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Influence of depigmentation of pearl millet (*Pennisetum glaucum L.*) on sensory attributes, nutrient composition, in vitro protein and starch digestibility of pasta

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Abstract

The effect of depigmentation on sensory characteristics and nutritional parameters of pearl millet pasta was studied. Pearl millet grains were depigmented by soaking in 0.2 N hydrochloric acid for 18 h, fol1owed by washing, blanching (98 °C for 30 s) and sun drying. Three types of pasta were prepared, from refined flour (control), native or unprocessed pearl millet (T-1) and depigmented pearl millet (T-II). Results indicated that depigmentation of pearl millet significantly ($P \leqslant 0.05$) improved the sensory attributes especially the colour of pasta. The protein, fat, ash and dietary fibre contents of pearl millet-based pastas (T-I and T-II) were significantly ($P \leqslant 0.05$) higher than those of the control pasta. Depigmentation significantly ($P \leqslant 0.05$) improved the in vitro protein and starch digestibilities by 6.56% and 16.9%, respectively in T-II pasta as compared with T-I pasta. On the other hand, decreases of 6.74% in protein and 4.01% in total dietary fibre were observed due to depigmentation in T-II pasta. The above results indicated that depigmentation was an effective processing technique for developing acceptable pearl millet products with better in vitro protein and starch digestibility.

Keywords: Depigmentation; Dietary fibre; In vitro protein digestibility; In vitro starch digestibility; Pasta pearl millet; Sensory attributes

1. Introduction

Pearl millet (*Pennisetum gluacum* L.), is one of the most important drought tolerant crops of the arid and semi-arid regions of the world; it is able to grow successfully on infertile land whereas other crops fail to survive. In India, pearl millet is grown for providing feed for cattle and food to sustain lives of the poor people. Its nutritive value, the especially protein, fat and mineral contents (Abadalla, Tinay, Mohamed, & Abadalla, 1998; Archana, Sehgal, Kawatra & Joshi, 1999; Radimam, Ali, & Malleshi, 1995), is comparable or even superior to those of other cereal food grains. Pearl millet no doubt has a great nutritional significance but certain polyphenolic pigments present in pericarp, aleurone and endosperm regions of the pearl millet seeds impart undesirable grey colour and taste to its products (McDonough & Rooney, 1989). This is one of the reasons for its poor acceptability by rice/wheat eaters and why it remains as a food for only economically weaker populations. Removal of these pigments to obtain white flour as the major objective of pearl millet processing.

Reichert (1979) first observed that the polyphenolic pigments present in pearl millet were pH sensitive. Various soaking media, with a range of pH have been tested to obtain bleached pearl millet. Acidic pH was found to be most effective and was advocated for obtaining white pearl millet flour (Naikare, Chavan & Kadam, 1986; Panwal & Pawar, 1989). Literature reports of the effect of acid soaking on sensory attributes and nutritional potential of pearl millet products are absent. Therefore the present study was conducted to investigate the influence of depigmentation of pearl millet on sensory and nutritional quality of pasta.

2. Materials and methods

2.1. Material

Pearl millet (*Pennisetum glaucum* L.), variety HHB-67, was procured from *Bajra* Section of the Department of Plant Breeding, CCS Haryana Agricultural

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University, Hisar, India, in a single lot. Refined flour, chickpea flour (flour obtained from chickpea splits) and other ingredients were purchased from the local market. All samples were screened to remove broken and cracked grains, weed seeds and other extraneous material.

2.1.1. Soaking

The cleaned pearl millet grains (200 g) of uniform size were soaked in a germination dish using double the amount of 0.2 N hydrochloric acid (HCl) prepared in distilled water. The mouth of the dish was covered with a muslin cloth and the grains were allowed to soak for 18 h at room temperature (30–35 °C). A period of 18 h was used as this duration has been reported to be effective for improving the colour of pearl millet without much affecting its nutritive value (Panwal & Pawar, 1989). During the soaking period, grains were rotated occasionally by a glass rod to facilitate the depigmentation.

