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Nutritional composition and popping characteristics of some selected varieties of pearl millet (*Pennisetum glaucum*)

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ABSTRACT

A comparative study carried out on nutritional and popping qualities of 11 cultivars of pearl millet (*Pennisetum glaucum* (L.) R. Br.) varieties have showed significant difference in popping yield, with highest mean popping yield of 73.6 %. Final popped product obtained is crunchy and ready-to-eat with proximate composition comprising 11.1% protein, 6.49% fat, 3.49% crude fibers, 3.19% ash, 74.05% carbohydrate and 1.90% moisture. This paper also highlights the significant reduction in phytic acid which comes down from 404.69 mg/100g in raw grains to 261.45 mg/100 g in popped grain. Based on popping characteristics and nutritional value five varieties, viz. CZP 9802, PC 443, PC 1201, PC 701 and PC 383 were found to have better popping and nutritional traits and can be exploited for novel product development that will help in diversifying this nutri-grain use and will be beneficial for human health and increase profits to farmers.

Key words: Expansion ratio, Nutrient, Pearl millet, Popping, Popping yield

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] grains are nutritionally comparable and even superior to other major cereals with respect to energy, protein, vitamins and minerals. Besides, they are a rich source of dietary fiber, phyotochemical and micronutrients hence; they are termed as "Nutri-cereals". Pearl millet is a rich source of energy (361 kcal/100 g) which is comparable with commonly consumed cereals such as sorghum (349 kcal/100 g), wheat (346 kcal/100 g), rice (345 kcal/100 g) and maize (325 kcal/100 g). Protein and fat contents of pearl millet varieties vary from 8.0 to 14.0% and 6.0 to 10.0%, respectively and protein digestibility ranges from 53.0 to 68.0% (Anita 2014). The amino acid profile of pearl millet is better than that of sorghum and maize and is comparable to that of wheat, barley, and rice (Hadimani *et al.* 1995, Abdalla *et al.* 1998). Niacin content is comparatively higher in pearl millet (Pradeep *et al*. 2013). Pearl millet is rich in B vitamins, potassium, phosphorus, magnesium, iron, zinc copper and manganese. It is gluten free grain and is the only grain that retains its alkaline properties after being cooked which is ideal for people with wheat allergy (Chauhan *et al.* 2015).

Pearl millet is highly nutritious, healthful and resourceful grain that would be a worthy addition to anyone's diet but the bioavailability is low due to the presence of certain anti nutritional factors like phytic acid, polyphenol etc. It has been suggested that various processing methods could reduce the anti-nutritional factors and improve the nutritional quality of pearl millet. The phytate level in plant material is found to decrease during certain processing operations such as milling, germination, fermentation, dry heating and popping (Nambiar *et al.* 2002, Kadlag *et al*. 1995, Chautervedi and Sarojini 1996). Popping of cereals has been practised since hundreds of years. It is a type of starch cookery, where grains are exposed to high temperature for short time. Popping of millet grains invariably improves taste and flavor. It is one of the easy and economic processing methods to prepare ready-to-eat products. Popping essentially creates a crisp, aerated product with desirable sensory qualities. During popping the lipase enzyme gets denatured and hence shelf-life of popped products is better than other kinds of millet products. This is highly advantageous with respect to pearl millet, as processed pearl millet has very low shelf-life. The popping not only improves the shelf-life but also improves the nutritional quality with respect to bioavailability of nutrients (Pradeep *et al.* 2013, Mishra *et al.* 2014). Global

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trend toward the development of healthy snacks using traditional crops may represent a strategy or value addition of agric-products (Vanisha *et al*. 2011).

Popping quality and the nutritive value varies with different pearl millet varieties. Hence the present study is undertaken to determine the popping quality of the pearl millet cultivars and to learn the relationship between the popping quality and nutritional characteristics of different pearl millet varieties.

