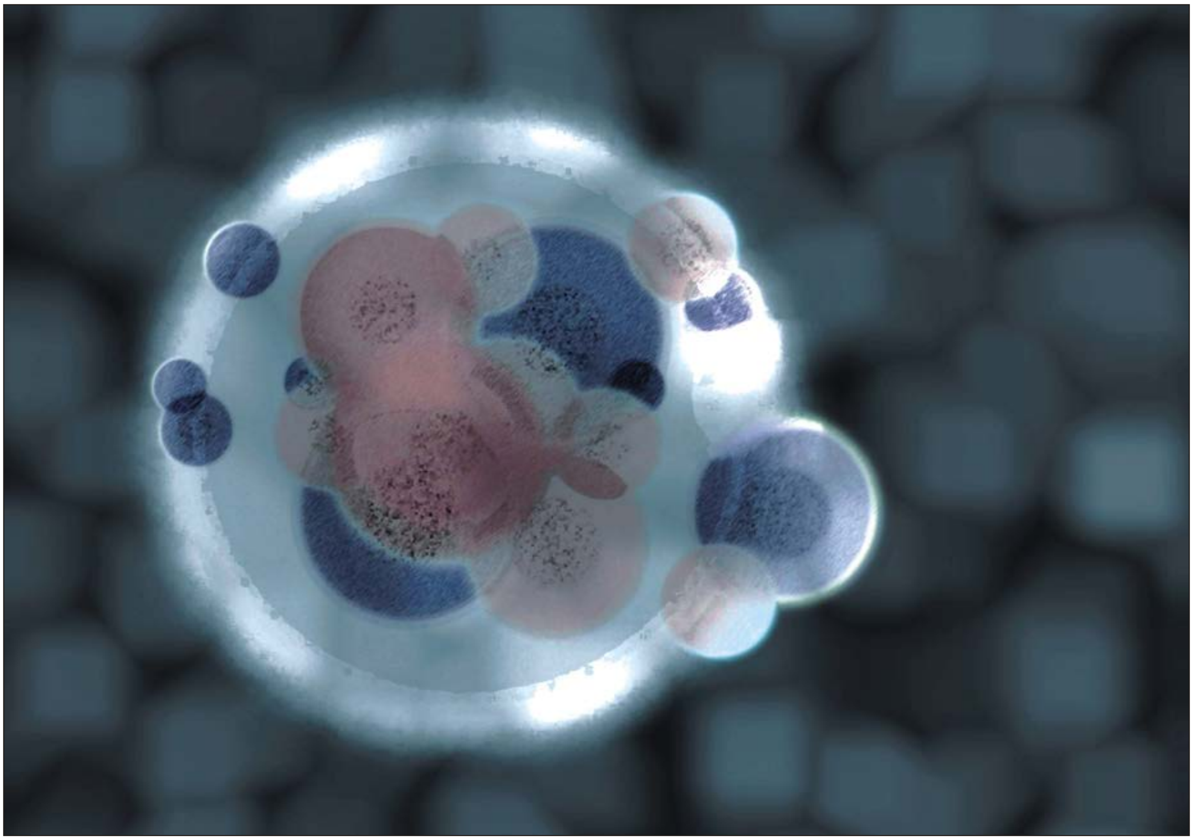

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Effect of Processing Methods on Nutritional and Anti-Nutritional Qualities of Hybrid (COHCU-8) and Traditional (CO7) Pearl Millet Varieties of India

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Abstract: Pearl millet is an essential food crop in the arid and semi-arid dry regions of Asia and Africa. It is a cheap source of several nutrients when compared to other cereals. Its use has been limited, however, due to the presence of anti-nutritional compounds such as phenols and tannins that result in poor digestibility and reduced palatability. It has been reported that different processing treatments would reduce the amount of anti-nutritional factors in the food grains. Nevertheless, the changes in the amount of important nutritional compounds with respect to the processing treatments are not yet clear. The objective of this experiment was to estimate the effect of different processing treatments such as soaking, sprouting and roasting on some of the important nutritional qualities of pearl millet. The experiment was conducted on a hybrid (COHCU-8) and a traditional (CO7) pearl millet variety to compare the changes in nutritional contents after different processing treatments. Untreated raw dry seeds were kept as control in all the experiments. Anti-nutritional factors such as total phenols (g 100 g^{-1}) and tannins (g 100 g^{-1}) as well as nutritional compounds such as carbohydrates (g 100 g^{-1}), fatty acids (g 100 g^{-1}), crude protein (%) and total free amino acid (g 100 g^{-1}) contents were analyzed. The results revealed that sprouting treatments were the best among them in reducing the anti-nutritional factors while maintaining essential nutritional compounds.

