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Effect of Popping on Nutrients and Anti-nutrients in Proso Millet

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AUTHORS CONTRIBUTION

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ABSTRACT

Millets are used as food and are widely used in rural areas. Millets having amazing values in their nutrition content and play a significant role in traditional diets in many regions. Proso millet is known as one of the most important cereal grains. In order to diversify the uses on proso millets, the study was undertaken to understand the changes caused due to processing on the selected physico-chemical parameters. Macronutrients, micronutrients and antinutrients which were analysed by standard procedure. The moisture content ranged from 3.50 to 8.95 per cent, protein 10.51 to 10.92 g, fat 0.80 to 0.90 g, crude fibre 1.95 to 2.45 g and carbohydrate 74.75 to 80.00 g/100g and energy 350 to 375 Kcal/100g, respectively. Minerals namely iron, zinc, calcium and phosphorous ranged from 4.40 to 5.12 mg, 4.13 to 4.40 mg, 21.52 to 24.01 and 188 to 202 mg/100g, respectively. Phytic acid and tannin content ranged from 656.78 to 1307.1 mg/100g and 74.00 to 115.78 TAE/100g, respectively. The antinutritional components reduced after the process of popping. The results revealed that popping can be done to enhance its nutritional profile and maximize health benefits.

Keywords : Proso millet, Nutrients, Antinutrients, Popping

MILLETS represent a unique biodiversity component in the agriculture and food security systems of millions of poor farmers in regions such as Sub-Saharan Africa (Bhattacharjee *et al.,* 2007). Millets are important foods in many under developed countries because of their ability to grow under adverse weather conditions like limited rainfall. It has been reported that millet has many nutritious and medical functions (Yang *et al.,* 2012). It is a drought resistant crop and can be stored for a long time without insect damage (Adekunle, 2012); hence, it can be important during famine. Diversification of food production must be encouraged both at national and household level in tandem with increasing yields. Growing of traditional food crops suitable for the area is one of the possible potential successful approaches for improving household food security (Shobha and Ravishankar, 2017).

Millet is the world's sixth most important cereal grain supporting as a major source of energy and protein for millions of people in India, Africa, China and especially for the people living in arid and semiarid regions. The UN Food and Agriculture Organization (FAO) have decided to observe 2023 as the International Year of Millets and year 2018 was declared as year of millets in India. Changes in the eating patterns / habits, living standards and increased health awareness has shifted the consumer acceptance towards nutritious, healthy and disease preventive food with their wider health benefits (Yadagouda and Ravindra, 2022).

Proso millet (*Penicum miliaceum*) is also called hog millet and golden millet. Proso millet is cultivated in China, India, Russia and North America. Proso millet is grown in Madhya Pradesh, Uttar Pradesh, Bihar, Tamil Nadu, Maharashtra, Andhra Pradesh and Karnataka. It contains good amount of vitamins and minerals. It is known as the low glycemic index and gluten free millet. Proso millet per 100g contains the energy (354kcal), carbohydrate (70.4g), protein (12.5g), fat (1.1g), fibre (5.2g), minerals (1.9g), calcium (8mg), phosphorus (206mg) and niacin (4.5mg) (Farheentaj *et al.,* 2017). Proso millet also exhibits the good antioxidant activity. It is rich in total carotenoids. Dietary protein of proso millet is helpful in the cholesterol metabolism. It is helpful in prevention of vitamin B3 deficiency that is pellagra. Proso millets rich in micronutrients in the daily diet along with cereals can help to improve the nutritional security by diversifying the food basket (Farheentaj *et al.,* 2017).

But, ironically, millets have high levels of antinutritional factors such as phytic acid, tannin and polyphenol hindering the minerals availability especially of iron which is of great concern due to the high prevalence of iron deficiency anaemia among population. Therefore, improving the bioavailability of minerals from millets would become one of the strategies to improve the nutritional security in terms of minerals especially among vulnerable and poorer section of the population to whom millets are staple.

Generally, millets, before consumption are preferred to be processed, to improve their edible, nutritional and sensory properties. Popping of cereals has been practiced since hundreds of years. Popping is a process in which kernels are heated until internal moisture expands and pops out through the outer shell of the kernel (Arkhipov *et al.,* 2005).

