant potential. Sorghum and pearl millet bran act as excellent bulking agents and exhibit better cholesterol-lowering effect than wheat bran [5, 6, 7, 8].

Populations consuming millets reportedly had lower incidences of esophageal cancer compared to those consuming wheat or maize. Luteolin, a flavone present in sorghum and millets is reported to have antioxidant, anti-inflammatory, cancer-preventive and anti-arrhythmic properties. The role of lignins present in millet in the modulation of different types of hormone-dependent cancers (such as breast cancer) is well documented. Regular consumption of millet is associated with reduced risk of type 2 *diabetes mellitus* because of its high magnesium and fiber content [9]. Scientific investigations on millets and their processing have received an impetus after the discovery of the bio-active molecules in millets and their role in disease prevention. Large scale epidemiological studies are required to further strengthen our understanding on the effect of millet consumption on the risk reduction of diseases like diabetes, cardio vascular diseases, cancers etc.

Status and Scope of Millets Processing

As mentioned, India is the largest producer of millets including pearl millet, finger millet, foxtail millet and *kodo* millet. Millets can be grown under diverse agro-climatic conditions with lesser inputs and possess unique nutrients and bioactive components that may promote health of consumers, particularly those from the less privileged groups. Most of the produce is consumed locally in the form of traditional foods and majority of the nutrients remain unavailable to consumers because of the presence of anti-nutrients. Certain anti-nutrients present in millets like tannin, phenolic, oxalate, phytate, protease and amylase inhibitors minimize the nutritional virtues of millets by adversely affecting their bio-availability. Phytate and oxalate bind with iron and calcium respectively, hence decrease their availability. Phenols and tannins form conjugates with proteins and make them unavailable. Studies need to be addressed on balancing the proportion of these compounds in millet products.

The awareness about the high nutritive values of millets is very low both among the producers and consumers. Besides, being small seeded and low price commodity, the produce is not properly cleaned, graded and dried before they are brought to the markets, fetching low price to the farmers and poses storage problems. Besides, rains at the time of maturity/harvest also leave to poor quality of *Kharif* produce. Presence of thick pericarp, pigments (dark seed coat of *Ragi* and pearl millet), certain phenolics, anti-nutrients and lack of secondary processing equipment's are the major hurdles that are preventing the widespread consumption of these crops and acceptance of food products of these commodities. The high fat, fibre, inert matters coupled with high moisture content/high humidity leads to infestation of insect/fungus during storage. Grains stored with high moisture content often develop mycotoxins/aflatoxins which is highly poisonous both for human and livestock. The shelf life of flour of millets is also low because of high fat content in the grains. Processing and utilization of these crops are largely confined to home scale that renders many of these valuable nutrients unavailable to human beings on wider scale. Process-mediated inactivation of anti-nutrients could be applied to enhance nutrient availability and product development.

Several primary processing equipments like pearler have been developed for dehulling of millets as dehulled grains can be more effectively utilized (Fig. 1). The problem of shorter shelf-life of millet grains and flour could be sorted out by adopting