MATERIALS AND METHODS

The 11 pearl millet varieties comprising local varieties, popular and new hybrid lines were obtained from farms of IARI, New Delhi; CCS HAU, Regional Station Bawal; CAZRI, Jodhpur and some varieties locally grown by farmers. The grains were cleaned thoroughly. About 100 g each of pearl millet varieties were equilibrated to a moisture content of 18% by adding water and tempered for 6 h in a closed container. The tempered grains were popped by high temperature and short time (HTST) treatment in a domestic grain popper at 230+5 degree C (Pradeep *et al.* 2013). The design consisted of 3 trials each.

1000-kernel weight: 1000-grain weight was determined by using method given by Waseem (2012). Weight of 1000 sorted grains measured on electronic balance and was expressed in g.

Popping yield: Popping yield was determined as per the method given by Malleshi and Desikchar (1981).

$$\text{Popping yield (\%)} = \frac{\text{Weight of popped grain (g)}}{\text{Weight of (popped} \times \text{unpopped) grains (g)}} \times 100$$

Puffing index: It is the ratio of the bulk density of the raw material and the bulk density of the product. Higher puffing index indicates higher volume of the product. The puffing index indicates higher volume of the product. The puffing index was calculated using the method of Hoke *et al.* (2007).

$$\text{Puffing index} = \frac{\text{Bulk density of raw grain}}{\text{Bulk density of popped grain}} \times 100$$

Expansion ratio: Expansion ratio is the ratio of size of popped grain to the size of raw grain. The expansion ratio was determined according to the method of Hoke *et al.* (2007).

$$\text{Expansion ratio} = \frac{\text{Breadth of popped grain}}{\text{Breadth of raw grain}} \times 100$$

The sensory quality of popped grains was evaluated by score card method and 9-point Hedonic scale as described by Obatolu *et al.* (2006). The 11 varieties were subjected to organoleptic evaluation by a semi-trained 12 member panel.

The nutritional content (protein, fat, crude fiber, ash) of the raw and popped grains were evaluated as suggested by AOAC (2000). The carbohydrate content was calculated by the difference method. The phytic acid was estimated by the method suggested by Sadasivam and Manickam (1991).

Table 1 Popping characteristics of pearl millet variety

Variety	1000 kernel weight (g)	Popping yield (%)	Puffing index	Size of popped grain (mm)
PC 1201	12.97	70.00	9.29	4.86
PC 383	10.04	68.00	7.15	6.47
HHB 203	10.37	58.00	8.02	6.03
Proagro 9444	9.87	58.00	7.74	4.34
Rasi 1827	8.75	44.00	5.27	5.41
Pioneer 86M74	10.90	43.00	5.91	5.62
HHB 67	10.65	71.00	9.19	6.00
PC 443	7.83	74.00	8.04	6.11
CZP 9802	6.84	85.00	7.91	5.30
PC 701	12.23	60.00	7.35	6.69
Pioneer 86M86	9.92	45.00	6.62	5.11

RESULTS AND DISCUSSION

The 11 varieties of pearl millets were popped and variation in physical popping quality was measured in terms of thousand-kernel weight, popping yield and expansion volume of grain during popping. The results are presented in Table 1.

The pearl millet varieties showed wide variation in thousand-kernel weight with range of 6.75 g to 12.97 g (Table 1). The weight was higher of pearl millet variety PC 1201 as compared to Rasi 1827. This indicated that grains of pearl millet variety PC 1201 was larger and sound than other varieties. Wide variations in thousand kernel weight had also been reported by Haldmani *et al.* (1995), Badu *et al.* (2002) and Varsha (2003).

After popping some grains popped, whereas few remained unpopped as shown in Fig 1, the important popping characteristics like popping yield, puffing index and expansion ratio were determined.