2.1.2. Washing

Water was drained off, cloth was removed and the acid soaked grains were thoroughly washed, about 6–7 times, with distilled water.

2.1.3. Blanching and drying

Washed pearl millet grains were subjected to blanching in order to remove residual hydrochloric acid, if any, and to inactivate lipase enzyme (Archana, Sehgal, & Kawatra, 1997). For blanching, distilled water was brought to boiling (98 °C) in an aluminium container. The depigmented grains were added to boiling water in the ratio 1:5 and boiled for 30 s. Blanched pearl millet grains were then sun-dried.

The pearl millet grains, obtained after the depigmentation process, were of a light colour instead of grey. Depigmented pearl millet grains were milled to flour in an electrical grinder (Cyclotec M/S tecator, Hoganas, Sweden) and the resultant flour was stored in an airtight container for further use.

2.2. Formulation of pasta

2.2.1. Types

Three types of pasta, i.e. Control, T-I and T-II were prepared from refined flour, native or unbleached pearl millet and depigmentated pearl millet, respectively. Chickpea flour was also added to pearl millet pastas in order to improve the nutritive value, especially the protein content. Description of the ingredients of test food products is given in Table 1.

2.2.2. Method of preparation of pasta

Each type of pasta was prepared separately using the particular ingredients (Table 1). All the ingredients were blended in extruder (La-Parmigiana Extruder) chamber until a homogenous mixture was obtained. The mixture was then passed through the extruder barrel with pressure and finally, after cutting with the die, pastas were dried at 40 °C for 2 h in a hot air oven.

Table 1
Compositions (g) of pasta prepared from pearl millet

Ingredients	Types of pasta		
	Control	T-I	T-II
Refined flour	125	–	–
Native pearl millet flour	–	100	–
Depigmented pearl millet flour	–	–	100
Chickpea flour	–	25	25
Water	1/3 of the total amount of blend used		

Control pasta = prepared from refined flour; T-I pasta = prepared from native pearl millet; T-II pasta = prepared from depigmented pearl millet.

2.3. Cooking of pasta

Pasta (50 g) was boiled for 10 min, strained and kept aside. In a separate pan, containing 2.5 g oil, garlic (2.5 g), ginger (2.5 g) and onion (20 g) were added and fried. Then 20 g capsicum, 20 g radish and 30 g cabbage were added and all were cooked until soft. To the above mixture, salt (0.6 g), tomato sauce (5 g), chilli sauce (1.25 g) and soya sauce (three drops) were added and stirred. Finally the boiled pasta was mixed with the cooked vegetables.

2.4. Sensory evaluation

Freshly cooked pastas were subjected to sensory evaluation. For sensory assessment, pastas were served on coded paper plates. Panelists were asked to assess their degree of liking by paper ballot, using a nine-point hedonic rating scale, where 9 = Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like nor dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely. Ten experienced judges evaluated randomly coded pastas in terms of colour, appearance, aroma, texture, taste and overall acceptability. Assessors were instructed to cleanse their palate with cold, filtered tap water before tasting each sample. Product characterization was carried out under 'daylight' illumination and in isolated booths.

2.5. Chemical analysis

For chemical analysis, the cooked pastas were dried (60 °C) and ground to a fine powder in an electrical grinder so as to pass through a 60-mesh sieve The standard methods of AOAC (1990) were employed for

analysis of crude protein, crude fat (ether extract) and ash. A factor of 6.25 was applied to convert N into crude protein. Soluble as well insoluble dietary fibre was analysed by enzymatic method (Furda, 1981) and the total dietary fibre was calculated from soluble and insoluble dietary fibre contents. In vitro protein digestibility of pastas was assessed by employing pepsin and trichlor acetic acid (Mertz, Kirlei, & Axtell, 1983). The nitrogen content of supernatant containing digestible proteins was determined by the micro-Kjeldhal method (AOAC, 1990). Starch digestibility (in vitro) was estimated by using pancreatic amylase and the liberated maltose was measured by using dinitrosalicylic acid reagent (Singh, Kherdekar, & Jambunathan, 1982).

