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Effect of traditional processing on proximate composition of biofortified pearl millet (*Pennisetum glaucum*) varieties

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Abstract

Pearl millet (*Pennisetum glaucum*) has a high scope for utilization as a nutritional food and nutraceutical. It is nutritionally comparable and superior to many other cereals. It requires processing before consumption to enhance the shelf life and increase the nutritional quality. Therefore, the present investigation has focused on the effect of traditional processing (soaking and germination) on the proximate composition of biofortified pearl millet varieties. Moisture, protein, fat, fiber, ash and carbohydrate ranged from 6.59-10.10, 4.49-10.05, 3.93-6.17, 1.02-2.37, 1.13-1.93 and 62.01-76.82 g/100 g respectively. Biofortified variety RHB 234 has high fat and fiber content whereas AHB 1200 have high ash and carbohydrate content even after processing. Control non-biofortified variety Pittaganti has high protein content. All the varieties have shown significant ($p < 0.05$) variation for all the proximates except for carbohydrates ($p > 0.05$). There is a significant ($p < 0.05$) decrease in all the proximates during soaking and germination.

Keywords: Pearl millet, biofortification, proximate composition, soaking and germination

Introduction

In terms of nutritional composition, Pearl millet is an impressive grain. Pearl millet is among the best tropical cereals with superior micronutrient and protein composition and a healthy source of energy. It is also known that pearl millet has a better nutritional profile than sorghum and other major cereals (Gwekwe *et al.*, 2024) [8].

Pearl millet occupies the sixth position in total crops, after rice, wheat, maize, barley and sorghum with 50 percent of the total world's millet production. Pearl millet also known as Bajra is a ubiquitous grain can be used as substitute to paddy, oats, quinoa, and other grain products in many cuisines (Elangovan *et al.*, 2024) [5].

In India, pearl millet is the principal source of dietary energy (360 k.cal/100 g) for rural populations in drier parts of the country. It is a rich source of protein, fat, calcium, phosphorous and iron. Pearl millet comprises a fairly high amount of thiamine, riboflavin and niacin. The energy level is highest among whole grain cereals. It is nutritionally comparable and superior to many cereals (Gupta *et al.*, 2022) [7].

Despite the beneficial effects of pearl millet, the consumption of millet as food has significantly declined over the past three decades. The major reasons for a decrease in its consumption are attributed to a lack of awareness of nutritional merits, inconveniences in food preparation, lack of processing technologies and also the government policy of disincentives towards millet grain production. Efforts have been made to scale up and optimize the utilization of millet and its products in an attempt to realize and derive the benefits thereof (James *et al.*, 2022) [9].

Materials and Methods**Details of the Experimental Material**

The experiment material used for the study was four biofortified varieties and one control variety (ABV-04, AHB-1200, RHB 234, Dhan Shakti and Pittaganti) which were collected from ICAR institutes, ICRISAT and State Agricultural Universities.

Pre-preparation of sample

Grains were thoroughly cleaned to remove extraneous matter and dried at 45 ± 5 °C to maintain the moisture content at 12 percent.

Soaking and Germination

Cleaned raw grains were soaked in water in a ratio of 1:3 for 12 h at 30 ± 2 °C. The soaked grains were stirred periodically to remove the gases accumulated around the grains and the steep water was changed after every 2 h interval to prevent the growth of undesirable microbes. The grains were dried at 60 ± 2 °C using a tray dryer to 13% moisture content.

After drying pearl millet grains were washed in water and subjected to the germination process for 24, 48 and 72 hours separately as given by Sara and Valerie (2016) ^[11] method with some modifications such as using a muslin cloth and drinking water for soaking to avoid contamination.

Raw, Soaked and germinated grains after drying were milled and sieved to form raw pearl millet flour, soaked pearl millet flour and germinated pearl millet flour separately.

