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Processing Driven Impact on Functional and Nutritional Profile of Pearl Millet

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ABSTRACT

Background: Pearl millet (*Pennisetum glaucum*) is one of the major food crops in most of the arid and semi-arid cropping regions of India being the fourth most important cereal crop. Though rich in nutrients, presence of anti-nutrients reduces nutrient bioavailability in grains. The present study focuses on the impact of different processing methods on functional and nutritional profile of pearl millet flour (PMF).

Methods: In present investigation, pearl millet grains were subjected to different processing treatments *viz*. roasting, blanching and malting and the post treatment effect on functional and nutritional profile of PMFs was studied. The influence of processing on functional properties, proximate, mineral and anti-nutrient composition of PMFs was studied.

Result: Results revealed that processing treatments significantly affected the functional and nutritional profile of PMFs with reference to untreated PMF. Functional property assessment of PMFs depicted that, roasting enhanced the water holding capacity (371.24%) and swelling power (6.10%) of PMF while reduced the other functional properties. Blanching negatively impacted foaming capacity (3.52%) and stability (2.46%). Malting enhanced oil holding capacity (150.95%), emulsion capacity (38.51%) and stability (32.93%). Results for post treatment effects on nutritional profile of PMFs remarked malting as best in terms of nutritional enhancement with anti-nutrient reduction than roasting and blanching.

Key words: Anti-nutrients, Functional properties, Nutritional properties, Pearl millet, Processing.

INTRODUCTION

Pearl millet (*Pennisetum glaucum*) is one of the major food crops in most of the arid and semi-arid cropping regions of India being the fourth most important cereal crop. The higher ratio of germ to endosperm is responsible for the higher protein content (Dendy, 1995). Though pearl millet is grown mainly for human consumption, it also serves as fodder for cattle and raw material for cattle feed industries. Though pearl millet is considered as a poor man's crop, it is rich in protein, fat and mineral contents. It is also rich in zinc and iron comparatively to other cereals.

Pearl millet has a high nutritional value but bioavailability is low, due to presence of anti-nutritional factors, such as phytic acid, polyphenols and tannins. These act on iron and zinc bioavailability (Camara and Amaro, 2003). Depending on their localization in cereal grains, the proportions of these anti-nutrients in diet can be reduced by roasting, malting, germination, *etc.* (Kheterpaul and Chauhan, 1991). Beside its nutritional availability, pearl millet contains significant amount of inositol hexaphosphates (IP6) generally referred to as phytic acid or phytates. Phytate has been recognized as an antinutritional factor affecting the bioavailability of major minerals such as calcium and phosphorous and trace ones such as zinc, iron, copper and manganese.

Other antinutrients of relevant importance are tannins and polyphenols, which are known to limit the utilization of it as a food. Decreasing of phytic acid is very important and advantageous as well, due to its influence on nutritional aspect. Therefore, interest has been grown to reduce its antinutritional effects (Mahajan and Chauhan, 1987).

Hence, the present investigation was carried out to study the effects of various processing treatments on the chemical composition in reference to enhancement in functional and nutritional profile along with reduction in anti-nutrients in treated pearl millet flours.

MATERIALS AND METHODS

Materials

Pearl millet grains, purchased from local market of Pune, were cleaned, freed from foreign materials including broken

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and shrunken seeds. The seeds were divided into four parts and kept for processing studies.

Processing treatments

Untreated pearl millet flour

Pearl millet grains were properly cleaned and milled in hammer mill (Sanco Valves Pvt. Ltd., Navi Mumbai, India) and sieved through 40 mesh sieve size to obtain plain or untreated pearl millet flour.

Roasted pearl millet flour

Pearl millet grains were properly cleaned and roasted for 10 mins at 80°C, then milled in hammer mill (Sanco Valves Pvt. Ltd., Navi Mumbai, India) and sieved through 40 mesh sieve size to obtain roasted pearl millet flour.

Blanched pearl millet flour

Pearl millet grains were properly cleaned and were blanched at 98°C for 30s followed by sun drying, then milled in hammer mill (Sanco Valves Pvt. Ltd., Navi Mumbai, India) and sieved through 40 mesh sieve size to obtain the blanched pearl millet flour.

Malted pearl millet flour

The pearl millet grains were properly cleaned and were soaked overnight in water at room temperature. Then the grains were placed in muslin cloth and frequently watering was done for full 48 h. The sprouted seeds were then kiln dried at 60°C and rootlets were removed and then grains were milled in hammer mill (Sanco Valves Pvt. Ltd., Navi Mumbai, India) and sieved through 40 mesh sieve size to obtain malted pearl millet flour.