Key words: Processing, carbohydrates, fatty acids, proteins, amino acids, pearl millet

INTRODUCTION

Pearl millet 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, pearl millet provides more nutrients and minerals to the people of rural India. Though pearl millet is grown mainly for human consumption, it also serves as fodder for cattle and raw material for cattle feed industries (Dahiya *et al*., 2000). In India, pearl millet occupies around 7.4% of the total food grain area and contributes to nearly 3.4% of the total food grain production of the country (Bhatnagar, 2002). Although pearl millet is considered as a poor man's crop, it is rich in protein, fat and mineral contents. In addition, it is particularly rich in zinc and iron as compared to other cereals (Khairwal *et al*., 1997). However, the presence of anti-nutritional factors such as tannins and phenols limit its use in the food industry (Narasinga Rao, 1987). Therefore, it was essential to find methods to reduce the anti-nutritional factors in pearl millet grains. Suryaprasad and Pattabiraman (1981) suggested that various processing treatments could reduce anti-nutritional factors and improve essential nutritional contents of pearl millet grains. Processing methods such as soaking (Jyothi and Mullaimani, 2001), sprouting (Jood *et al*., 1987) and roasting (Suryaprasad and Pattabiraman, 1981) could facilitate reduction of anti-nutritional compounds in minor millets. Nevertheless, the impact of these treatments on the amount of important nutritional compounds is not yet clear. Therefore, an experiment was conducted with an objective to study the effect of soaking, sprouting and roasting treatments on some of the nutritional and anti-nutritional contents of pearl millet grains. It was hypothesized that processing treatments would reduce anti-nutritional compounds while maintaining essential nutrient composition of pearl millet grains.

MATERIALS AND METHODS

Lab experiments were carried out in 2003 in the department of soil science, Tamil Nadu Agricultural University, India and the Department of biochemistry, PSG college of Arts and Science, Bharathiar University, India to investigate the changes in nutritional and

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anti-nutritional factors of pearl millet grains with respect to different processing treatments. Pearl millet traditional (CO7) and hybrid (COHCU-8) seeds were obtained from Millet Breeding Station, Tamil Nadu Agricultural University, Coimbatore, India. The dry, untreated pearl millet seeds were finely powdered and used as control. Pearl millet traditional (CO7) and hybrid (COHCU-8) seeds were obtained from Millet Breeding Station, Tamil Nadu Agricultural University, Coimbatore, India.

Soaking: In soaking treatments, the raw, clean seeds were soaked in distilled water for 14 h at room temperature (around 25°C). The soaked seeds were then dried at 60°C, grinded to fine powder (<0.5 mm) and used for further analysis.

Sprouting: It was done by soaking the seeds overnight in distilled water at room temperature (around 25°C). The seeds were placed between the folds of Whatmann No. 1 filter paper. Continuous watering was done for 48 h and the seeds were allowed to germinate. The sprouted seeds were dried at 60°C, grinded to fine powder (<0.5 mm) and used for further analysis.

Dry heat treatment: In dry heat treatments, the dry, whole grains were heated in a hot air oven at 110°C for an hour. The treated seeds were then grinded to fine powder (<0.5 mm) and used for further analysis.

Nutrient analysis: Anti-nutritional factors such as total phenols and tannins as well as the nutritional compounds such as starch, reducing sugars, amylose, free fatty acids and free amino acids were estimated following the procedures given by Sadasivam and Manickam (1996). Total carbohydrates and total sugars were estimated following the experimental procedures given by Dubois *et al.* (1956). The experimental methods given by Muthuvel and Udayasoorian (1999) were used for the estimation of crude fibre content in pearl millet grains.