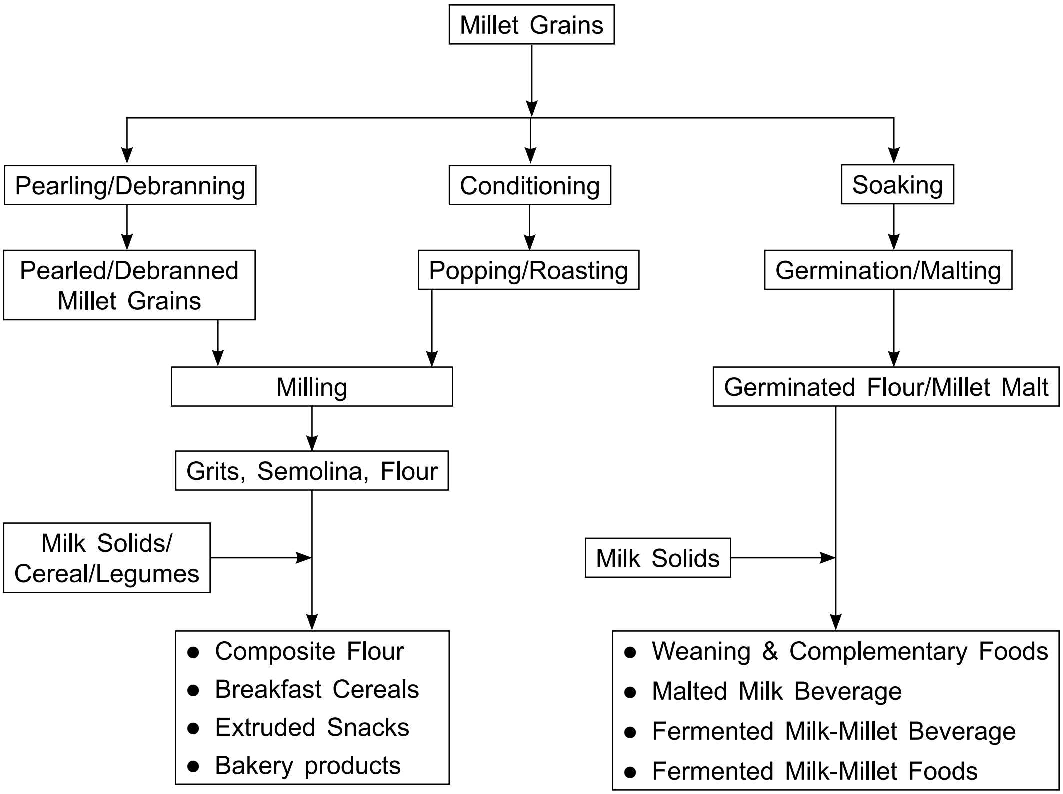

Fig. 1. Prospective scheme for developing composite health foods based on millets

hydrothermal treatment similar to that used for parboiling paddy [10]. Millet flours may complement wheat or maize flour in formulation of several processed foods. Preliminary investigations indicate that 50% replacement is possible in majority of food products. Fine-tuning and optimization of the proportion of the millet and wheat to make it suitable for making biscuits, pasta, noodles and bread etc., would certainly help the food industry to make use of millet flour on par with wheat and corn flour. This may be useful in enhancing the nutritional advantage of resultant products.

There is rapid increase in the number of persons suffering with celiac disease and removal of wheat from the diet of such persons could only possible by using millets. However, development of gluten free products is real challenge in front of food formulators and interventions such as addition of milk proteins or enzymes could be useful. Cereals, usually barley malt, in combination with milk solids are generally used for the preparation of complementary food for weaning purpose.

However, majority of barley malt is used by brewing industry; hence the industry is also looking for some suitable substitute for barley malt. Preliminary trials indicated the possibility of utilizing millet malt specially finger millet and pearl millet malt, in such formulations. Germinated, popped and roasted millet flours have been used for the manufacture of complementary foods along with milk solids; legume flour and other cereals to develop low cost weaning and complementary foods [11, 12].

The importance of breakfast cereal is gaining significance in an era of changing life-style, rapid urbanization, convenience and above all, a health-conscious society. Roasting, popping and puffing are the traditional processes normally used to produce breakfast cereals. Millets have seldom been used in preparation of such products, though utilization of millets will certainly enhance nutritional quality. It is another approach for increasing the level of dietary fibres, micronutrients and nutraceutical concentrations in RTE products. Processing technologies such as extrusion processing, flaking and toasting needs to be evaluated for their suitability and efficacy in delivering novel foods based on millets in combination with other food sources. Extrusion processing has been found to lower the level of antinutrients and enhanced the digestibility of proteins and starch [13, 14]. Extruded millet could also be promoted as healthy snack due to lower proportion of fat. Certain lactic cultures mainly those belonging to lactobacilli possess phytase activity that effectively reduce phytate levels in fermented millet products.