Popping yield

The popping percent ranged from 43.0% (Pioneer 86M74) to 85.0% (CZP 9802). The maximum popping

Fig 1 Popped and unpopped cultivar of pearl millet

yield was found in CZP 9802 of 85% followed by PC 443 (74%), HHB 67 (71%), PC 1201 (70%) and PC 383 (68%). Hence the composites CZP 9802, PC 443 and hybrid HHB 67 were identified as best genotypes for popping. Chauhan *et al*. (2015) also found PC 443 as a genotype for ready to eat popped up snacks. They also reported that if optimum processing conditions are provided popping yield can be increased from 30 to 64%.

Puffing Index

Higher the puffing index, higher is the volume of the popped grains. Puffing index ranged from 5.27 to 9.29.

Expansion ratio

It indicates the increase in size of the raw grain after popping. Higher size of the product is more desirable. The size of popped grain of different pearl millet varieties varied from 2.00 to 5.09 mm (width as major dimension). It was found that there was 58.67% increase in the width of grain after popping and it was higher in composite variety Pusa 1201 and lower in hybrid Proagro 9444. The expansion ratio of different cultivars varied from 9.30 to 7.46, similar findings had also been reported by Chauhan *et al*. (2015).

From the popping charterstics of different pearl millet varieties it was found that five varieties namely, CZP 9802, PC 443, HHB 67, PC 701 and PC 383 of pearl millet have maximum popping yield/percentage (i.e. 85% for CZP 9802), good puffing index and popping size, hence considered best in terms of popping characteristics.

Sensory quality

The varieties HHB 67, CZP 9802, PC 1201, PC 443 and PC 701 liked the most among the eleven varieties (Table 2). The HHB 203 and Proagro 9444 varieties were also liked moderately for colour, flavor, appearance, softness, texture and taste.

Nutrition evaluation of raw and popped grain

The proximate composition of raw and popped grain of selected pearl millet varieties were determined and shown in Table 3.There were increase in the fat, crude fiber, ash and carbohydrate contents of the popped grain of all the varieties as compared to unpopped grains, it was due to increased concentration of these nutrients as the moisture was lost during popping.

The fat content varied from 7.98 to 5.52% and 5.74 to 4.02% in the popped and unpopped grains of pearl millet respectively. The popped grain showed higher fat content. The carbohydrate content varied from 77.18 to 70.73% and 70.77 to 67.90% in the popped and unpopped grains, here the popped grains also showed higher carbohydrate content. Similarly the crude fiber and ash content varied from 4.13 to 2.87%; 2.19 to1.25%; 4.25 to 2.03 and 1.92 to 0.86% in popped and unpopped grains respectively and were higher in popped grains; it was due to increased concentration of these nutrients as the moisture was lost during popping. The hybrid HHB 67 registered maximum ash per cent (4.25%) in the popped grains.

Regarding the quality traits (Table 3), the crude protein content of normal grains varied from 13.22% to 11.14% whereas, popped grains registered 12.53 to 10.02% and the interaction was also found to be significant. The highest crude protein content in the popped product was observed in PC 383 (12.53%). Among all the varieties, crude protein content of the popped grains was slightly lower than raw grains. Similar findings were reported by Nithya *et al*. (2007) who reported loss of crude protein in the heat treated grains which could be due to denaturation and degradation of protein.

Anti nutrient

Among the anti nutrients the phytic acid content of popped varieties was ranged from 435.50 to 207.7 mg/100

Table 2 Sensory evaluation of 11 pearl millet varieties

Variety	Color	Flavor	Softness	Texture	Taste	Appearance	Overall acceptability
PC 1201	7.1	8.0	8.1	8.0	8.0	8.1	8.1
PC 383	7.1	8.0	8.0	8.0	8.0	8.0	8.1
HHB 203	6.6	7.4	7.4	7.5	7.6	7.6	7.5
Proagro 9444	6.10	7.1	6.6	6.6	6.8	7.0	7.1
Rasi 1827	6.06	6.8	6.5	6.4	6.5	6.6	6.8
Pioneer 86M74	7.1	7.8	7.8	7.6	7.8	7.8	7.8
HHB 67	6.9	7.6	7.5	7.4	7.2	7.0	7.1
PC 443	6.6	7.5	7.6	7.6	7.6	7.6	7.6
CZP 9802	7.1	7.6	7.8	7.4	7.6	7.6	7.6
PC 701	6.9	7.6	7.6	8.0	7.8	8.0	8.1
Pioneer 86M86	6.6	6.8	7.0	7.2	6.8	7.0	7.4
SEM	0.013	0.020	0.020	0.043	0.029	0.029	0.004
CD (P=0.05)	0.199	0.241	0.241	0.353	0.288	0.290	0.117

The values are in 3 replications.