Statistical analysis: The experiment was replicated four times and the analysis of variance was calculated following the methods given by Gupta and Kapoor (1995).

RESULTS AND DISCUSSION

Anti-nutritional factors: The results revealed that there was a significant reduction in the anti-nutritional compounds such as total phenols and tannins during soaking, sprouting and roasting treatments in both the traditional (CO7) and the hybrid (COHCU-8) pearl millet. Among the treatments imposed, sprouting was very effective in reducing total phenols and tannins when compared to untreated control in both CO7 and COHCU-8 (Table 1 and Fig. 1).

The reduction in anti-nutritional factors during soaking treatments might be attributed to the leaching of polyphenols in soaking water as suggested by Jood *et al.* (1987). In addition to leaching, increased enzymatic hydrolysis might have facilitated the reduction of total phenols and tannins in sprouting treatments (Bishnoi *et al.*, 1994; Fordham *et al.*, 1975).

Reduction in total phenols and tannins during roasting treatments might be due to the loss of compounds while treating at a high temperature as shown by Shinde *et al.* (1991). The hybrid pearl millet (COHCU-8) contained lesser amounts of anti-nutritional factors, when compared to the traditional variety (CO7) (Table 1 and Fig. 1).

Table 1: Effect of processing treatments on anti-nutritional factors and nutritional compounds of pearl millet variety CO7

	Treatments			
Parameters	Soaking	Sprouting	Roasting	Control
Anti-nutritional factors				
Total phenols (g 100 g^{-1})	2.55 (0.18)a*	0.68 (0.08)b*	2.27 (0.22)c*	3.00 (0.14)
Tannins (g 100 g^{-1})	1.40 (0.02)a*	1.00 (0.03)b*	1.30 (0.02)c*	1.52 (0.02)
Carbohydrates				
Total carbohydrate (g 100 g^{-1})	52.83 (1.47)a*	48.70 (1.21)b*	55.17 (1.48)c^{NS}	57.33 (1.63)
Amylose (g 100 g^{-1})	7.68 (0.23)a*	5.45 (0.22)b*	9.47 (0.18)c*	10.37 (0.16)
Starch (g 100 g^{-1})	45.08 (1.29)a*	36.97 (1.10)b*	50.02 (0.90)c*	53.65 (2.56)
Reducing sugar (g 100 g^{-1})	2.23 (0.16)a*	4.30 (0.18)b*	2.55 (0.11)c*	1.85 (0.22)
Total sugars (g 100 g^{-1})	6.87 (0.33)a*	19.40 (0.29)b*	3.23 (0.30)c*	5.27 (0.33)
Crude fibre (%)	1.25 (0.10)a^{NS}	1.55 (0.10)b*	1.42 (0.02)c^{NS}	1.30 (0.10)
Lipids				
Free fatty acids (g 100 g^{-1})	2.05 (0.14)a*	2.37 (0.02)b*	1.50 (0.14)c*	1.85 (0.02)
Proteins and amino acids				
Crude protein (%)	10.40 (0.20)a*	9.49 (0.01)b*	10.57 (0.02)c*	11.70 (0.10)
Free amino acids (g 100 g^{-1})	0.72 (0.01)a*	1.42 (0.01)b*	0.25 (0.02)c*	0.38 (0.18)

Statistical comparisons: [a]Control vs soaking; [b]Control vs sprouting; [c]Control vs roasting; *$p<0.05$, NS: Not-Significant. The values of Standard Deviation (SD) are given in parenthesis

Table 2: Effect of processing treatments on the carbohydrate contents of the pearl millet hybrid COHCU-8

	Treatments			
Parameters	Soaking	Sprouting	Roasting	Control
Total carbohydrate (g 100 g^{-1})	59.0 (1.14)a*	55.33 (1.64)b*	60.67 (1.21)c*	63.17 (1.47)
Amylose (g 100 g^{-1})	15.03 (0.57)a*	10.40 (0.28)b*	16.17 (0.29)c*	17.93 (0.37)
Starch (g 100 g^{-1})	53.13 (1.22)a*	45.10 (1.27)b*	60.38 (1.20)c*	64.17 (1.06)
Reducing sugar (g 100 g^{-1})	1.97 (0.29)a*	4.80 (0.26)b*	2.01 (0.26)c*	1.37 (0.29)
Total sugars (g 100 g^{-1})	8.27 (0.37)a*	16.17 (0.29)b*	4.00 (0.28)c*	6.40 (0.28)
Crude fibre (%)	1.40 (0.10)a^{NS}	1.69 (0.10)b*	1.53 (0.15)c^{NS}	1.40 (0.10)