Proximate Composition

The proximate analysis is a quantitative method to determine different macronutrients present in pearl millet grain. It is the partition of seed compounds into various categories such as moisture (g %), crude protein (g %), fat (g %), crude fibre and crude ash (g %), was estimated as per AOAC method (2006) ^[2]. Carbohydrate (g %) and energy (k.cal) was estimated by differential method.

Results and Discussion

There is a significant decrease in all the proximates as shown Table.1. The percent retention of the proximate is given in the Table. 2.

Table 1: Effect of processing on proximate composition of biofortified pearl millet

Variety	Processed grains	Moisture	Protein	Fat	Fiber	Ash	Carbohydrate
		g/100 g (% retention)					
Control (Pittaganti)	1	9.02	10.05	5.19	2.28	1.87	75.67
	2	7.83 (86.81)	9.47 (94.23)	4.77 (91.91)	2.20 (96.49)	1.67 (89.30)	72.59 (95.93)
	3	7.79 (86.36)	9.19 (91.44)	4.50 (86.71)	1.73 (75.88)	1.60 (85.56)	70.19 (92.76)
	4	7.50 (83.15)	8.78 (87.36)	4.37 (84.20)	1.67 (73.25)	1.47 (78.61)	63.64 (84.10)
	5	6.59 (73.06)	8.94 (88.96)	4.13 (79.58)	1.67 (73.25)	1.40 (74.87)	63.10 (83.39)
ABV-04	1	8.75	8.62	4.74	1.50	1.60	71.07
	2	7.64 (87.31)	8.60 (99.77)	4.47 (94.30)	1.46 (97.33)	1.47 (91.88)	70.30 (98.92)
	3	7.79 (89.03)	8.04 (93.27)	4.14 (87.34)	1.20 (80.00)	1.33 (83.13)	70.49 (99.18)
	4	7.45 (85.14)	7.68 (89.10)	4.12 (86.92)	1.14 (76.00)	1.33 (83.13)	62.82 (88.39)
	5	6.71 (76.69)	7.47 (86.66)	4.04 (85.23)	1.13 (75.33)	1.34 (83.75)	62.48 (87.91)
AHB 1200	1	9.74	6.90	5.87	2.19	1.93	76.82
	2	7.46 (76.59)	6.70 (97.10)	5.37 (91.48)	1.98 (90.41)	1.47 (76.17)	74.01 (96.34)
	3	7.51 (77.10)	6.37 (92.32)	5.08 (86.54)	1.14 (52.05)	1.40 (72.54)	73.86 (96.15)
	4	7.80 (80.08)	5.31 (76.96)	5.03 (85.69)	1.24 (56.62)	1.67 (86.53)	63.09 (82.13)
	5	7.01 (71.97)	4.78 (69.28)	4.93 (83.99)	1.22 (55.71)	1.67 (86.53)	65.08 (84.72)
Dhanshakti	1	8.69	8.78	5.05	1.50	1.93	73.63
	2	8.06 (92.75)	8.61 (93.51)	4.69 (92.87)	1.49 (99.33)	1.27 (65.80)	69.22 (94.01)
	3	7.92 (91.14)	8.04 (91.57)	4.21 (83.37)	1.02 (68.00)	1.33 (68.91)	67.48 (91.65)
	4	7.22 (83.08)	8.00 (91.12)	4.07 (80.59)	1.12 (74.67)	1.27 (65.80)	66.84 (90.78)
	5	6.79 (78.14)	6.17 (70.27)	3.93 (77.82)	1.24 (82.67)	1.40 (72.54)	62.01 (84.22)
RHB 234	1	10.10	6.70	6.17	2.37	1.73	75.22
	2	8.00 (79.21)	6.37 (95.07)	5.58 (90.44)	2.19 (92.41)	1.33 (76.88)	70.68 (93.96)
	3	8.19 (81.09)	5.76 (85.97)	4.77 (77.31)	1.23 (51.90)	1.13 (65.32)	69.25 (92.06)
	4	7.58 (75.05)	5.15 (76.87)	4.68 (75.85)	1.28 (54.01)	1.47 (84.97)	66.94 (88.99)
	5	7.13 (70.59)	4.49 (67.01)	4.68 (75.85)	1.28 (54.01)	1.53 (88.44)	64.50 (85.75)
Mean		7.85	7.38	4.74	1.54	1.51	68.84
Range		6.59-10.10	4.49-10.05	3.93-6.17	1.02-2.37	1.13-1.93	62.01-76.82
SEM		0.28	0.25	0.15	0.11	0.13	2.89
SED		0.39	0.36	0.21	0.17	0.19	4.09
C.D.		6.16	5.91	5.55	13.41	15.37	7.28
C.V.		0.79	0.71	0.43	0.34	0.38	8.22

