

## Effect of Traditional Processing on Phosphorus Content and Some Anti Nutritional Factors of Pearl Millet (*Pennisetum Glaucum* L.)

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**Abstract:** Three traditional products, fermented dough, *damirga* flour and sprouted flour, were prepared from two cultivars of pearl millet (Ugandi and Dembi yellow). Fermentation and sprouting significantly ( $P \leq 0.05$ ) lowered the total P content, while *damirga* preparation tremendously reduced it by 60.5%. The three traditional processes brought about a significant ( $P \leq 0.05$ ) enhancement in non phytate P and inorganic P with a corresponding decline in phytate P content of the two cultivars. Polyphenols content of fermented dough and *damirga* flour were found to be significantly ( $P \leq 0.05$ ) lower compared to the whole flour. In contrast sprouting significantly ( $P \leq 0.05$ ) raised the polyphenols content of the two cultivars. *Damirga* preparation, sprouting and fermentation significantly ( $P \leq 0.05$ ) reduced the phytic acid content of the two cultivars by 10.60-68.50%.

**Key words:** Pearl millet, traditional processing, fermentation, sprouting, *damirga* flour, phytic acid, polyphenols and total, inorganic, phytate and non phytate phosphorus.

### INTRODUCTION

Pearl millet (*Pennisetum glaucum*) is one of the most important drought tolerant crops of the tropical and subtropical regions of the world<sup>[1,6]</sup>. Western Sudanese natives process pearl millet in several types of foodstuffs such as fermented or unfermented breads, stiff or thin porridges, alcoholic or non alcoholic beverages and *damirga*, which is fine sour white flour obtained traditionally from pearl millet grains<sup>[2]</sup>.

Due to the presence of anti-nutritional factors including polyphenols and phytic acid the availability of minerals from pearl millet may be low. Natural fermentation, sprouting and *damirga* preparation were previously reported to decrease phytic acid<sup>[17, 21, 2]</sup>. Also fermentation, dehulling and germination reduced polyphenols content of pearl millet<sup>[3,4,18]</sup>.

The objectives of the present study were to investigate the effect of fermentation, *damirga* preparation and sprouting on total, inorganic, phytate and non-phytate phosphorus content and certain anti-nutritional factors (phytic acid and polyphenols).

### MATERIALS AND METHODS

**Materials:** Two pearl millet cultivars Ugandi and Dembi yellow were obtained from Elobeid Agriculture

Research Station, Sudan. The seeds of each cultivar were cleaned from damaged grains, foreign materials, and broken seeds then processed to three products, fermented dough, *damirga* flour and sprouted pearl millet flour.

#### Methods:

**Dough Preparation:** Fermented dough was obtained according to the method used in Sudanese homes<sup>[12]</sup>. Whole millet flour was mixed with water (1:2 ratio) in a plastic laboratory beaker, a starter from previously fermented dough (*Khumar*) was then added to the mixture of flour and water (The starter of each dough was of the same cultivar of millet and was about 10% of the dough volume). The mixture was then incubated for 14 hours at 37 °C; the fermented samples were then dried in an air oven at 70 °C.

***Damirga* Flour Preparation:** *Damirga* flour was prepared traditionally as described by Abdalla *et al.*<sup>[2]</sup>. The grains were first moistened with water (approximately 20% of their weight) and then hand pounded by wooden mortar and pestle until the required degree of dehulling was reached (about 30 min.). The grains were then winnowed in the winnowing basket to remove the hulls. The bran free kernels were soaked in water (1:2 ratio) and fermented

for 72 h at ambient temperature ( $30\pm 2^\circ\text{C}$ ). Water was then decanted and the fermented dehulled grains were sun dried and finely ground (1 mm mesh) in Grain Mills type 120 No. 69444, RPM 2800.

**Sprouted Pearl Millet Flour:** The sprouting of pearl millet was carried out according to the method of Bhise *et al.*<sup>[5]</sup> with some modifications. Pearl millet grains were steeped in distilled water for 24 h. The water was then decanted and seeds incubated in wooden trays covered with gane at ambient temperature ( $30\pm 2^\circ\text{C}$ ) and germinated for 3 days. Water was sprinkled on the grains every day to avoid drying. The germinated grains were then sun dried. The root portions were manually removed. The grains were milled into fine flour, passing a 1mm mesh using Grain Mills type 120 NO. 69444, RPM 2800. The samples were kept in a polyethylene sacks in a refrigerator.