There is scope for introducing innovative products like Bajra *lassi*, developed by National Dairy Research Institute, Karnal that possess the nutritional supremacy of pearl millet along with healthy lactic bacteria [15]. The process developed also enhances the mineral bio-availability and consumer acceptability. Probiotic organisms are now widely employed in the manufacture of functional foods, owing to their reported beneficial attributes. Fermentation using selected probiotic strains results in better acidification, cell count, and such fermented milks could be used as an application for the production of lactic beverages containing probiotic organisms. Probiotic strains of *Lactobacillus acidophilus* reduce the serum cholesterol level. *Lactobacillus acidophilus* and *Bifidobacteria* synthesize folic acid, niacin, thiamine, riboflavin, pyridoxine and vitamin K [16, 17, 18]. Addition of millet or malt components to milk or by-product obtained from dairy industries is another opportunistic entrance in the area of functional foods. Millets act as food substrate for probiotics and improve flavour, texture and overall acceptability of the product [19].

The Way Forward to Utilise Potential of Millet-based Processed Products

Consumer interest in the relationship between diet and health has increased the demand for information on functional foods. The Academy of Nutrition and Dietetics

(ADA) defines functional foods as foods "that include whole foods and fortified, enriched or enhanced foods have a potentially beneficial effect on health when consumed as part of a varied diet on a regular basis, at effective levels." The ADA breaks down functional foods into four categories: conventional foods, modified foods, medical foods, and foods for special dietary use [20]. Rapid advances in science and technology, increasing healthcare costs, changes in food laws affecting label and product claims, an aging population and rising interest in attaining wellness through diet are among the factors that have fueled the rising interest in functional foods. Credible scientific research indicates many potential health benefits from food components.

There is readymade demand for quality weaning foods based on milk-cereal blend. Experience with such food products which are adequately formulated and processed in meeting the nutritional needs of infants and children, is quite encouraging. Although certain products are already a big hit in the marketplace, they are not affordable to all segments of the society. Developing millet based weaning foods would come at an affordable price to the poorer sections of the society meeting the nutritional needs of infants and children an extremely high priority for India.

Various challenges both at production and processing levels would have to be met. Research and technology development initiatives are needed for storage and processing of raw food materials, novel food product development, fabrication of indigenous processing equipments, appropriate packaging materials and techniques and rapid and reliable quality control methods. 'Diversification' is the key word for sustainability, may it be of agriculture or of industry. However, diversification will not succeed until it is of commercial significance. There is a great scope for optimizing processing technologies for utilization of minor agricultural crops for the manufacture of novel foods with unique nutritional and therapeutic profile. Considering the popularity of millets for their health benefits and excellent organoleptic qualities, the major task that lies ahead is to design these basic ingredients into products that help in alleviating child malnutrition, female undernourishment and ill health and also appeal to the sophisticated plates of educated and health conscious consumers. In this regard several technologies developed in the universities and research institutes can be tested and fine tuned for up scaling.

Majority of health foods attract little effective demand in Indian market and have to face competitions from established brands. The recent growth and upward trend of Indian food market offer new opportunities for the development of such health foods by judicious blend of millets with other cereals/milk or milk ingredients, into convenient, long-life form with proven health benefits to consumers. A number of traditional food products are prepared by combining cereal grains/flour with milk. It not only enhances the palatability of these commodities, but also improves the nutritional value. The classical example of 'Composite Dairy Foods' based on milk and cereals is malted milk foods that have been consumed by people of all age groups specially by children. Malting generates a number of intermediaries like malted flour and malt extract that may be included in the formulation of a wide range of processed health foods from millet. Malted milk foods and weaning foods basically complement the nutritive value of cereals and milk alike. It offers most of the vital nutrients in more digestible and easily absorbable form. There is scope for developing milk-millet based weaning or complementary foods at more economical levels. Millets, owing to their non-glutinous nature can serve as a suitable base material for gluten-free products including bakery products. The demand for gluten-free products including India and use of millets as source of gluten free grain does not require any certification from any regulatory agency and it not only reduces the product cost but also enables hassle free marketing of millet products. Several millet-based fortified biscuits have appeared recently in India.