1- Raw grains, 2- soaked grains, 3- 24 hr sprouted grains, 4- 48hr sprouted grains, 5- 72 hr sprouted grains

Moisture

There is a significant ($p < 0.05$) variation of moisture for different varieties at soaking and different periods (24, 48 and 72 hours) of germination. RHB 234 variety have shown significantly low ($p < 0.001$) moisture retention (70.59%) followed by AHB 1200 (71.97%) after 72-hour germination whereas control has recorded low moisture content (6.59 g/100 g) after 72 hour germination followed by ABV 04 (6.71 g/100 g) and Dhanshakti (6.79 g/100 g).

Similar results were observed in the study of Mane *et al.* (2023) ^[13] where the moisture content was reduced from 8.55 to 7.23 and 8.65 to 7.25 in germinated finger millet and foxtail millet flours respectively. Bajaj *et al.* (2021) ^[4] reported a significant decrease in moisture content (-18.60 to -28.59%) of malted flours of two varieties compared to unprocessed flour similar to the results obtained in the present study.

Protein

Highest protein content was observed in soaked control grains (9.47 g/100 g) even after 72-hour germination control has high protein content (8.94 g/100 g). Among biofortified varieties ABV 04 has high protein content 7.47 g/100 g after 72 germination followed by Dhanshakti with 6.17 g/100 g. RHB 234 has shown a significantly ($p < 0.01$) low retention rate (67.01%) and content (4.49 g/100 g) of protein after 72 hours of germination, while high retention is observed in control (88.96%) followed by ABV 04 (86.66%) after 72 hour germination when compared to the other varieties.

Reduction in crude protein content concerning soaking treatment might be due to the leeching out of low-weight nitrogen compounds into the leachate. The decrease in protein content in response to sprouting treatment may be due to the transfer of nutrients to the growing embryo. Elbaloula *et al.* (2014) [6] reported that the protein content decreased significantly during three days of germination. This might be due to the part of the protein was utilized for embryo growth and development. Ali and Elozeiri, 2017 [1] reported that antitryptic and antichymotryptic activities were observed to be markedly reduced in the endosperm of finger millet on germination which might be attributed to the proteolytic activity in hydrolysis of the inhibitory proteins. Hydrolysis of stored proteins produced free amino acids, which support protein synthesis in endosperm and embryo and so proceeding of the germination process

Fat

Fat has shown highly significant variation ($p < 0.001$) among all the varieties during processing. RHB 235 72-hour germinated grains have shown non-significant low-fat retention (75.85%) followed by significant high retention observed in ABV 04 with 85.23%. Dhanshakti has recorded significantly low-fat content (3.93g/100 g) after 72-hour germination.

Bajaj *et al.* (2021) [4] reported that malting, blanching and roasting of HC-20 and Dhanshakti varieties, caused a 3.71 to 18.90 and 2.37 to 21.20 percent, decrement in the fat value, respectively. This reduction of fat in germinated flours (malt) was explicated to enhance lipolytic enzyme activity or to utilize grain nutrients by growing shoots during germination. Elbaloula *et al.* (2014) [6] have statistically presented that oil content decreased significantly at the second and third day of grain germination in the study which might be attributed to the biochemical and physiological changes that required bioenergy. Thus, part of oil was used for endogenous energy formation.