Functional parameters

Water absorption capacity and oil absorption capacity of flours were measured by the centrifugation method described by Sathe *et al*. (1982) as modified by Fagbemi (2008). Emulsion activity and Emulsion stability were calculated as described by Yasumatsu *et al.* (1972). Foam capacity and Foam stability were estimated as described by Narayana and Narsinga Rao (1982). Swelling power and water solubility were determined by centrifuge method described by Sosulski (1962) with slight modification.

Proximate composition

Processed PMF samples were evaluated for moisture, crude fat, crude protein, crude fibre, ash content and carbohydrate using standard methods (AOAC, 2005).

Mineral composition

Mineral analysis of processed PMFs was carried out on samples digested with hydrochloric acid. Minerals calcium was estimated titrimetrically by standard method (AOAC, 2005). Total iron was analyzed by colorimetric method given by Ranganna (1986). Total phosphorous content was estimated by colorimetric method as described by Chapman and Pratt (1982).

Antinutritional factors

Processed PMFs were assessed for various anti-nutritional factors *viz*. phytic acid, tannins and total polyphenols. Phytic acid was determined by standard procedure of Wheeler and Ferrel (1971). The tannin content was determined by calorimetric method using Folin-Denis reagent whereas total polyphenols content was determined by modified Folin-Ciocalteu calorimetric method using gallic acid as standard (AOAC, 2005).

Statistical analysis

Each sample was analyzed in triplicate. The figures then were averaged. The data obtained was analyzed statistically using standard methods given by Snedecor and Cochran (1990) and by Duncan's multiple range test with the probability $p \leq 0.05$ (Duncan, 1955).

RESULTS AND DISCUSSION

Functional properties

Water holding capacity means the ability of flours to hold water which plays an important role as a functional attribute of the flours. From data recorded for the functional properties of processed PMFs (Table 1), it was observed that processing of pearl millet grains *i.e*., roasting, blanching and

Table 1: Functional properties of pearl millet flour as influenced by processing.

Properties	UPMF	RPMF	BPMF	MPMF
Water holding capacity (%)	345.93±0.42^{c}	371.24±0.23^{a}	356.15±0.18^{b}	327.53±0.21^{d}
Oil holding capacity (%)	125.12±0.08^{c}	119.33±0.14^{d}	134.44±0.29^{b}	150.95±0.27^{a}
Emulsion activity (%)	34.95±0.03^{c}	32.28±0.06^{d}	36.82±0.02^{b}	38.51±0.03^{a}
Emulsion stability (%)	30.36±0.13^{c}	28.18±0.21^{d}	31.86±0.23^{b}	32.93±0.16^{a}
Foaming capacity (%)	4.87±0.08^{a}	2.36±0.11^{d}	3.52±0.05^{b}	2.75±0.16^{c}
Foam stability (%)	5.23±0.05^{a}	2.12±0.01^{d}	2.46±0.02^{b}	2.33±0.01^{c}
Swelling power at 85°C (g/g)	5.75±0.02^{c}	6.10±0.03^{a}	5.82±0.02^{b}	3.67±0.03^{d}
Water solubility (g/g)	0.16±0.01^{b}	0.08±0.02^{d}	0.12±0.02^{c}	0.55±0.04^{a}

UPMF = Untreated pearl millet flour, RPMF = Roasted pearl millet flour, BPMF = Blanched pearl millet flour, MPMF = Malted pearl millet flour.
Each value is the average of three determinations.
Values are means (± standard deviation).
Means not sharing a common superscript letter(s) in a row are significantly different at $p \leq 0.05$ as assessed by Duncan's multiple-range test.

malting significantly affected the water holding capacity of respective flours. Samples treated with roasting and blanching processes showed increase while those treated with malting process showed decrease in water holding capacity as compared to untreated PMF. This variation in water holding capacity of processed PMF may be due to changes in particle size and the protein content of the flour due to processing (Kinsella, 1976).

Oil holding capacity means the ability of flours to hold oil which influences the flavour retention capacity of the flours and the mouth feel of the products (Adebowal *et al.*, 2004). The oil holding capacity of treated PMFs recorded to be 125.12, 119.33, 134.44 and 150.95 % for UPMF, RPMF, BPMF and MPMF, respectively. The higher oil holding capacity of the PMF could be due to its higher fat contents, which can entrap more oil. Basically, the mechanism of oil holding capacity is mainly due to the physical entrapment of oil by capillary attraction (Kinsella, 1976). Also processing of pearl millet grains i.e., roasting, blanching and malting caused changes in the fats which might have significantly affected the oil holding capacity of respective flours.