Table 3　Proximate compositions of raw and popped varieties of pearl millet

Variety	PC 1201	PC 383	HHB 203	Proagro 9444	Rasi 1827	Pioneer 86M74	HHB 67	PC 443	CZP 9802	PC 701	Pioneer 86M86	Mean	CD (P=0.0 5)
Moisture (%)	10.06±0.17	10.5±0.08	10.35±0.10	11.12±0.06	10.75±0.08	9.34±0.06	10.21±0.14	8.74±0.23	10.40±0.92	10.50±0.25	9.86±0.06	10.21	0.228
(Raw popped)	1.96±0.01	1.97±0.03	1.98±0.05	1.88±0.06	1.83±0.03	1.81±0.05	1.87±0.06	1.84±0.04	1.89±0.03	1.85±0.08	1.87± 0.04	1.87	
Protein (%) (Raw	11.62±0.10	13.14±0.39	12.24±0.07	11.74±0.06	11.19±0.04	11.45±0.05	13.22±0.22	12.14±0.45	12.60±0.20	11.14±0.09	11.67± 0.06	12.01	0.152
popped)	11.33±0.05	12.53±0.27	11.03±0.08	10.75±0.06	10.02±0.05	10.05±0.04	12.04±0.11	11.61±0.26	11.91±0.15	11.11±0.29	10.18±0.15	11.14	
Fat (%) (Raw	4.73±0.11	5.10±0.44	4.49±0.09	5.01±0.01	4.02±0.06	4.98±0.06	5.74±0.06	5.19±0.13	4.8±0.27	5.26±0.17	5.22±0.10	4.96	0.268
popped)	5.52±0.16	6.12±0.33	5.85±0.06	5.62±0.11	6.43±0.16	6.22±0.14	7.79±0.15	7.98±0.15	5.96±0.05	7.98±0.17	5.99±0.08	6.49	
Crude fiber (%)	1.91±0.04	1.99±0.16	1.89±0.08	1.81±0.06	1.90±0.03	1.87±0.06	1.25±0.18	1.95±0.16	2.19±0.17	1.84±0.05	1.68±0.03	1.84	0.111
(Raw popped)	3.00±0.15	3.83±0.08	3.17±0.08	3.67±0.07	3.79±0.06	3.67±0.04	3.33±0.10	3.19±0.20	4.13±0.09	3.75±0.05	2.87±0.06	3.49	
Carbohydrate (%)	70.82±0.74	67.90±0.38	69.76±0.19	70.77±0.15	70.52±0.04	70.77±0.10	67.66±0.18	68.64±0.25	68.25±0.97	69.80±0.32	70.16±0.11	69.55	0.504
(Raw popped)	77.18±0.24	71.63±0.75	76.36±0.09	75.01±0.12	74.26±0.13	75.01±0.21	70.73±0.11	72.32±0.67	73.60±0.18	72.41±0.48	76.10±0.17	74.05	
Ash (%) (Raw	0.86±0.08	1.50±0.06	1.27±0.08	1.59±0.03	1.62±0.03	1.59±0.07	1.92±0.06	1.69±0.09	1.23±0.04	1.67±0.07	1.41±0.07	1.49	0.171
popped)	2.01±0.08	2.24±0.23	2.40±0.06	3.24±0.04	3.67±0.05	3.24±0.06	4.25±0.13	3.95±0.47	3.22±0.04	3.87±0.05	2.99±0.08	3.19	