2.6. Statistical analysis

Data were subjected to analysis of variance using a completely randomized block design according to the standard method (Panse & Sukhatme, 1961, pp. 12–87). Three replications and a 5% confidence level ($P \leqslant 0.05$) were used to compare two different means.

3. Results and discussion

3.1. Sensory evaluation

The mean acceptability scores for sensory attributes of three types of pasta are given in Table 2. All developed pastas were found to be acceptable, in terms of colour, appearance, aroma, texture and taste, by sensory assessors. The colour of pasta prepared from depigmented pearl millet (T-II) was liked very much and was as good as control pasta (prepared from refined flour), whereas the colour attribute of pasta prepared from native pearl millet (T-I) was liked moderately by the judges. The sensory evaluation panel noted a highly acceptable light colour of pasta prepared from depigmented pearl millet (T-II) and a grey discolouration in pasta prepared from native pearl millet (T-I). Similar to the present study, improvement in colour, due to acid soaking, was also observed in pearl millet flat bread (Naikare et al., 1986; Panwal & Pawar, 1989). When appearance, texture and taste of T-I and T-II pasta were taken into consideration, it was noted that slightly higher scores were assigned to pasta prepared from depigmented pearl millet (T-II) than to the pasta prepared from native pearl millet (T-I). Overall acceptability scores suggested that depigmentation significantly ($P \leqslant 0.05$) improved the sensory characteristics pearl millet pasta.

3.2. Nutritional composition

The results of nutrient analysis of different types of pasta are summerized in Table 3.

Crude protein contents of pasta prepared from refined flour (Control), native pearl millet (T-I), and depigmented pearl millet (T-II) were 6.15, 9.42 and 8.70%, respectively. The protein content of pasta prepared from native pearl millet (T-I) was 53.2% and that of pasta prepared from depigmented pearl millet (T-II) was 41.46% higher than that of control pasta. Several reports on nutritive value of pearl millet (Archana et al., 1999; Hadimani & Malleshi, 1993) have proved that its protein content is better than cereal crops such as wheat. This might explain the observed high protein contents of pearl millet-based pastas (T-I and T-II) as compared with control pasta. Besides, chickpea flour, used in pearl millet pastas, might have also contributed towards their higher protein content, as chickpea contains about 22.0% protein (Attia, Snehlata, Aman, & Hamza, 1994). When the effect of processing was taken into consideration, it was noted that depigmentation of pearl millet resulted in a significant ($P \leqslant 0.05$) decrease (7.64%) in protein content of T-II pasta as compared with T-I pasta (prepared from native pearl millet). A decrease in protein content during the depigmentation procedure can be partly related to the hydrolysis and

Table 2
Effect of depigmentation on sensory attributes of pasta prepared from pearl millet[a]

Types of pasta	Control	T-I	T-II	CD at 5% ($P \leqslant 0.05$)
Sensory attributes				
Colour	8.00±0.00a	7.20±0.13b	8.00±0.00a	0.22
Appearance	8.00±0.00a	7.50±0.16b	7.80±0.13ab	0.36
Aroma	8.00±0.00a	7.60±0.16a	7.60±0.16a	NS
Texture	8.00±0.00a	7.20±0.13b	7.40±0.l6cb	0.35
Taste	8.00±0.00a	7.20±0.13b	750±016b	0.36
Overall acceptability	8.00±0.00a	7.38±0.10b	7.66±0.09c	0.23

Control pasta = prepared from semolina; T-I pasta = prepared from native pearl millet; T-II pasta = prepared from depigmented pearlmillet; Values are means±S.E. of 10 independent determinations; NS = non-significant. Critical difference at 5% level of significance. Difference between two means exceeding this value was significant.

[a] Values with different letters (a–c) differ significantly from each other.