Processing and product diversification of proso millet has caught lot of attention recently. Nutritional evaluation of the popped proso millet showed significant decrease in phytic acid, a major antinutritional factor in proso millet and the nutritive popped grain was found to be a very good snack. The exploitation of popped proso millet for development of ready-to-use products like snack bar may help in increased consumption and thus nutritional security of the consumers. Popping also improves the digestibility of starch as it involves gelatinization of starch and degradation of dietary fibres (Holm *et al.,* 1985 and Nyman *et al.,* 1987). Hence a study was undertaken to evaluate the nutritional and antinutritional components in proso millet grains which were subjected to popping process.

Material and Methods

Proso millet (*Penicum miliaceum*) selected for study was procured from All India Co-ordinated Small millets Improvement Project, University of Agricultural Sciences, Bangalore. They were cleaned to remove foreign materials and impurities and subjected to popping process.

Popping

Different methods of popping was used in the study for standardization. Grains (5g) were soaked in two pre conditioning treatments (2 per cent of salt and 5 per cent of buttermilk) for 2 hrs. Pre known quantity of conditioned grains was put on hot iron pan at 180 and 200ºC temperature and stirred briskly over a steady fire until popping sound stop. The popped grains were removed after hissing sound stopped (Malleshi and Desikachar, 1981).

Popping quality was checked for Popping yield (%) and Expansion volume (ml/g)

$$\text{Popping yield (\%)} = \frac{\text{Total weight of popped seeds}}{\text{Total weight of popped + unpopped seeds}} \times 100$$

Expansion value (ml/g)

$$\text{Expansion volume} = \frac{\text{Total (10g) of popped volume (ml)}}{\text{Weight of kernal popped (10g)}}$$

Analysis of Nutritional Composition of Raw and Processed Proso Millet

The sample was homogenized into fine powder using mixer grinder and were used for analysis of nutrient and antinutrient parameters. Nutrient analysis was carried out following 'Official Methods of Analysis of AOAC International' (AOAC, 2012). Moisture content was determined gravimetrically after uniformly drying the test portion in preheated oven (AOAC, 2012). Ash content was determined gravimetrically after reducing the test portion into inorganic matter in Muffle furnace (AOAC, 2012).

Total fat content was determined in the petroleum ether extract of the of raw and popped millet flour samples using classic SoxPlus apparatus (AOAC, 2012) after moisture removal. Total nitrogen content was determined by titrimetry in Kjeldahl instrument and multiplied with a conversion factor of 6.25 to obtain the protein content. The carbohydrate and energy was calculated by the difference method.

Estimation of Minerals (AOAC, 2012)

Raw and popped millet flour was weighed (1g) in duplicate in silica crucibles for ashing. The ash of the samples was digested by adding 5ml of HCl and 1 ml of distilled water were added and the sample digested in hot plate at 200°C for 10 min. The clear residue thus obtained was diluted with double distilled water and minerals were analyzed. The Fe and Zn were estimated by Atomic Absorption Photometer. Calcium was estimated by titrimetric method and phosphorous by spectrophotometer method.

Determination of Anti-nutrients in Raw and Processed Proso Millet

Estimation of Tannins (Ranganna 2002)

One ml of extract was taken in 100 ml volumetric flask to which 3ml of Folin Denis Reagent (FDR) and 10ml of Sod. Carbonate were added. The contents were mixed and diluted to 100ml using distilled water and allowed to stand for 30mins and absorbance was measured at 760nm.

$$\text{Tannins as tannic acid (\%)} = \frac{\text{mg of tannic acid x dilution x 100}}{\text{Aliquot taken for the estimation x weight of the sample}} \text{ x 100}$$

Estimation of Phytic Acid (AOAC, 2012)

The phytic acid estimation was based on the principle that phytate is extracted with TCA (tricholroacetic acid) and precipitated as ferric salt. The iron content of the precipitate is determined calorimetrically and phytate phosphorous content is calculated from this value assuming a constant 4Fe: 6P molecular ratio in the precipitate.

$$\text{Phytic acid} = \frac{\mu\text{Fe (NO3) x 3 x 15}}{\text{Weight of the sample}}$$

Statistical Analysis

The data was subjected to analysis of variance (ANOVA) for testing the significance of variation in nutrient composition, minerals, phytic acid and tannins minerals using the statistics *i.e* software Statistical Package for Social Sciences (SPSS) version 12.0. Mean values were calculated and compared at different significance level. Pearson's correlations of the means were determined using the software OPSTAT (CCS, Haryana Agricultural University, Hisar, India).