It is encouraging that the Government has recognized the role of millets in the food chain. To promote higher production, upgrade processing technologies and to create health benefits awareness of these cereals, a provision of Rs.300 crore was made in 2011-12 under Rashtriya Krishi Vikas Yojana for promotion of millets as nutri-cereals. The Scheme on Initiative for Nutrition Security through Intensive Millets Promotion (INSIMP) has been formulated to operationalize the initiative. The scheme aims to demonstrate the improved production and post-harvest technologies in an integrated manner with visible impact to catalyze increased production of millets in the country. Besides increasing production of millets, the Scheme through processing and value addition techniques is expected to generate consumer demand for millet based food products and would support ten lakh millet farmers of arid and semi-arid regions of the country to help improve nutritional security and increase feed and fodder supply for livestock. The initiative will be strengthened in the XII Plan. In order to have a better out reach of the food processing sector, a new centrally sponsored scheme titled National Mission on Food Processing will be started in cooperation with the States in 2012-13.

The Brainstorming Session concluded that the following measures are essential towards integrating millets into the mainstream food supply chain.

- Increasing the minimum support price for millets,
- Ensuring proper markets for millets and millet based food products,

- Increasing the awareness of the nutritive quality of millets and millet based food products,
- Increasing the consumption of millets, and
- Integration of millets in fortified foods chain.

RECOMMENDATIONS OF THE BRAINSTORMING SESSION

Enhancing Productivity

1. Although the first hybrid variety which was developed in India was of a millet-pearl millet, presently the varietal turn-over and availability of quality seed of millets is poor. There is need of total revival of system of flow of quality seed of new varieties from breeder to farmer.
2. Critical review by a group of field crop-oriented scientists to show that millets can indeed yield high if managed properly and if proper incentive for higher production is in place. It will also show the unique value of these crops in terms of their resource use efficiency and in view of their resilience to climate change and adaptability to rainfed areas.
3. The allele mining of millets with aim of complete genome mapping should be the part of priority research areas.

Harnessing the Nutritional and Therapeutic Virtues of Millets

1. Millets, very rich in micronutrients Zn, Fe, Ca & P, which are often deficient in diet of most Indian population, are undervalued as far as their nutritional potential is concerned, and this gap should be bridged.
2. Post-harvest handling of millets is most crucial in the entire value-chain system. Extension of millet flour shelf-life is one of the most important considerations. The problem may be addressed for each millet crop and variety-wise. Effectiveness of parboiling may be explored to get the best results in terms of product quality. As millets milling requires specific considerations, flour Millers may be provided incentive to take up millets processing. The problem of low palatability of millets also needs to be addressed properly.
3. The MMM - marriage of millets with milk (integration of milk and millet) has been found to provide the best nutritional synergy. Currently available products must be tested for large scale consumer acceptance and must also be validated for their nutritional and therapeutic attributes through Inter-Institutional linkages.

4. Primary processed products of millets should also be utilized in formulation of consumer products such as bakery, composite grains and snack foods in place of wheat or rice. The technological hurdles must be addressed with all logical interventions including use of additives and modification of millet constituents.

Policy Initiatives for Enhancing the Consumption of Millets

1. Farmers should be made aware of Government initiatives for millets. They should be provided with inputs and financial support from funds allocated for millet.
2. The "Millets Mid-day Meals" initiative of Government is a welcome development. But still millets are missing in Public Distribution System (PDS). Locally produced millets must be procured by the Government and channeled through PDS.
3. Minimum Support Price (MSP) for millets and its effective implementation is urgently required, as it will encourage farmers to grow more millet. The shrinking acreage under millets can thus be reversed.
4. The "awareness campaign for millets" should become a national movement. Now it has been established that millets are not merely to be called coarse gains or minor millets, they are "Nutricereals", and their nutritional values must be publicized through "Millets Network of India".