Crude fiber

All the varieties have shown significant variation ($p < 0.05$) during soaking and germination for crude fiber. Dhanshakti had highly significant ($p < 0.001$) low fiber content (1.02 g/100 g) after 24-hour germination and RHB 234 recorded low retention after 48 and 72-hours germination (54.01%). High retention of 75.33% was observed in ABV 04 after 72-hour germination. High fiber content was found in control (1.67 g/100 g) after 72-hour germination.

Arora *et al.* (2011) [3] revealed that the dietary fiber contents of the germinated food blend were significantly ($p < 0.05$) lower as compared to the non-germinated food blend. It might be because germination caused a significant reduction in all the dietary fiber components. The decrease in the polysaccharide and mucilage content may be attributed to

their breakdown and utilization by the growing sprouts. Bajaj *et al.* (2021) [4] reported a decrease in dietary fiber from 11.83 to 11.33 after germination for 72 hours in two pearl millet varieties studied but there is an increase in crude fiber and many other studies such as, Sharma *et al.* (2023) [12], Mane *et al.* (2023) [13]; Kumar *et al.* (2021) have shown an increase in crude fiber after germination.

Ash

There is a significant decrease ($p < 0.001$) in the ash content of the varieties studied during processing. The lowest ash content was observed in 24-hour germinated grains of RHB 234 (1.13 g/100 g). Highest was observed in control-soaked grains (1.67 g/100 g). Dhanshakti grains have shown significantly low retention (72.54%) after 72-hour germination. Significantly ($p < 0.01$) high retention was observed in soaked grains of ABV 04 (91.88%)

According to Bajaj *et al.* (2021) [4], malted flours ash (mineral matter) decreased by 4.83 to 8.99 percent, in comparison to unprocessed, and this may be owing to leaching and loss of mineral ions from grains soaked in water, a step during malting, or due to their utilization by the growing sprouts.

Carbohydrate

Processing has shown both increased and decreased patterns of carbohydrates. There is no significant ($p > 0.05$) variation of carbohydrates during processing. Control (83.39%) has shown low retention followed by Dhanshakti (84.22%) after 72 hours of germination and high retention was recorded by ABV 04 (99.18%) soaked grains.

Kumar *et al.* (2021) [10] revealed that reducing sugars increased from an initial 0.86% to 10.54% and total sugars from 1.70% to 16.10% after 96 h of germination. The increase in sugars and decrease in starch might be due to the breakdown of starch into sugars during germination. Seed germination is a complex phenomenon in which due to the activity of hydrolytic enzymes starch is broken down to sugars and other intermediates. Ali and Elozeiri, (2017) [1] reported that the starch content of sorghum flour decreased significantly ($p < 0.05$) during 3 days of grain germination. It could be the result of starch hydrolysis to monosaccharide by hydrolytic enzymes, which were used as an energy source during grain germination and embryo growth. The decrease in carbohydrates after germination may be due to consumption as a source of energy during the germination process.

The reduction in carbohydrate content is important for the preparation of low energy, high fiber products and also having slightly lower glycemic index in prepared products (Mane *et al.*, 2023) [13].

Conclusion

There is a significant decrease in the proximate composition of biofortified pearl millet varieties after soaking and germination, which might be because of leeching out of nutrients into soaked water and utilization by the growing sprouts. Even though there is a decrease in nutrient content the bio accessibility of minerals and protein digestibility can be improved due reduction of antinutrients and inhibitors. Processing has reduced the fat content which considered to be a significant challenge for pearl millet due its high lipid composition. Hence the traditional processing methods

soaking and germination can enhance the quality and prolong the shelf life of pearl millet.

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