Statistical comparisons: [a]Control vs soaking; [b]Control vs sprouting; Control vs roasting; *$p<0.05$, NS: Not-Significant. The values of Standard Deviation (SD) are given in parenthesis

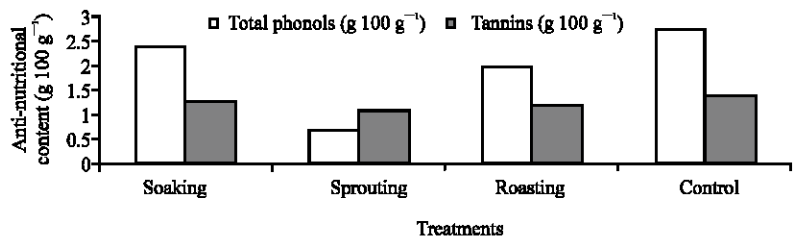

Fig. 1: Effect of different processing methods on the anti-nutritional contents of the hybrid COHCU-8

Carbohydrates: In general, different processing methods reduced the amount of carbohydrates such as total carbohydrate, amylose and starch when compared to the raw untreated seeds. On the other hand, there was a significant increase in the levels of reducing sugar, total sugars and crude fibre over untreated control (Table 1 and 2).

Total carbohydrate: There was a significant decrease in total carbohydrate content in all the treatments over control in the hybrid COHCU-8 (Table 2). In the traditional variety (CO7), though total carbohydrate content decreased in the roasting treatment, it was not statistically significant (Table 1). Among all these treatments, the highest reduction in total carbohydrate content was noticed in the sprouting treatment. This could primarily be due to the utilization of carbohydrate as a source of energy by the developing young seedlings as advised by Ologhobo and Fetuc (1986). While comparing the traditional variety and the hybrid, higher levels of total carbohydrate were recorded in the hybrid pearl millet.

Amylose: In both the pearl millet varieties (CO7 and COHCU-8), amylose content showed a significant decrease in all the treatments over untreated raw seeds (Table 1 and 2). Among them, sprouting treatment recorded the lowest values of amylose content and this was followed by soaking and roasting treatments, respectively. Parvathy (1995) proposed that the reduction in amylose content with respect to sprouting treatment might be due to the increased activity of • -amylase during seed germination. The lowest reduction of amylose content in the roasting treatments could be due to the inactivation of this enzyme at higher temperature. Among the varieties studied, the hybrid pearl millet (COHCU-8) recorded higher values of amylose when compared to the traditional variety (CO7).

Starch: With respect to the starch content, there was a significant reduction in all the treatments over untreated control (Table 1 and 2). Among these treatments, the highest reduction in starch content was recorded with the sprouting and this was followed by soaking and roasting treatments. This could be due to the fact that soaking and sprouting results in the activation of amylase which in turn promotes the hydrolysis of starch molecules (Sharma and Kapoor, 1997). Kataria and Chauhan (1988) suggested that the reduction in starch content in the roasting treatment is due to the rupturing of starch granules followed by amylolysis at high temperatures. Though the same trend was observed in both the cultivars, higher values of starch content were recorded with the hybrid pearl millet (COHCU-8).

Reducing and total sugar: There was a significant increase in reducing sugar content in all the treatments over control (Table 1 and 2). However, total sugar content increased with soaking and sprouting treatments and decreased with roasting treatment. The same trend was observed in both the pearl millet cultivars (CO7 and COHCU-8). Among all of them, sprouting treatment recorded highest values of both the reducing and total sugar. Soaking and sprouting treatments increased the educing and total sugar contents due to increased activities of • and •-amylases as shown by Dogra *et al.* (2001). The hybrid pearl millet (COHCU-8) recorded higher values of both the reducing and total sugar contents when compared to the traditional variety (CO7).

