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'Nutri-cereal'- pearl millet: Production and utilization

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Pearl millet (*Pennisetum glaucum* L.) is a C_4 plant and is a major coarse grain crop of the world. The plant has a mechanism for efficient photosynthesis and rapid translocation of food materials from source to sink (grains) favours it to withstand drought conditions. It is highly resistant to high temperature, adaptable to poor soil, low vulnerability to disease and insect, pests and has good nutritive value. Its tolerance to drought, heat and soil salinity and its high water use efficiency make it a climate-smart crop and called poorman's food. It is grown in drought prone areas where it performs better than other cereals and is a major crop for food stay in hot and arid areas of India and Africa. It provides sufficient energy to the field workers at a very low cost. In India alone, 90 per cent of the world and in Rajasthan 65 per cent of country's total pearl millet is grown. In the state of Rajasthan, it is grown on 4.9 m ha of area (only 2% area is under irrigation) with a production of 6.43 mt while it is grown on 8.7 mha with a production of 10.05 mt as a country as whole (Vital Agricultural Statistics 2011-12, GOR, Jaipur). The other states like Gujarat, Haryana, Punjab, Maharashtra, Uttar Pradesh grow pearl millet and their contribution is less than 1.0 lakh ha., individually. The districts of Rajasthan those grow pearl millet have a cropping intensity less than 120 per cent. It is a major source of dietary energy for a large number of people and provides quality feed to animals also in these areas where the major source (50-75%) of livelihood is animal based. The pearl millet grains have a biological value similar to wheat and rice and impart substantial energy to body. Its nutritive values designated pearl millet as nutri-cereals and are excellent nutritious food for those who are habituated to this food. The few varieties like ICTP-8203 have high iron content and governments of some states promoted to grow it for removal of malnutrition caused due to iron deficiency or anemia. The composition of amino acids like lysine, threonine and methionine were inversely correlated and leucine, isoleucine and tryptophan were positively correlated with the protein contents.

In India, pearl millet cultivation is generally preferred in soils are poor in fertility, farmers never prefer to give costly inputs like fertilizers to this crop comparing other cereals. The impact of green revolution is visible but climatic and environmental conditions limits to grow wheat and rice in these areas so it ranks fourth in production and consumption after rice, wheat and sorghum. It is used mainly as whole, cracked or ground flour, dough, or grain-like rice. These are used to prepare fermented breads, other foods and thick porridges, steam cooked dishes, non-alcoholic beverages and snacks. Pearl millet is also grown for silage and hay production. Crop residue and green plants provide building materials for fencing, thatching and making basket. Pearl millet is grown as rainfed crop on more than 80 per cent sown area and the erratic conditions prevent the farmers for heavy investment on costly but most remunerative inputs like seed and fertilizers which results in lower productivity in comparison to other cereals. Being a drought evading crop, it can cut short of its life cycle and comes to flowering and is having the characteristics of maturity within 40 to 60 per cent of its actual life cycle period.

Agronomical constraints and strategies: As it is mainly grown in western Rajasthan where soils are sandy to sandy loam in nature, low in organic matter, N and P contents, medium in K content, low water holding capacity, high permeability for water and crust formation after light rainfall are severe soil contributing factors limit the production potential of cop. The topographical features like undulating surface and movable sand dunes hinder mechanization ultimately increase cost of cultivation, losses at maturity and ultimately reduce the yield of crop. The ground water is available at very deep and its poor quality along with insecure return prevent the farmers to invest the latest technologies to follow pearl millet cultivation for marketable surplus.

Improve soil fertility: Farmers in western Rajasthan apply cow dung directly from shed to field without decomposition while they have sufficient period for decomposition (10 month from July to May of next year)

as they follow monocropping where sowing is done in June-July. Recent research findings indicate that sulphur is fourth most required nutrients followed by N, P and K. The requirement of S is almost equal to P. The farmers use DAP as a source of P instead of SSP which supplies S also and is superior from availability of nutrients and per unit cost of nutrient point of view. Farmers also follow blind application of N and P (DAP and Urea) and imbalanced nutrients cause considerable reduction and increase cost of inputs. So soil test based application of nutrients along with well decomposed FYM application to crop really gave a boost in production and gain surplus for market.

Seed: Seed is a critical input and is a major cause of reduction in production of pearl millet in rainfed areas. The impact of climate change is clearly visualized as the number of rainy days is reduced considerably. Also the distribution of monsoon, onset of monsoon etc cause considerable effect on selection of crop and the varieties. The farmers of rainfed areas prefer to grow their traditional seed (seed from previous crop) those potential reduce year by year because of more and more infection of seed borne disease like ergot and green year to great extent. Approximately 200 varieties of pearl millet have been developed since 1960 suited to different cropping situations but the SRR is very less in case of rainfed farmers. Some promising cultivars like HHB 67-Improved, RHB 161, MH 169, HHB 234, CZP 9802 may change the scenario of the state if they are cost effective and available on time.