Table 3
Effect of depigmentation on nutritional composition of pasta prepared from pearl millet (% dry matter basis)

Types of pasta	Control	T-I	T-II	CD[a] at 5% ($P \leqslant 0.05$)
Proximate composition				
Crude protein	6.15±0.08	9.42±0.49	8.70±0.15	1.03
Crude fat	3.15±0.16	6.88±0.12	6.92±0.05	0.41
Ash	1.39±0.02	2.40±0.24	2.35±0.15	0.47
Dietary fibre profile				
Total dietary fibre	3.48±0.01	11.5±0.06	11.0±0.09	0.34
Soluble dietary fibre	0.87±0.01	3.85±0.02	3.91±0.02	0.04
In-soluble dietary fibre	2.61±0.01	7.61±0.02	7.09±0.02	0.03

Control pasta = prepared from refined flour; T-I pasta = prepared from native pearl millet; T-II pasta = Prepared from depigmented pearl millet; Values are means±S.E. of three independent determinations.

[a] Critical difference at 5% level of significance. Difference between two means exceeding this value was significant.

partly to the leaching of protein at the time of acid soaking (Panwar & Pawar, 1989) and blanching (Palande, Kadlag, Kachare, & Chavan, 1996).

Crude fat content of control pasta was 3.15% as against 6.88% and 6.92% in pasta prepared from native pearl millet (T-I) and depigmented pearl millet (T-II), respectively. The fat contents of pearl millet-based pastas (T4 and T-II) were significantly ($P \leqslant 0.05$) higher than that of control pasta (Table 2). Many researchers have worked on proximate composition of pearl millet (Archana et al., l999; Palande et al., 1996) and reported a high range (7.00–7.88%) of fat in pearl millet kernels. High proportions of inherent fat in pearl millet might consequently have influenced the fat content of pearl millet-based pastas in present study. Depigmentation of pearl millet did not have any significant ($P \leqslant 0.05$) effect on fat content of pasta, as indicated by non-significant differences between T-I and T-II pasta.

Ash content of pasta prepared from refined pearl millet (Control), native pearl millet (T-I) and depigmented pearl millet (T-II) were 1.39, 2.40 and 2.35%, respectively (Table 2). The observed variation in ash content of three types of pasta may be attributed to differences of ingredients used.

The data pertaining to total, soluble and insoluble dietary fibre contents of pastas are presented in Table 3. The total dietary fibre contents of pasta prepared from native (T-I) and depigmented pearl millet (T-II) were 11.5 and 11.0%, respectively, as against 3.48% in control pasta prepared from refined flour. The pearl millet pastas (T-I and T-II) had significantly ($P \leqslant 0.05$) higher amount of total dietary fibre than control pasta. The observed high total dietary fibre contents of pearl millet-based pastas may be attributed mainly to the high inherent fibre of pearl millet grains (Hadimani & Mallesbi, 1993) as compared to refined flour (Bawa & Singh, 1998) that was used to prepare control pasta. Addition of chickpeaflour in T-I and T-II might have contributed to some of the fibre content as chick pea is reported to contain about 17.6% of total dietry fibre (Perez-Hidalgo, Guerra-Hernandez, & Garcia-Villanova, 1997).

Soluble dietary fibre content of different pastas ranged from 0.87 to 3.9 1%, the lowest and highest being in control pasta and in pasta prepared from depigmented pearl millet (T-II), respectively. An intermediate amount of soluble dietary fibre (3.85%) was found in pasta prepared from native pearl millet (T-I). The insoluble dietary fibre content of pasta prepared from native pearl millet (T-I) was found to be 7.61%, and it was significantly higher than the corresponding values in control pasta and in pasta prepared from depigmented pearl millet (T-II), which were 2.61 and 7.09%, respectively. Replacement of native pearl millet with depigmented pearl millet for the preparation of pasta (T-II) caused a significant ($P \leqslant 0.05$) decrease in total (4.01%) and insoluble (6.83%) dietary fibre, whereas it resulted in significant ($P \leqslant 0.05$) increase (1.55%) of soluble dietary fibre. The observed decrease of insoluble dietary fibre might be due to conversion of some insoluble dietary fibre to short-length units under the influence of acid and heat during the depigmentaion process. These short length units may be precipitated (not up to the same magnitude) at the time of estimation of soluble dietary fibre and might explain the slight increase of soluble dietary fibre due to depigmentation. Khanum, Siddalingaswamy, Sudarshan Krishna, Santhanam, and Viswanathan (2000) also presented evidence of the relationship between moist heat and decrease of insoluble dietary fibre with simultaneous increase in soluble fibre.