**Chemical Analysis:** Phytate P was determined spectrophotometrically (Jenway 6305 vis/uv at 519 nm); phytic acid was then calculated using the factor 3.55<sup>[14]</sup>. Polyphenols were determined according to Prussian blue spectrophotometric method<sup>[27]</sup>. Inorganic P was extracted by the method described by Ketarpaul and Chauhan<sup>[17]</sup> and then determined according to the method described by Hanson<sup>[13]</sup> using spectrophotometer (Jenway 6305 vis/uv at 440 nm). Total P was determined according to the method described by Hanson<sup>[13]</sup>. Non phytate P was calculated by subtracting phytate P from total P of the untreated samples.

**Statistical Analysis:** Data were assessed by analysis of variance (ANOVA)<sup>[29]</sup> using CRD with three replicates, treatments means were compared using Duncan multiple-range test with probability  $P\leq 0.05$ <sup>[11]</sup>.

## RESULTS AND DISCUSSION

**Total, Inorganic, Phytate and non Phytate Phosphorus Content:** As indicated in Table 1, fermentation significantly ( $P\leq 0.05$ ) lowered total P of Ugandi and Dembi yellow from 1110 mg/100g for both to 1043.7 and 1025.7 mg/100g, respectively. Sprouting significantly ( $P\leq 0.05$ ) reduced total P of Ugandi to 858.2 mg/100g and that of Dembi yellow to 867.2 mg/100g, which in line with the findings of Malleshi and Desikachar<sup>[23]</sup> who observed a decrease in P content of pearl millet from 265 to 222 mg/100g as a result of germination. *Damirga* preparation tremendously reduced the total P of the two cultivars by about 60.5%. This was supported by the findings of Abdalla *et al.*<sup>[2]</sup> who reported that *damirga* flour retained only 32.7 to 44.8% of the original P. The combined effect of soaking and dehulling in reducing

P content was earlier noticed<sup>[26]</sup>.

The three traditional treatments brought about a significant ( $P\leq 0.05$ ) enhancement in non phytate P and inorganic P with a corresponding decline in phytate P content of the two cultivars. The greatest influence was exerted, in a decreasing manner, by *damirga* preparation followed by fermentation and then sprouting. As shown in Table 1, fermentation and sprouting significantly ( $P\leq 0.05$ ) increased the inorganic P content of Ugandi from 134 mg/100g to 147.20 and 145.60 and that of Dembi yellow cultivar from 133 mg/100g to 147.20 and 145.80 mg/100g, respectively. *Damirga* preparation significantly ( $P\leq 0.05$ ) elevated the inorganic P content to 148.7 mg/100g for Ugandi and to 149.9 mg/100g for Dembi yellow.

Fermentation and sprouting significantly ( $P\leq 0.05$ ) reduced the phytate P content of Ugandi cultivar from 299.58 to 249.96 and 264.61 mg/100g, and from 287.44 to 217.34 and 243.68 mg/100g for Dembi yellow, respectively. *Damirga* reduced phytate P content in both cultivars to the same level of phytate P (93.37 mg/100g). A decrease in phytate P simultaneously with an increase in non phytate P and inorganic P of pearl millet has been reported during fermentation<sup>[17, 18, 19, 9]</sup>. The reduction of phytate P concurrently with elevated levels of non phytate P and inorganic P during traditional processing could probably be due to hydrolysis of phytic acid by phytase leading to release of inorganic P.

**Effect of Traditional Processing on Some Anti Nutritional Factors of Pearl Millet:** Table 2 shows changes in anti nutritional factors (polyphenols and phytic acid) during traditional processing of pearl millet.

**Polyphenols:** The polyphenolic content of fermented Ugandi (111 mg/100g) and Dembi yellow (107 mg/100g) were significantly ( $P\leq 0.05$ ) lower compared to the whole flour. Traditional Sudanese fermentation was reported to cause a considerable reduction in polyphenols content of pearl millet<sup>[1, 4]</sup>. Dhankher and Chauhan<sup>[10]</sup> observed significant reduction in polyphenols during fermentation of rabadi (Indian pearl millet food). Khetarpaul and Chauhan<sup>[18]</sup> reported an increased polyphenols content of pearl millet when subjected to sequential culture fermentation by lactic acid bacteria at  $30^\circ\text{C}$  for 72 hrs.