Table 4　Level of phytic acid in raw and popped varieties of pearl millet

Variety	Phytic acid (mg/100 g)	
	Raw grain	Popped grain
PC 443	516.37	373.82
PC 383	370.00	223.04
PC 701	356.02	209.12
PC 1201	382.11	309.13
CZP 9802	342.14	207.70
HHB 67	405.32	235.30
HHB 203	603.33	435.50
Pioneer 86M74	358.34	221.32
Proagro 9444	366.23	231.06
Rasi 1827	362.44	216.04
Pioneer 86M86	389.30	214.04
Mean	404.69	261.45
t value raw versus popped	17.34*	

The statistical difference at P<.0001.

g and for unpopped varieties of pearl millet ranged from 516.37 to 342.14 mg/100g. It was observed that there was significant (P<.0001) reduction in phytic acid content of popped pearl millet, which may be attributed to the heat treatment. There was 54.78% difference of phytic acid level observed in between raw and popped grains of pearl millet cultivars. The present data was comparable to the concentration that had been reported by Chauhan *et al.* (2015).

Conclusion

The pearl millet can be suitability processed to increase its popularity. Popping is simple economic technique to develop RTE and shelf stable products. In the present study the eleven varieties of pearl millet were evaluated for their popping characteristics and nutrient content. Five varieties namely, CZP 9802, PC 443, HHB 67, PC 701 and PC 383 were found with the highest popping yield and popping index indicates their potential for popping. Product's proximate composition estimated is: 11.1% protein, 6.71 % fat, 3.05 % crude fibers, 1.90 % ash, 73.42% carbohydrate and 1.90% moisture. The information generated from the present study will be very useful in increasing the knowledge bank of the edible varieties, selecting the appropriate ones and exploring nutri- crops for developing more cost effective and healthier RTE products. Thus, pearl millet has considerable scope to be utilized as ready to eat popped up snacks. Also, it has good nutritional quality which will help in developing low cost dietary formulations. Owing to its potential role as high energy food for poor, diabetic people as well as people allergic to gluten, its potentiality for health and nutritional security needs to be explored.

REFERENCES

AOAC. 2000. Official Methods of the Association of official

Agricultural Chemists, 11th edn. Washington DC.

Abdalla A A, El-Tinay A H , Mohamed B E and Abdalla A H . 1998. Proximate composition, starch, phytate and mineral contents of 10 pearl millet genotypes. *Food Chemistry* **63**(2): 243–6 .

Badau M H, Nkama I and Ajalla C O. 2002. Physico-chemical characteristics of pearl millet cultivars in northern Nigeria. *International Journal of Food Properties* **5**(1): 37–47.

Bhati Dashrath, Bhatnagar Vibha and Acharya Vibha. 2016. Effect of pre-milling processing techniques on pearl millet grains with special reference to *in-vitro* iron availability. *Asian J. Dairy and Food Res* **35**(1): 76–80.

Baskaran V, Mahadevamma N G, Malleshi R, Shankara B R and Lokesh. 1999. Acceptability of supplementary foods based on popped cereals and legumes suitable for rural mothers and children. *Plants Foods for Human Nutrition* **53**(3): 237–47.

Chauhan, B M, Suneja N and Bhat C M. 1986. Nutritional value and fatty acid composition of some high yielding varieties of *Bajra. Bull. Grain Technology*. **21**(1): 441–92.

Chauhan S S, Jha S K, Jha G K, Sharma D K, Satyvathi T and Kumari Jyoti. 2015. Germplasm screenining of pearl millet (*Pennisetum glaucum*) for popping characteristics. *Indian journal of Agricultural Sciences* **85**(3): 344–8.

Chaudhary P. 1981. Nutritive value of *bajra* flour as influenced by storage conditions. M Sc thesis, CCS HAU, Hisar.

Chaturvedi A and Sarojini G**.** 1996. Malting of pearl millet (*Pennisetum typhoidum*): its effects on starch and protein digestibility. *Journal of Food Science and Technology* **33**(4): 343–4.