Results and Discussion

Popping Yield

Moisture content plays a significant role in popping as the right amount of moisture is required to increase enough pressure inside the grain so that it can burst open. When the moisture content is low, there is insufficient generation of steam in the endosperm which is required for complete expansion while high moisture content can lead to cracks in the outer seed coat due to swelling which then prevent pressure build-up. Similarly, the temperature of the particulate medium is necessary to change the moisture present inside the grain into superheated steam. Low temperature does not generate sufficient heat inside the grain to convert the moisture into superheated steam and too high temperature can impart a burnt flavor to the grain or, at times, burn the grain.

Popping per cent which different treatments of proso millet ranged from 51.02 to 59.80 per cent. Highest popping of 59.80 per cent was observed in butter milk treated of popping and lowest in water treatment (Table 1). The statistical analysis also showed that there was significant difference among the treatments for popping percent. The results obtained in the present study are in agreement with reports of (Priyanka, 2013) who observed that little millet showed highest popping yield when the moisture levels were between 14 -18 per cent and it was also

TABLE 1

Popping yield and popping percentage of proso millet

Treatments	Popping yield	Expansion volume
Water treatment	51.02	4.75
Salt treatment	57.65	5.20
Butter milk	59.80	6.35
F	*	*
SEM	0.99	0.13
CD@5	3.44	0.48

*. Significant at p<0.05 level

observed that at temperatures below 220°C the percentage of popped grains was very low whereas with increase in temperature to 250°C the popping yield increased. Bhargavi *et al.* (2020) reported highest popping yield in finger millet at 19.0 per cent moisture levels which confirms that moisture and temperature had significant influence on the popping yield.

Expansion Volume

The degree of expansion occurring in a grain depends on the conversion of water to superheated steam and the pressure differential between the vessel and the atmosphere. Highest Expansion volume was observed in butter milk treated of proso millet (6.35g/ml) followed by salt treatment (5.20 g/ml) and water treatment (4.75g/ml). Similar results were obtained by (Bhargavi *et al.,* 2020), that maximum expansion volume was observed when the grains were tempered to 18 per cent moisture. (Kumari, 2018) reported that highest popping quality, *i.e.,* popping volume, were obtained from grains with a moisture content of 14 per cent and as the water content deviates from the optimum, the expansion volume and size declined significantly.

Nutrient Composition of Raw and Popped Proso Millet

Table 2 showed the proximate composition in raw and popped proso millet. Popping reduced the moisture content significantly to 3 - 5 per cent that increased shelf life of popped millets. High moisture content leads to the increased susceptibility towards the storage spoilage due to the fungal and insect problems. The moisture content of proso millet under the study was found to be 8.95 per cent. The popped proso millet moisture content ranged from 3.50 to 3.80 per cent, decreased in moisture content due to grains are subjected to high temperature during popping. Popping caused slight reduction in total ash content. The reason may be due to the removal of seed coat during popping and due to greater concentration of minerals present in the germ and the bran layers than in the endosperm which contribute to a greater extent towards the reduced amount of total ash content in popped finger millet (Choudhury *et al.,* 2010). Millet oil could be a good source of natural oil rich in linoleic acid and tocopherols. During popping, fat content was decreased significantly. It may be due to lipolytic enzymes are denatured. However, the fat content in

TABLE 2

Effect of popping on nutrient composition of proso millet (g/100g)

Treatments	Moisture	Protein	Fat	Total ash	Crude fibre	CHO	Energy
Raw	8.95 a	10.90 c	0.90 a	2.05 a	2.45 a	74.75 a	350 a
Water treatment	3.50 b	10.70 b	0.81 b	1.62 b	2.15 b	80.00 b	374 b
Salt treatment	3.60 c	10.51 a	0.80 b	1.45 c	2.05 b	79.59 c	375 b
Butter milk	3.80 d	10.92 a	0.83 c	1.43 c	1.95 c	79.07 c	375 b
F Value	*	*	*	*	*	*	*
Sem	0.23	0.25	0.31	0.12	0.36	2.25	2.63
CD	0.68	0.77	1.10	0.64	1.12	5.17	5.83

* Significant at p<0.05 level, In each column, mean values with different letters are significantly different

millets is found to be on par with that reported by Saleh (2013). Value for crude fiber contents were found to be similar with other studies and fell within the range of 1.95 to 2.45 g/100g. In this process, the seed coat gets removed to some extent, which could be the reason for lower fibre content in popped sample compared to that of raw sample. However similar trend was observed by (Mishra *et al.,* 2014).

Protein content reported in the range of 10.51 to 10.92 g/100g. The mean values of carbohydrate content in popped samples were also found to be increased significantly similar as observed by different studies. Carbohydrate content in popped form was significantly higher which may be due to the fact that popped seeds were concentrated more with endosperm which contributes 94 per cent of starch to the kernel (Choudhury *et al.,* 2010). However energy values increased during the process of popping of proso millet. This increase in energy values in finger millet may be due to increase in the amount of carbohydrate content Kumari *et al.* (2018).