Water management: As discussed earlier the quality of water is poor and quantity is scare on one hand, undulating topography, high water permeability on other hand may be over take if applied by sprinkler system of irrigation either for irrigated farmers or irrigation as life saving from adjoin farmer or water from water harvesting structure. The initial investment is higher so farmer can't afford so it should be available at subsidized prize to get higher production per unit water use.

Crust formation: It is locally known as 'Rod' and develop if no rains or light rain after sowing of crop affect the emergence of seedlings resulted in poor and non uniform plant population due to crust formation at surface. A device known as 4 kg weight rubber wheel developed by Agriculture Research Station Mandor to make better contact of seed with moisture will boost up germination and emerge the seed early as compared to normal sowing. The device attached behind the tynes of seed drill.

Disease management: A considerable loss in production caused by diseases like ergot and green ear and insect like grasshopper. Ergot can be managed by adopting seed treatment with brine solution or seed replacement. Bird damage at the time of grain filling and maturity also lower the production considerably.

Nutritional quality, constraints and management : Millets are known for their health benefits from time immemorial. Each of the millets has its nutritional and nutraceutical specialities and probably because of this, traditionally, different millets are consumed specifically in different seasons of the year. For example, pearl millet *Roti* is normally recommended during the winter season probably due to its high energy content. Similarly, pearl millet is a very good source of niacin and pyridoxine. Apart from this, these are good source of B-group vitamins. The seed coat of almost all the millets is coloured and the endosperm of some of the millets also contain light coloured pigments. The pigments are generally constituents of carotene and because of that, some of the millets contain beta-carotene. Polyphenols are important phytochemicals with strong anti-oxidants potential and because of this they offer protective action against several non-communicable diseases. The other prominent phytochemical in the millet is phytate, which also exerts some health benefits due to its metal chelating properties, especially with 'Fe' chelation and there by hindering free radical formation. Carbohydrates of the millets comprise of large proportion of starch (65-70%) and a good amount (16-20%) of non-starchy polysaccharides (NSP). The NSP, which constitute nearly 95 per cent of the dietary fibre content of the grain, are derived not only from bran portion but also from the endosperm cell walls.

The bread or chapatti prepared from pearl millet is called as Sogra' and consumed with multi vegetables or dried vegetable like dried clusterbean, greengram dal, curd and kari by majority of peoples. The rancidity developed in Bajra is very harmful and contributed by higher values of lipid, phospholipids and phytin contents also limits its consumption. As an added bonus, this iron-rich pearl millet also contained more zinc, which was similarly absorbed in sufficient amounts meet the children's full daily zinc needs. Lack of zinc in children can lead to stunting and impaired immune response against common infections. These findings, from two different parts of the world, have

established that iron-rich pearl millet can be an excellent source of iron and even zinc, much more so than wheat and rice".

In addition, given its high protein and mineral content (especially iron and zinc), high dietary fibre, gluten-free protein, the area under pearl millet cultivation is expected to increase in the future, including its adoption in non-traditional growing environments. The niacin content in pearl millet is higher than all other cereals.

Constraints in utilization: This nutri-cereal's (pearl millet) utilization is restricted to poor and rural section of population due to various constrains. The major constraints for the utilization of pearl millet are the low shelf-life of its flour which develop rancid odour after few days of milling because of high concentration of lipids. It leads to development of fat acidity, lipolytic activity and accumulation of peroxides of lipids in the meal during storage. The presence of anti-nutrients like phytate (354-795 mg/100g) and polyphenols ((470-780 mg/100g)those hinders mineral availability, inhibits proteolytic and amylolytic enzymes, reduce protein and starch digestibility, mineral bio-availability etc. also limits its consumption considerably. The peripheral area of grains contains polyphenolic pigment contribute gray colour to pearlmillet and its by-products further restricts its efficient utilization.

Pearl millet is underutilized crop and its consumption is limited to low-income group in the forms of chapatti, dalia, rabari, etc. But their utilization is limited due to the presence of anti-nutrients, poor digestibility and low palatability (Pawar and Parlikar, 1990).

Techniques to improve keeping quality: The keeping quality of pearl millet and consumer acceptability can be improved by following post harvest value addition and some bio-chemical reactions like malting, blanching, sprouting, dry heat treatment, fermentation, popping and soaking the seed under controlled condition. However, when pearl millet grain was subjected to processing treatment, *i.e.* blanching and malting, it helped to reduce the anti-nutrients, rancidity and bitterness in the flour. After that, this processed flour was incorporated in biscuit to increase the consumption in human beings. Biscuit was also developed in combination with soybean flour to improve the protein quality, as pearl millet is deficient in lysine whereas soybean flour is rich in lysine. These techniques lower the anti nutritional factors so it may be used in diversified manner. The shelf-life of pearl millet flour may be extending by thermal treatment to grain such as either roasting or blanching or both. The results showed that the polyphenols and phytate content may be reduced and protein quality of pearl millet will be improved by dehulling and soaking (Pawar and Parlikar, 1990).