The biological utilization of protein and starch, in any food product, is primarily dependent on digestibility (Table 4). Among three different pastas studied, the pasta prepared from depigmented pearl millet (T-II) had the highest in vitro protein digestibility (24.0%) as compared with those prepared from native pearl millet (68.8%) and refined flour (71.6%). The relatively low in

Table 4
Effect of depigmentation on in vitro protein (%) and starch (mg maltose released/g) digestibilities of pasta prepared from pearl millet (on dry matter basis)

Types of pasta	Control	T-I	T-II	CD[a] at 5% ($P \leqslant 0.05$)
In vitro digestibility				
Protein digestibility	71.6±0.058	68.8±0.03l	74.0±0.067	0.19
Starch digestibility	44.7±0.056	30.5±0.050	35.6±0.049	0.18

Control pasta = prepared from refined flour; T-I pasta = prepared from native pearl millet; T-II pasta = prepared from depigmented pearl millet; Values are means±S.E. of three independent determinations.

[a] Critical difference at 5% level of significance. Difference between two exceeding this value was significant.

vitro protein digestibility of pasta prepared from native pearl millet (T-I) may be attributed to the presence of considerable amounts of antinutrients in unprocessed or native pearl millet (Archana, Sehgal, Kawatra, & Nijhawan, 2000). Antinutrients, especially phytic acid, bind protein to form a protein–mineral complex that inhibits the enzymatic degradation of protein. Significant ($P \leqslant 0.05$) increase (6.56%) in the in vitro protein digestibility of pearl millet pasta, developed by depigmentation of pearl millet flour, might be due to the leaching out of antinutrients under the influence of a concentration gradient in the soaking medium. Heat employed during the processing may also have contributed to the enhancement, of in vitro protein digestibility, by altering and breakdown of high molecular weight protein or by destroying the heat labile protease inhibitor. Earlier reports also mentioned the diminishing effect of soaking on antinutrients and simultaneous improvement of in vitro protein digestibility (Saharan, Khetarpaul, & Bishnoi, 2002). Pawar, Khandagale, and Quadri (1990) reported on improved protein efficiency ratio (PER) of acid-soaked pearl millet.

In vitro starch digestibilities of pasta prepared from native (T-I) and depigmented (T-II) pearl millet were 30.5 and 35.6 mg maltose released/g, respectively (Table 4). The in vitro starch digestibility of control pasta (44.7 mg maltose released/g) was significantly ($P \leqslant 0.05$) higher than that of pearl millet-based pastas (T-I as well as T-II). With depigmentation, the in vitro starch digestibility of pearl millet pasta (T-II) improved significantly ($P \leqslant 0.05$), by 16.9% as compared with T-I pasta (prepared from native pearl millet). In native pearl millet, factors, such as amylase inhibitors, phytic acid and polyphenols, have been reported to inhibit α-amylase and thus the in vitro starch digestibility (Thompson & Yoon, 1984). Increased in vitro starch digestibility of T-II pasta (prepared from depigmented pearl millet) as compared to T-I pasta (prepared from native pearl millet) might be attributed to the leaching of antinutrients and to the swelling and rupturing of starch granules during the depigmentation process. This facilitates starch hydrolysis. Similar observations regarding the improvement of in vitro starch digestibility of pearl millet on bleaching and blanching have been reported (Palande et al., 1996).

From the present investigation, it could be established that one of the major constraints in widespread utilization of pearl millet could be successfully and appreciably avoided by depigmentation. Depigmentation of pearl millet was effective in improving the sensory attributes, soluble dietary fibre, in vitro protein digestibility and in vitro starch digestibility of pearl millet pasta without much affecting its nutritive value. Thus, the depigmentation of the pearl millet could be commercially exploited for the development of products with better organolaptic acceptability and better nutritional profile.

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