Data showed that the polyphenols content of *damirga* flour prepared from Ugandi (99.18 mg/100g) and Dembi yellow (98.75 mg/100g) were significantly ( $P\leq 0.05$ ) lower compared to their whole flours. The great reduction of polyphenols observed during preparation of *damirga* might be due to the combined influence of dehulling, soaking and fermentation.

**Table 1:** Effect of traditional processing on the total, inorganic, phytate and non phytate phosphorus content of pearl millet

		Total P(mg/100 g)	Inorganic P (mg/100 g)	Phytate P (mg/100 g)	Non phytate P (mg/100g)
Ugandi	Untreated	1110.0 ± (10.6) <sup>a</sup>	134.1 ± (1.90) <sup>d</sup>	299.85 ± (4.23) <sup>a</sup>	810.15 <sup>d</sup>
	Dough	1043.7 ± (19.8) <sup>b</sup>	147.2 ± (0.60) <sup>b</sup>	249.96 ± (1.97) <sup>c</sup>	860.04 <sup>b</sup>
	Damirga	671.3 ± (20.3) <sup>d</sup>	148.7 ± (1.40) <sup>a</sup>	93.37 ± (0.00) <sup>d</sup>	1016.63 <sup>a</sup>
	Sprouted	858.2 ± (21.8) <sup>c</sup>	145.6 ± (0.40) <sup>c</sup>	264.61 ± (4.23) <sup>b</sup>	845.39 <sup>c</sup>
Dembi yellow	Untreated	1110.2 ± (10.55) <sup>a</sup>	133.0 ± (1.21) <sup>d</sup>	287.44 ± (0.00) <sup>a</sup>	822.76 <sup>d</sup>
	Dough	1025.7 ± (15.25) <sup>b</sup>	147.2 ± (0.79) <sup>b</sup>	217.34 ± (3.59) <sup>c</sup>	892.86 <sup>b</sup>
	Damirga	671.3 ± (18.70) <sup>d</sup>	149.9 ± (2.51) <sup>a</sup>	93.37 ± (0.00) <sup>d</sup>	1016.63 <sup>a</sup>
	Sprouted	867.2 ± (16.33) <sup>c</sup>	145.8 ± (0.23) <sup>c</sup>	243.68 ± (4.16) <sup>b</sup>	866.52 <sup>c</sup>

Each value is an average of three experimental samples expressed on dry matter basis.

Values are means ± (standard deviation).

Means not sharing a common superscript letter in a column are significantly different at  $p \leq 0.05$  as assessed by Duncan's Multiple Range Test.

**Table 2:** Effect of traditional processing on polyphenols and phytic acid content of pearl millet

		Polyphenols (mg/100 g)	Phytic acid (mg/100 g)
Ugandi	Untreated	120.43 ± (4.07) <sup>b</sup>	1050 ± (15.0) <sup>a</sup>
	Dough	111.08 ± (2.54) <sup>c</sup>	887 ± (7.0) <sup>c</sup>
	Damirga	99.18 ± (1.00) <sup>d</sup>	331 ± (0.0) <sup>d</sup>
	Sprouted	123.86 ± (0.05) <sup>a</sup>	939 ± (15.0) <sup>b</sup>
Dembi yellow	Untreated	125.12 ± (0.05) <sup>b</sup>	1020 ± (00.0) <sup>a</sup>
	Dough	107.26 ± (0.17) <sup>c</sup>	759 ± (25.5) <sup>c</sup>
	Damirga	98.75 ± (0.11) <sup>d</sup>	331 ± (00.0) <sup>d</sup>
	Sprouted	128.62 ± (1.45) <sup>a</sup>	865 ± (14.8) <sup>b</sup>

Each value is an average of three experimental samples expressed on dry matter basis.

Values are means ± (standard deviation).

Means not sharing a common superscript letter in a column are significantly different at  $p \leq 0.05$  as assessed by Duncan's Multiple Range Test.

Decortication of pearl millet was known to decrease the levels of polyphenols<sup>[28]</sup>. Moreover the combination of dehulling with soaking was reported to decrease total polyphenols<sup>[26]</sup>. Abdalla<sup>[1]</sup> concluded that the leaching of polyphenols at the acidic pH could be the probable reason for diminishing the polyphenols in *damirga* flour.