Emulsion activity of treated PMF ranged between 32.28 to 38.51%. The highest emulsion activity was observed for MPMF (38.51%) whereas the lowest emulsion activity was observed in case of RPMF (32.28%). Emulsion stability of different PMFs varied from 32.93 to 28.18%. Highest emulsion stability was observed for MPMF (32.93%) followed by BPMF (31.86%) while RPMF showed lowest emulsion stability *i.e.,* 28.18%. The variation in emulsion activity and emulsion stability of PMF samples may be the resultant effect of processing treatments on the protein fractions of the PMFs.

Foaming capacity and stability of flours are greatly affected by the type of protein molecules present in them as it may be related to the surface tension of air/water interface caused by protein molecules. The foaming capacity of treated PMFs were 4.87, 2.36, 3.52 and 2.75% for UPMF, RPMF, BPMF and MPMF, respectively. The foam stability of treated PMFs were 5.23, 2.12, 2.46 and 2.33 % for UPMF, RPMF, BPMF and MPMF, respectively. The highest foam capacity was observed to be highest for UPMF (4.87%) and lowest for RPMF (2.36%) whereas foam stability was observed to be highest UPMF (5.23%) and lowest for RPMF (2.12%). An inverse relation between foam capacity and stability was observed among all flours. The variation in foaming capacity and foaming stability of treated PMFs may be attributed to effect of processing on the protein molecules that altered the functionality of flours.

Swelling power is ability index of starch granules to imbibe water and swell. Higher swelling power represents the larger extent of associative forces within the granules (Moorthy and Ramanujam, 1986). The swelling power of PMFs observed to be significantly affected by processing treatments. Roasting and blanching of pearl millet caused increase while malting caused decrease in the swelling power of PMF samples. Dorporto *et al*., (2011) reported that swelling power is temperature dependent and accompanied by solubilization of starch granule constituents.

The water solubility of PMFs recorded to be decreased in roasted and blanched PMFs whereas increased in malted PMF. High solubility in malted PMF was attributed to high amylose content which leached out easily during swelling process (Sanni, *et al*., 2001). Furthermore, high amylose content was also linked with low swelling power due to greater reinforcement of amylose molecules (Hoover, 2001).

Proximate composition

The proximate composition of PMFs was significantly affected by processing of pearl millet grains in comparison to plain flour (Table 2). Roasting of pearl millet caused decrease in moisture from 12.23 to 10.47%, protein content from 9.78 to 9.03%, fat content from 6.83 to 6.11% and crude fiber content from 1.02 to 0.84% with increase in ash content from 1.65 to 1.88% and carbohydrate content from 69.51 to 72.51%. Blanching of pearl millet decreased the moisture, ash and crude fiber content to 11.95, 6.72 and 0.98%, respectively, while increased the protein, fat and carbohydrate contents to 10.14, 6.72 and 69.61%, respectively. Malting of pearl millet caused decrease in ash and fat contents to 1.42 and 5.91%, respectively whereas increase in moisture, protein, fibre and carbohydrate contents to 12.61, 10.38, 1.17 and 69.68%, respectively.

Table 2: Effect of processing on proximate composition of pearl millet flour.

Properties	UPMF	RPMF	BPMF	MPMF
Moisture (%)	12.23±0.34^b	10.47±0.34^c	11.95±0.37^b	12.61±0.35^a
Protein (%)	9.78±0.26^c	9.03±0.38^d	10.14±0.22^b	10.38±0.13^a
Fat (%)	6.83±0.18^a	6.11±0.24^b	6.72±0.26^a	5.91±0.11^b
Ash (%)	1.65±0.041^b	1.88±0.027^a	1.58±0.044^c	1.42±0.026^d
Crude fibres (%)	1.02±0.037^b	0.84±0.008^d	0.98±0.008^c	1.17±0.016^a
Carbohydrates (%)	69.51±1.33^b	72.51±1.59^a	69.61±1.64^b	69.68±1.92^b
Energy (Kcal)	378.63±0.49^c	381.15±0.58^a	379.48±0.58^b	373.43±0.70^d

UPMF = Untreated pearl millet flour, RPMF = Roasted pearl millet flour, BPMF = Blanched pearl millet flour, MPMF = Malted pearl millet flour.

Each value is the average of three determinations.

Values are means (± standard deviation).

Means not sharing a common superscript letter(s) in a row are significantly different at $p \leq 0.05$ as assessed by Duncan's multiple-range test.

Table 3: Mineral composition of treated pearl millet flours.

Properties	UPMF	RPMF	BPMF	MPMF
Calcium	43.12±1.73[c]	39.75±1.42[d]	52.46±1.26[b]	53.67±1.12[a]
Phosphorus	275.45±2.33[a]	263.33±2.37[b]	251.58±3.37[c]	236.24±2.42[d]
Iron	6.56±0.04[a]	4.27±0.01[d]	5.33±0.05[b]	4.84±0.02[c]

UPMF = Untreated pearl millet flour, RPMF = Roasted pearl millet flour, BPMF = Blanched pearl millet flour, MPMF = Malted pearl millet flour.
Each value is the average of three determinations.
Values are means (± standard deviation).
Means not sharing a common superscript letter(s) in a row are significantly different at $p \leq 0.05$ as assessed by Duncan's multiple-range test.