Crude fibre: There was no significant change observed in all the treatments except for sprouting in both the traditional (CO7) and hybrid (COHCU-8) pearl millet (Table 1 and 2). Here, the sprouting treatments recorded significantly higher values of crude fibre over untreated control. It may be attributed to the fact that germination stimulates the synthesis of more cell wall materials to support the shoots and rootlets thereby increases the fibre contents (Akubar and Obiegbuna, 1999). In soaking and roasting treatments there was no change in the amount of insoluble and non-digestible materials and therefore there was no significant variation in terms of the crude fibre content (Malik *et al.*, 2002).

Lipids

Free fatty acid: Significant increase in free fatty acid content was recorded with soaking and sprouting treatments while it showed a decreasing trend with respect to roasting treatment in both the varieties (CO7 and COHCU-8) (Table 1 and Fig. 2). Among them, sprouting treatments resulted in the highest Values of free fatty acid content. Marked increase in the free fatty acid content in soaking and sprouting treatments was due to the high lipolytic enzyme activity which broke down triglycerides into simpler free fatty acids. The decrease in free fatty acid content in dry heated grains could be due to the inactivation of lipase activity under high temperature (Raham and Aal, 1986).

Proteins and amino acids

Crude protein: There was a significant decrease in crude protein content in all treatments over control in both the traditional (CO7) and hybrid (COHCU-8) pearl millet (Table 1 and Fig. 2). Among these treatments, the highest reduction in crude protein content was recorded in sprouted samples which were followed by soaked and roasted samples. The decrease in crude protein content in response to sprouting treatment may possibly be due to the transfer of nutrients to the growing embryo (Madhuri *et al.*, 1996). Loss of crude protein in heat treated grains could be due to the denaturation and degradation of protein. Reduction in crude protein content with respect to soaking treatments might due to the leaching out of low molecular weight nitrogen compounds into the leachate as suggested by Sharma and Kapoor (1997). While comparing the cultivars, COHCU-8 recorded higher values of crude protein over CO7.

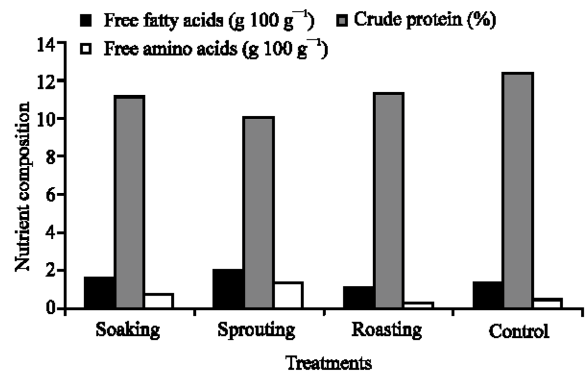

Fig. 2: Influence of processing treatments on free fatty acids, crude protein and free amino acid contents of the pearl millet hybrid COHCU-8

Free amino acids: Significant increase in free amino acid contents were observed with soaking and sprouting treatments in both the cultivars (CO7 and COHCU-8) (Table 1 and Fig. 2). Among them, sprouting treatments recorded higher values of free amino acids over soaking treatments. This could be attributed to the partial hydrolysis of storage proteins by endogenous proteases during the germination of seeds (Bhise *et al.*, 1988; Shere *et al.*, 1990). Conversely, free amino acid contents were decreased with respect to roasting treatments (Table 1 and Fig. 2). This could be due to the denaturation and degradation of proteins at high temperature (Sharma and Kapoor, 1997). Among the cultivars, the hybrid COHCU-8 recorded higher values of free amino acids over the traditional variety (CO7).

CONCLUSIONS

There was a significant variation with respect to anti-nutritional factors and nutritional compounds in both the traditional (CO7) and hybrid (COHCU-8) pearl millet in response to different processing treatments. Among them, sprouting treatments performed well interms of reducing anti-nutritional factors while significantly increasing the nutritional compounds. It was also found that the hybrid (COHCU-8) appears to be the best source of nutrients when compared to the traditional variety (CO7). Considering the above mentioned benefits, it is recommended that the sprouted pearl millet seeds could be used to obtain high quality malt.

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