Sprouting significantly ( $P \leq 0.05$ ) elevated the polyphenols content from 120.34 to 123.86 and from 125.12 to 128.62 mg/100g for Ugandi and Dembi yellow, respectively. These results were in line with the findings of Chavan and Kadam<sup>[7]</sup> who found an increase in total polyphenols (from 0.33 to 0.49%) after 48 h germination of pearl millet grains at 25°C. McGrath *et al.*<sup>[24]</sup> stated that in the course of malting, roots and shoots developed a large complement of polyphenols. Khetarpaul and Chauhan<sup>[18]</sup> reported insignificant reduction in polyphenols content of pearl millet (from 761 to 753 mg/100g) after 24 hours germination.

**Phytic Acid:** *Damirga* preparation, sprouting and fermentation, significantly ( $P \leq 0.05$ ) reduced the phytic acid content of Ugandi cultivar from 1050 to 331, 887

and 939 mg/100g; and from 1020 to 331, 865 and 759 mg/100g for Dembi yellow, respectively. The three traditional treatments were observed to vary in their ability to reduce phytic acid; with *damirga* preparation most effectively to do so, followed by sprouting and then fermentation. Previously, fermentation was found to be effective in decreasing phytic acid content of pearl millet<sup>[2, 20]</sup>. Enzymatic hydrolysis of phytic acid by indigenous phytase activity and that of fermenting microflora may account for most of the loss of phytic acid during fermentation<sup>[22]</sup>.

The 68% decrease in phytic acid during preparation of *damirga* can be attributed to the combined effect of dehulling, soaking and fermentation. Dehulling was known to efficiently reduce phytic acid concentration in pearl millet<sup>[25,8,2,4]</sup>. Phytase activity had been reported to increase during soaking<sup>[26]</sup>.

Previous investigations confirmed that germination for periods varying from 24 to 72 h at temperature ranging from 25 to 35°C significantly reduced phytic acid content of pearl millet. The reduction of phytic acid was attributed to the activation of the inherent phytase during germination<sup>[23,21]</sup>.

**Conclusion:** The three traditional treatments brought about a significant ( $P \leq 0.05$ ) enhancement in non phytate P and inorganic P with a corresponding decline in phytate P content of the two cultivars. The greatest influence was exerted, in a decreasing manner, by Damirga preparation followed by fermentation and then sprouting.

Fermentation as well as *damirga* preparation reduced polyphenols of Ugandi and Dembi yellow, in contrast sprouting increased the polyphenols content of the two cultivars.

Phytic acid was significantly ( $P \leq 0.05$ ) reduced as a result of traditional processing. The three traditional treatments were observed to vary in their ability to reduce phytic acid, with *damirga* preparation most effectively to do so, followed by sprouting and then fermentation.