Malting and fermentation : Malting is a biotechnological processes adopted for cereal processing for food and brewing. Pearl millet grains are allowed to germinate at temperature of 25–30°C for 3–5 days. Improves the germination of grains in such a way as to degrade or modify the endosperm with a minimal loss in grain weight. The sprouted seeds were washed and spread on a blotting paper to remove excess moisture and sun dried. Then the millets were lightly toasted and sprouts were removed by hand abrasion. The toasted millets were then ground to fine powder in an electric grinder and sieved through 40 mesh size sieves. The resulted product is high DP, α- and β-amylase activity, good FAN and moderate malting loss gave quality malt equals to sorghum malt. Pearl millet malt can therefore be used for the production of sorghum type beers.

Blanching: Moist heat *i.e.* blanching is a process of exposing seed to high temperatures for a short period. It is commonly used in food processing to inactivate enzymes and destroy micro-organisms. It improves the shelf life of pearl millet flour by inactivating the enzymes responsible for browning (polyphenoloxidase, lipoxygenase and peroxidase) without much altering the nutrient content. Blanching also add colour and flavour to flour.

Blanching affect the nutrients composition in endosperm as well as in germ and bean portion of pearlmillet, reduce the starch content and improvein in-vitro and starch digestibility. The effect of blanching with citric acid (1.0% and 2.0%) was more pronounced as reported by Saxena *et al.* (2012).

Popping : Popping of other millets is practiced to some extent but s very popular in finger millets among the millets as it develops highly desirable aroma with crunchy texture *i.e.* normally, the expansion volume of the popped millet is about 7-10 ml/g. Popping produces low bulk density and improved in vitro digestibility. Popped millets are good sources of dietary fibre and carbohydrates. The varieties with hard endosperm and medium thick pericarp exhibit superior popping quality. The lipolytic enzymes are denatured during the process of popping and hence, popped product including pearl and foxtail millets also will have good shelf-life. In the standardized process of popping, the whole millet grains of known weight were moistened and heated at 230° C for almost 4 hours. Then the conditioned samples (10 g at a time) were added to sand bed and allowed the seeds to pop for 15 s (Choudhury*et al.,* 2011). It can be done using common salt as heating medium in an open iron pan in the ratio of 1:10 at 240 to

260°C for 15-25 seconds (Sehgal and Kawatra, 2013)

Popped millet could be consumed as snacks after seasoning with salt and spice and also for preparation of sweets. Popped millet flour blended with popped or toasted legumes, such as puffed bengal gram and jaggery or sugar makes delicious and nutritionally balanced convenience foods for growing children and lactating mothers. Since millets are rich source of micronutrients and phytochemicals, such products may score over similar products from rice and wheat.

Dry heat treatment: Microwave heating of pearl millet grains decreased lipase activity significantly with an increase in moisture level from 12 to 18 per cent and maximum reduction was observed at 18 per cent moisture level for 100 s. Based on lipase inactivation and pasting properties, 80-s duration of microwave exposure at 18 per cent grain moisture was considered optimum. The treatment minimizes lipid decomposition during storage upto 30 days. Micro wave heating to grain showed overall acceptability of flour if treated with 18 per cent moisture level for 80 s was acceptable upto 30 days of storage at ambient conditions as compared to even 10 days where flour produce unpleasant off odour and bitter taste (Yadav *et al.*, 2012).

Increase in fat acidity and free fatty acids in the meal obtained from heated pearl millet grains after storage is found to be 3-4 times lower than the control.

Sprouting: Pearl millet grains are stepped in distilled water for 24 hours follwed by draining water and seeds are incubated and allow to germinate for 72 hours at 28-32^{0}C. The germinated grains are sun drid and milled into floured and stored in refrigerator (Ahmed *et al*., 2009). It will signifiantly improve the *in vitro* starch digestibility due to pre-digestion of starch molecules by amylolytic enzymes. Amylase and phosphorylase may become active during germination (Sehgal and Kawatra, 2013).

Value addition to pearl millet: Feasibility for production of non-conventional products such as extrusion cooked and expanded ready-to-eat snacks and supplementary foods, noodles, malt foods, *Papad* and such other food adjuncts, decorticated ready-to-cook cereals, and flakes have been established which would pave the way for their commercial-scale processing and their utilization even by the non-millet consumers. Hence, there is a great scope for utilization of the millets in variety of foods and value added products in the years to come.

Conclusion : Thus adoption of improved package of practices, crop insurances against natural calamities, availability of quality seed etc enhance the production of pearl millet without much addition in cost of cultivation. Now-a-days hybrids are the most common cultivars types used commercially in pearl millet and form an important component in improving the productivity after follow the adoption of low cost and site specific précised agronomic practices.

The knowledge base on the millet grain quality, processing and value addition is now increasing with recent R&D work across the world exploit of the millet for value addition and also for widening the scope of their utilization. The processed millet obtained as the outcome of the present study will be useful in developing low cost dietary formulations for children as well as geriatrics. Millets have considerable scope to be utilized as weaning food, because it has better nutritional quality as compared to some other cereals in many respects and studies on this line are progressing.

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