REFERENCES

1. Von-Grebmer, K., Torero, M., Olofinbiyi, T., Fritschel, H., Wiesmann, D. and Yohannes, Y., Schofield, L. and Von-Oppeln, C. (2011). Global Hunger Index. The challenge of hunger: Taming price spikes and excessive food price volatility. DOI: http://dx.doi.org/10.2499/9780896299344ENGHI2011.
2. UNICEF 2011. The situation of children in India: a profile (http://www.unicef.org/india).
3. Singh, T.P., Rao, B.D., Patil, J.V. and Ansari, A. 2010. Overview of millets cultivation in India. In "Research and Development in Millets: Present Status and Future Strategies". National Seminar on Millets. 12th November. pp. 1-11.
4. Gopalan, G., Sastri, B.V.R. and Balasubramanian, S.C. 2007. Nutritive value of Indian foods. Revised and updated by Rao, B.S.N., Deosthale, Y.G. and Pant, K.C. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad.

5. Awika, J.M. and Rooney, L.W. 2004. Sorghum phytochemicals and their potential impact on human health. *Phytochemistry*, **65**: 1199-1221.

6. Taylor, J.R.N., Schober, T.J. and Bean, S.R. 2006. Novel food and non-food uses for sorghum and millets. *Journal of Cereal Science*, **44**: 252-271.

7. Kaur, K.D., Jha, A., Sabikhi, L. and Singh, A.K. 2012. Significance of coarse cereals in health and nutrition: a review. *Journal of Food Science and Technology*, DOI 10.1007/s13197-011-0612-9.

8. Dykes, L. and Rooney, L.W. 2007. Phenolic compounds in cereal grains and their health benefits. *Cereal Foods World*, **52(3)**: 105-111.

9. Kumari, P.L. and Sumathi, S. 2002. Effect of consumption of finger millet on hyperglycemia in non-insulin dependent diabetes mellitus (NIDDM) subjects. *Plant Foods for Human Nutrition*, **57**: 205-213.

10. Dharmaraj, U. and Malleshi, N.G. 2011. Changes in carbohydrates, proteins and lipids of finger millet after hydrothermal processing. *LWT-Food Science and Technology*, **44(7)**: 1636-1642.

11. Singh, A.K., Raju, P.N. and Ahuja, K.K. 2011. Technological aspects of composite dairy foods. Lecture compendium of Winter School on *Technological Advances in Novel Dairy Products*, 1-21 March. pp. 135-140.

12. Griffith, L.D., Castell-Perez, M.E. and Griffith, M.E. (1998). Effects of blend and processing method on the nutritional quality of weaning foods made from select cereals and legumes. *Cereal Chemistry*, **75(1)**: 105-112.

13. Bargale, P.C. and Kulkarni, S.D. 2010. *Extruded functional foods using plant and dairy ingredients*. Central Institute of Agricultural Engineering, Bhopal, India.

14. Singh, S., Gamlath, S. and Wakeling, L. 2007. Nutritional aspects of food extrusion: a review. *International Journal of Food Science and Technology*, **42**: 916-929.

15. NDRI 2008. Development of *raabadi*-like cereal based traditional fermented milk foods with extended shelf life. *Annual Report 2007-08*. National Dairy Research Institute, Karnal. pp. 41-43.

16. Sanders, M.E. and Klaenhammer, T.R. 2001. The scientific basis of *Lactobacillus acidophilus* NCFM functionality as a probiotic. *Journal of Dairy Science*, **84**: 319-331.

17. Picard, C., Fioramonti, J., Francois, A., Robinson, T., Neant, F. and Matuchansky, C. 2005. Bifidobacteria as probiotic agents-physiological effects and clinical benefits. *Alimentary Pharmacology and Therapeutics*, **22(6)**: 495-512.

18. Gomes, A.M.P. and Malcata, F.X. 1999. *Bifidobacterium* spp. and *Lactobacillus acidophilus*: biological, biochemical, technological and therpeutical properties relevant for use as probiotics. *Trends in Food Science and Technology*, **10(4-5)**: 139-157.

19. Charalampopoulos, D., Wang, R., Pandiella, S.S. and Webb, C. 2002. Application of cereal and cereal components in functional foods: a review. *International Journal of Food Microbiology*, **79(1-2)**: 131-141.