## REFERENCES

1. Abdalla, A.A., 2003. Evaluation of biochemical and nutritional profile during processing of pearl millet (*pennisetum glaucum* L.) to different products. Ph.D. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.
2. Abdalla, A.A., A.H. El-tinay, B.E. Mohamed and A.H. Abdalla, 1998. Effect of traditional processes on phytate and mineral content of pearl millet. *Food Chemistry*, 63: 79-84.
3. Ahmed, S.H., 1999. Effect of natural fermentation on nutritive value and the *in vitro* protein digestibility of pearl millet. M.Sc. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.
4. Alhag, M.A., 1999. Effect of fermentation and dehulling on nutritive value and the *in vitro* protein digestibility of pearl millet. M.Sc. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.
5. Bhise, V.J., J.K. Chavan and S.S. Kadam, 1988. Effect of malting on proximate composition and *in vitro* protein and starch digestibilities of sorghum grain. *Journal of Food Science and Technology*; 25: 327-329.
6. Bravo, L., 1998. Polyphenols: Chemistry, dietary source, metabolism and nutritional significance. *Nutrition Reviews*, 56: 317-333.
7. Chavan, J.K. and S.S. Kadam, 1989. Nutritional improvement of cereals by sprouting. *Critical Reviews of Food Science and Nutrition*, 28: 401-437.
8. Dendy, D.A.V., 1995. Sorghum and millets: Chemistry and Technology. Grain after harvest. Upton, Oxford, United Kingdom, Published by the American Association of Cereal Chemists, Inc. St. Paul, Minnesota, USA.
9. Dhankher, N. and B.M. Chauhan, 1987. Effect of temperature and fermentation time on phytic acid and polyphenols content of Rabadi a fermented pearl millet food. *Journal of Food Science*, 52: 828-829.
10. Dhankher, N. and B.M. Chauhan, 1989. Effect of fermentation on HCl extractability of minerals in Rabadi an Indigenous fermented food of India. *Journal of Science Food and Agriculture*, 49: 467-472.
11. Duncan, B.D., 1955. Multiple range and multiple F test. *Biometrics*, 11: 1-42.
12. ElTinay, A.H., A.M. Abdelgadir and M. Elhidai, 1979. Sorghum fermented kiswa bread 1: Nutritive Value of kiswa. *Journal of Science Food Agriculture*, 30: 859-863.
13. Hanson, N.W., 1973. Official, standardized and recommended methods of analysis, London: the Society for Analytical Chemistry. xxiv, pp: 895. Tables (Society[SH: 32070] for analytical chemistry).
14. Haug, W. and H.J. Lanhzch, 1983. Sensitive method for the rapid determination of phytate in cereals and cereal products. *Journal of Science Food and Agriculture*, 34: 1423-1426.
15. Hosoney, R.C., D.J. Anderson and H. Clark, 1987. Sorghum and pearl millet, Nutritional quality of cereal grains: Genetic and Agronomic improvement. *Agronomy Monograph*, 28: 397-456.
16. Hulse, J.H., E.M. Laing and O.E. Pearson, 1980. Sorghum and millets their composition and nutritive value. Pp. 16-25. New York, USA: Academic Press.
17. Khetarpaul, N. and B.M. Chauhan, 1989. Effect of fermentation on protein, fat, minerals and thiamine content of pearl millet. *Plant Food for Human Nutrition*, 39: 169-177.
18. Khetarpaul, N. and B.M. Chauhan, 1990. Improvement in HCl extractability of minerals from pearl millet by natural fermentation. *Food Chemistry*, 37: 69-75.
19. Khetarpaul, N. and B.M. Chauhan, 1991a. Effect of pure sequential culture fermentation by yeasts and lactobacilli on HCl extractability of minerals from pearl millet. *Food Chemistry*, 39: 347-355.
20. Khetarpaul, N. and B.M. Chauhan, 1991b. Effect of natural fermentation on antinutrients and *in vitro* digestibility of starch and protein in Pearl millet flour. *Journal of Science Food and Agriculture*, 55: 189-195.
21. Kumar, A. and B.M. Chauhan, 1993. Effects of phytic acid on protein digestibility (*In vitro*) and HCl extractability of minerals in pearl millet sprouts. *Cereal Chemistry*, 70: 504-506.

22. Mahajan, S. and B.M. Chauhan, 1987. Phytic acid and extractable phosphorus of pearl millet flour as affected by natural lactic acid fermentation. *Journal of Food Science and Agriculture*, 41: 381-386.
23. Malleshi, N.G. and H.S.R. Desikachar, 1986. Nutritive value of malted millet flour. *Qual. Plant Foods for Hum Nutrition*, 36: 191-196.
24. McGrath, R.M., W.Z. Kaluza, K.H. Daiber, W.B. Vander Riet and C.W. Glennie, 1982. Polyphenols of sorghum grain, their changes during malting and their inhibitory nature, *Journal of Agriculture and Food Chemistry*, 30: 450-459.
25. Monawar, L.Y., 1983. Food value of Sudanese indigenous cereal grains. Ph.D. Thesis, University of Khartoum, Sudan.
26. Pawar, V.D. and G.S. Parlikar, 1990. Reducing the polyphenols, phytate and improving the protein quality of pearl millet by dehulling and soaking. *Journal of Food Technology*, 27: 140-143.
27. Price, M.L. and L.G. Butler, 1977. Rapid visual estimation and spectrophotometric determination of tannin content of sorghum grain. *Journal of Agriculture and Food Chemistry*, 25: 1268-1273.
28. Reichert, R.D. and C.G. Youngs, 1979. Bleaching effect of acid on pearl millet. *Cereal Chemistry*, 56: 287-290.
29. Snedecor, G.W. and W.G. Cochran, 1987. *Statistical methods*, 7<sup>th</sup> edition. Ames, IA, USA, Iowa State University Press.