Table 4: Mineral and anti-nutritional composition of treated pearl millet flours.

Properties	UPMF	RPMF	BPMF	MPMF
Phytic acid	615.42±3.02[a]	438.53±3.06[b]	396.67±3.01[c]	307.95±3.04[d]
Tannins	226.87±1.05[d]	232.68±1.04[b]	231.57±1.03[c]	239.31±1.03[a]
Polyphenols	405.56±2.05[a]	284.59±2.01[c]	336.38±2.04[b]	272.31±2.03[d]

UPMF = Untreated pearl millet flour, RPMF = Roasted pearl millet flour, BPMF = Blanched pearl millet flour, MPMF = Malted pearl millet flour.
Each value is the average of three determinations.
Values are means (± standard deviation).
Means not sharing a common superscript letter(s) in a row are significantly different at $p \leq 0.05$ as assessed by Duncan's multiple-range test.

The moisture contents of all flour samples were under the maximum allowable limits (*i.e.,* 13%) as per the recommendations of FAO/WHO to be fit for human consumption. The reduction in moisture content of RPMF may be attributed to the drying effect due to roasting (Komeine *et al*., 2008). The decrease in protein content of RPMF might be due to alteration of structures of endogenous protein due to roasting (Fasasi, 2009). Malting significantly increased the protein content of PMF compared to BPMF and RPMF. This phenomenon maybe the result of protein biosynthesis during malting (Tian *et al.,* 2010). Reduction in ash content in case of BPMF and MPMF may be attributed to losses due to leaching of soluble inorganic salts (Akinola *et al.*, 2017).

Mineral composition

PMF samples were analyzed for their minerals *viz.* calcium, phosphorus and iron content (Table 3). Among the treated PMFs, the highest calcium content was recorded for MPMF (53.67 mg/100 g) followed by BPMF (52.46 mg/100 g) whereas lowest calcium content was observed in case of RPMF (39.75 mg/100 g). This variation may be the effect of high temperature during roasting which resulted in higher losses of calcium. UPMF recorded highest phosphorus content (275.45 mg/100 g), RPMF being the intermediate (263.33 mg/100 g) whereas MPMF contained lowest phosphorus content (236.24 mg/100 g). Among the PMFs, UPMF contained highest iron content (6.56 mg/100 g) followed by BPMF (5.33 mg/100g) whereas the lowest iron content was observed in RPMF (4.27 mg/100 g).

The overall results with respect to minerals in PMFs were more or less similar to earlier reports given in the literature. Decrease in mineral content of roasted PMF may be attributed to the application of heat which has the tendency to induce both nutritional and biochemical variation in food composition (Yarkwan and Uvir, 2014).

Anti-nutritional factors

Pearl millet flours were analyzed for their anti-nutrients like phytic acid, tannins and polyphenols (Table 4). Processing of pearl millet grains, *i.e.*, roasting, blanching and malting, caused decrease in phytic acid content (615.42 to 307.95 mg/100 g) and total polyphenol content (405.56 to 231.57 mg/100 g) while increase in tannins content (226.87 to 239.31 mg/100 g) in the respective flours. Variation in phytic acid, tannins and polyphenol content among treated pearl millet flours can be attributed to flour type, extraction rate and both genetic and environmental conditions. Kheterpaul and Chauhan (1991) reported pearl millet with a value of 990 mg/100 g of phytic acid, Kumar and Chauhan (1993) reported value of 825.7 mg/100 g. The polyphenol content of pearl millet was reported to be 761 mg/100 g (Kheterpaul and Chauhan, 1991). Abdelrahman *et al*. (2005) reported that the phytic acid and polyphenol contents of pearl millet cultivars ranged from 969.3 to 1101.0 mg/100 g and 306.65 to 669.39 mg/100 g, respectively. Tannins and polyphenol compounds bind proteins, carbohydrates and minerals thus reducing their digestibility (Linda and Rooney, 2006).

CONCLUSION

The results obtained in the present investigation and with reference to observations of various researchers, it is reported that processing of pearl millet grains can be helpful in obtaining desired effect in functional properties and nutritional profile. Also, processing of pearl millet by roasting, blanching and malting can be useful in destruction of antinutrients with increased bioavailability of essential nutrients. Among all treatments, malting recorded better results in terms of improvement in both functional and nutritional profile of pearl millet.

Conflict of interest: None.

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