Mineral Composition of Raw and Popped Proso Millet

Minerals are of critical importance in the diet, even though they comprise only 4 to 6 per cent of the human body. Minerals are of importance due to their pro-oxidant activity and health benefits. Among the minerals, calcium, phosphorus, iron and zinc contents were determined in popped proso millet. The iron, zinc, calcium and phosphorus content were found to be significantly different in raw and popped (Table 3).

TABLE 3

Effect of popping on mineral composition of proso millet (mg/100g)

Treatments	Iron	Zinc	Calcium	Phosphorous
Raw	5.12 ^{b}	4.40 ^{a}	24.01 ^{a}	202 ^{a}
Water treatment	4.52 ^{b}	4.12 ^{b}	21.52 ^{b}	186 ^{b}
Salt treatment	4.62 ^{b}	4.14 ^{c}	21.49 ^{b}	188 ^{b}
Butter milk	4.40 ^{a}	4.13 ^{d}	22.9 ^{a}	196 ^{a}
F Value	*	*	*	*
Sem	0.68	0.18	1.71	1.91
CD	1.91	0.82	4.34	4.85

* Significant at p<0.05 level, In each column, mean values with Different letters are significantly different

The iron content was found to be 5.12 and 4.40 to 4.52 mg/100g in raw and popped millet, respectively. However, decrease in total iron is not very significant. However there was decrease in the zinc content in popped proso millet compared to raw proso millet. The calcium content was found to be 24.01 mg/100g in raw sample, calcium content was found to be highest in butter milk treatment (22.90 mg/100g). Krishnan *et al*. (2012) reported popping of millet, slightly decreased (7 g/100 g) the total calcium content. The phosphorous content was 202 and 186 to 196 mg/100g in raw and popped condition, respectively. During popping there was decrease in phosphorus content which was in tune with the findings of study conducted by Bhargavi *et al.* (2020). The decrease in calcium and phosphorous content in popped millets was because of the removal of seed coat during popping, which contributes towards the reduction in the total mineral content in the samples.

Antinutrient Composition of Raw and Popped Proso Millet

Proso millet is well known for its antinutritional constituents such as phytates, phenols and tannins. However phytate and tannins are also known to interfere with mineral availability. A balance has to be struck between the positive and negative aspects of nutritional quality of Millets. It was observed that raw millets had high antinutrient content than in popped millet (Table 4).

Phytic acid and tannin content was found to be reduced after popping which ranged from 1307.1 to 656.78 mg/100g, 115.78 to 74.00 mg/100g, respectively. The anti-nutritional factors get reduced during popping as these components are located mainly in outer layers (bran) of cereal grains and seed coats Mishra (2014) which are affected during popping. Bhargavi *et al.* (2020) reported heat causes the reduction in tannins of popped amaranth grains. Phytate is hydrolyzed because of the activation of intrinsic plant phytases, extrinsic microbial phytases, or both. However, thermal processing can lead to a partial non enzymatic

TABLE 4

Effect of popping on anti nutrient composition of proso millet (mg/100g)

Treatments	Phytic acid	Tannin
Raw	1307.1 a	115.78 a
Water treatment	660.50 b	75.13 b
Salt treatment	658.12 b	74.13 b
Butter milk	656.78 b	74.00 c
F Value	*	*
CV	4.32	3.59
CD	11.51	7.23

* Significant at $p<0.05$ level, In each column, mean values with Different letters are significantly different

hydrolysis of phytate. Because phytate is heat-stable, significant heat destruction of phytate is not expected to occur. In the present study at elevated high, Prolonged times at elevated high temperatures may have lead to a progressive inactivation of the endogenous enzymes. Similarly popping also reduced the tannins content. This high temperature can affect the molecular structure of tannins and polyphenols and thus improve digestibly; Furthermore, the chemical modification may alter solubility of tannins or chemical reactivity. Kumari (2018) stated that thermal processing methods were the most effective in the reduction of phytic acid. Accordingly, using optimum moisture level and ideal barrel temperature can enhance nutritional value of end products processed by popping.

The study concludes that popping is one of the efficient processing methods where antinutrients get reduced. Consumption of such processed products can help in alleviating nutritional insecurity. Moreover, processing methods like popping will also make the millet more acceptable by sensory qualities. Thus, popping can be considered as effective processing method and popped proso millet value added products can be promoted.

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