20. Hasler, C.M., Brown, A.C. 2009. Position of the Academy of Nutrition and Dietetics: functional foods. *J. Am. Diet. Assoc.*, **109(4)**: 735-746.

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3. Dr S. Balasubramanian, Senior Scientist, CIPHET, Ludhiana.
4. Dr R.P. Dua, ICAR, New Delhi.
5. Dr H.S. Gujral, Associate Professor, Department of Food Science and Technology, GNDU, Amritsar.
6. Dr H.S. Gupta, Director, IARI, New Delhi.
7. Dr Arun Gupta, Senior Scientist, VPKAS, Almora.
8. Dr Rajneesh Hora, R&D Manager, Danone India, Gurgaon.
9. Dr Alok Jha, Professor & Head, Centre of Food Science and Technology, BHU, Varanasi.
10. Dr Raj Kapoor, Managing Director, Assocom-India Pvt. Ltd., District Centre Laxmi Nagar, Delhi.
11. Mr Sandeep Kapoor, Director, Punjab Agricultural Implements Pvt. Ltd., Saharanpur.
12. Dr I.S. Khairwal, Senior Advisor, Harvest Plus, ICRISAT, Hyderabad.
13. Dr S. Lalitha, Manager (R&D), Britannia Industries Ltd., Chennai.
14. Dr N.G. Malleshi, Retd. Scientist, CFTRI, Mysore.
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16. Mr Anuj Mehta, Director (Quality), Danone India, Gurgaon.
17. Dr Rama K. Naik, Dean, College of Rural Home Science, UAS, Dharwad.
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19. Mr Prashant Parameswaran, MD & CEO, Kottaram Agro Foods Pvt. Ltd., Bangalore.
20. Dr S. Patel, Professor & Head, Department of Process Engineering, IGKV, Raipur.

21. Dr A.A. Patel, Head, Division of Dairy Technology, NDRI, Karnal.
22. Dr M.P.R. Prasad, Scientist E (Deputy Director), NIN, Hyderabad.
23. Dr K.N. Rai, Director, HarvestPlus-India, ICRISAT, Hyderabad.
24. Dr P. Narender Raju, Scientist, Division of Dairy Technology, NDRI, Karnal.
25. Dr Dayakar Rao, Principal Scientist, Directorate of Sorghum Research, Hyderabad.
26. Dr Kavitha Reddy, Director, Nutritech Consultancy Services, New Delhi.
27. Dr Latha Sabikhi, Senior Scientist, Dairy Technology Division, NDRI, Karnal.
28. Dr Gopal Sankhala, Senior Scientist, Division of Dairy Extension, NDRI, Karnal.
29. Dr Amith Sebastian, Managing & Sales, Kottaram Agro Foods Pvt. Ltd., Bangalore.
30. Dr (Mrs.) Salil Sehgal, Professor (F&N), CCSHAU, Hisar.
31. Prof R.B. Singh, President, NAAS, New Delhi.
32. Dr J.P. Singh, Director, Directorate of Millet Development, Jaipur.
33. Dr Gajendra Singh, Former DDG (Engg.), ICAR, New Delhi.
34. Dr K.K. Singh, ADG (PE), ICAR, New Delhi.
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36. Dr Ashish Kumar Singh, Senior Scientist, Division of Dairy Technology, NDRI, Karnal.
37. Prof H.B. Singh, Professor, Dept. of Mycology & Plant Pathology, Inst. of Agril. Sciences, BHU, Varanasi.
38. Prof A.K. Srivastava, Director and Vice-chancellor, NDRI, Karnal.
39. Dr Sarita Srivastava, Professor, Department of Food & Nutrition, GBPUAT, Pantnagar.
40. Dr I. Suresh, CEO, Nutritech Consultancy Services, New Delhi.
41. Dr Dinesh Tiwari, Director, Punjab Agricultural Implements Pvt. Ltd., Saharanpur.
42. Dr S.K. Tomar, Senior Scientist, NDRI, Karnal.
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