Gupta N, Srivastava A K, Pandey V N. 2012. Biodiversity and nutraceutical quality of some Indian millets*. Proc Natl Acad Sci India Sect B Biol Sci* **82**(2):265–73.

Hadimani N A, Ali S Z and Malleshi N G. 1995. Physicochemical composition and processing characteristics of pearl millet varieties. *Journal of Food Science and Technology* **32**(3): 193–8.

Hoke K, Houska M, Pruchova J, Gabrovska D, Vaculova K and Paulickova I. 2007. Optimization of puffing naked barley. *Journal of Food Engineering* **80**: 1016–22.

Khatak Anita. 2014. 'Evaluation, processing and utilization of pearl millet for preparation of value added RTE snacks.' Ph D thesis, CCSHAU, Hisar.

Kadlag R V, Chavan J K and Kachare D P. 1995. Effects of seed treatments and storage on the changes in lipids of pearl millet meal. *Plant Foods Human Nutr* **45**:279–85.

Nithya K S, Ramachandramurty B and Krishnamoorthy V V. 2006. Assessment of anti-nutritional factors, minerals and enzyme activities of the traditional (Co7) and hybrid (Cohcu-8) pearl millet (*Pennisetum glaucum*) as influenced by different processing methods. *Journal of Applied Sciences Research* **2**(12): 1164–8.

Malleshi N G, Raghavendra Rao S N, Sreedharamurty S and Desikachar H S R. 1986. Development of weaning foods based on some traditional technologies. *J Food Sci Technology* **23**:315–8.

Mirza N, Sharma N, Shrivastav S and Kumar A. 2015. Variation in popping quality related to physical, biochemical and nutritional properties of finger millet genotype. *Proc. Natl. Acad., India Sect. B. Biol Sci.* **85**(2):507–15.

Mishra Gayatri, Joshi, D C and Panda B K. 2014. Popping and puffing of cereal grains: A review. *Journal of Grain Processing and Storage* **1**: 34–46.

Malik M. 1999. 'Functional and nutritional properties of newly developed hybrids and varieties of pearl millet.' M Sc thesis, CCSHAU, Hisar.

Mahajan S. 1986. 'Studies on the improvement of nutritional value of *bajra* through fermentation.' M Sc thesis, CCSHAU, Hisar.

Nambiar V S, Sareen N, Daniel M and Gallego E B 2012. Flavonoids and phenolic acids from pearl millet (*Pennisetum glaucum*) based foods and their functional implications. *Functional Foods in Health and Disease* **2**(7): 251–64.

Nithya K S, Ramachandramurty and Krishnamoorthy V V. 2007. Effect of processing methods on nutritional and antinutritional qualities of hybrid and traditional pearl millet varieties of India. *J. of Biological Sci.* **7**(4): 643–7.

NIN. 2003. *Nutritive value of Indian Foods*. Gopalan and Deosthale (Eds). National Institute of Nutrition, Hyderabad.

Pradeep P M, Dharmaraj U, Sathyendra Rao B V, Senthil A, Vijayalakshmi N S, Malleshi N G and Singh Vasudeva. 2013. Formulation and nutritional evaluation of multigrain ready-to-eat snack mix from minor cereals. *J. Food Sci. Technol*. **51**(12): 3812–20.

Vanisha S Nambiar, Dhaduk J J, Sareen Neha, Shahu Tosha and Desai Rujuta. 2011. Potential functional implications of pearl millet (*Pennisetum glaucum*) in health and disease. *Journal Applied and Pharmaceutical Science* **1**(10): 62–7.

Varsha. 2003. 'Nutritional evaluation and utilization of selected cereals and pulses for value addition of wheat based products.' M Sc thesis, CCSHAU, Hisar.

Waseem M M. 2012. 'Studies on popping and flaking characteristics of selected sorghum cultivars.' M Tech thesis, College of Food Technology. VNMKV, Parbhani.