Effect of Germination on Tannin, Mineral, and Trace Element Composition of Groundnut Varieties

P. Udayasekhara Rao
National Institute of Nutrition, Indian Council of Medical Research, Hyderabad — 500 007, India

ABSTRACT: Groundnut varieties were analyzed for their tannin, ionizable iron, soluble zinc, phytate phosphorus, total iron, total phosphorus, total zinc, copper, magnesium, and manganese contents in ungerminated seed and after 0, 24, 48, and 72 h of germination. Tannin content varied between 100 and 623 mg/100 g; ionizable iron ranged from 136–2178 μg/100 g; phytate phosphorus ranged from 415–655 mg/100 g; soluble zinc varied between 776 and 951 μg/100 g of kernels. Soaking groundnuts overnight in water resulted in a decrease in content of most of the minerals, trace elements, tannins, and soluble zinc. As the germination period increased from 0 to 24, 48, and 72 h, ionizable iron (50%) and soluble zinc (95%) increased substantially. Ionizable iron as percent of total iron increased from 10% in ungerminated kernels to 23% in 72-h germinated kernels. Soluble zinc as percent of total zinc also increased from 18% in ungerminated groundnuts to 31% in 72-h germinated ones. There was a negative correlation between tannin content and ionizable iron content of ungerminated and germinated kernels ($r = -0.5203$). Germination decreased the antinutritional factors, such as tannin, and increased the bioavailable forms of iron and zinc, namely ionizable iron and soluble zinc contents of groundnut kernels.
JAOCS 72, 477–480 (1995).

KEY WORDS: Germination, groundnuts, ionizable iron, phytate phosphorus, soluble zinc, tannins.

Groundnuts are the major source of edible oil in India. Like other oilseeds, they are a good source of oil and protein. The nicotinic acid content of groundnut kernels is high, comparable to that of rice bran (1). Groundnut kernels are consumed in the immature form, as well as after maturation (2). Low-fat groundnut flour, alone or in combination with bengal gram, has been employed for the treatment of protein–energy malnutrition, which is prevalent among the children belonging to low socioeconomic groups in developing countries (3).

Tannins are known to bind proteins and inhibit protein digestibility (4). Geeta *et al.* (5) observed a negative correlation between tannin content and *in vitro* protein digestibility of ragi. The viscosity of malted ragi flour preparations was found to be inversely correlated with energy content (6). Iron deficiency anemia is widely prevalent in developing countries (7). Tannins are known to inhibit iron absorption in humans (8). Germination raji varieties had decreased tannin contents with a concomitant increase in ionizable iron and soluble zinc content (9). The present investigation was undertaken to examine the beneficial effect of germination on groundnut varieties. In this study, groundnuts were analyzed for their tannin, mineral, and trace element composition both before and after germination.

*Address correspondence at National Institute of Nutrition, Indian Council of Medical Research, Jamai Osmania PO, Hyderabad — 500 007, India.

MATERIALS AND METHODS

Six groundnut varieties were obtained from Dr. Pankaj Reddy (IARI, Regional Research Station, Rajendranagar, Hyderabad, India). Aliquots of 20-g samples were steeped in distilled water for 18 h at room temperature. They were then germinated for 0, 24, 48, and 72 h in sterile Petri dishes lined with moist filter paper. At the times indicated, samples were dried in a forced-air oven at 60°C. After grinding, fat was extracted with diethyl ether as solvent. Fat-free samples were analyzed for tannin, ionizable iron, soluble zinc, phytate phosphorus, other minerals, and trace elements.

Tannin content was estimated by the modified vanillin hydrochloride method of Price *et al.* (10). Catachin was used as a standard, and the results are expressed as catachin equivalents. After dry-ashing, all ungerminated and germinated samples were analyzed for phosphorus and iron by Association of Official Analytical Chemists methods (11). Zinc, magnesium, copper, and manganese were determined in an atomic absorption spectrophotometer (Varian Techtron Model AAS, 1000; Varian Associates, Palo Alto, CA). Phytate phosphorus was estimated according to the method of Makower (12).

Ionizable iron and soluble zinc contents were estimated according to methods developed by Narasinga Rao and Prabhavathi (13) and Mrunalini (14), respectively.

The data were evaluated by an analysis of variance technique with an SPSSPC software package (Statistical Package for Social Sciences Inc., Chicago, IL).

RESULTS AND DISCUSSION

Table 1 gives the tannin, mineral, and trace element compositions of ungerminated groundnuts. Tannin content of groundnut varieties varied between 100 and 623 mg/100 g. Ionizable

TABLE 1
Tannin, Mineral, and Trace Element Composition of Groundnut Varieties[a]

Variety	Tannin (mg/100 g)	Ash (%)	Total iron (mg/100 g)	Ionizable iron (µg/100 g)	Total zinc (mg/100 g)	Soluble zinc (µg/100 g)	Total phosphorus (mg/100 g)	Phytate phosphorus (mg/100 g)	Magnesium (mg/100 g)	Manganese (mg/100 g)	Copper (mg/100 g)
PI-315608	100	5.6	6.8	2178	6.9	803	616	395	176	1.7	2.7
PI-393527-B	201	6.9	5.6	333	5.9	860	967	571	198	1.5	2.0
Makulu-red	317	6.7	6.2	419	5.4	776	951	480	212	2.4	1.7
TMV-10	325	5.1	8.0	564	2.9	951	900	449	191	1.9	2.5
ICG-404	436	5.1	5.6	275	5.4	887	969	623	226	2.3	1.7
JL-24	623	5.0	6.5	136	4.4	856	921	610	229	3.0	2.8
Mean ± SE	334 ± 75	5.7 ± 0.42	6.4 ± 0.42	650 ± 311	5.2 ± 0.56	856 ± 23	887 ± 55	521 ± 38	205 ± 8	2.1 ± 0.22	2.2 ± 0.20
%CV	55	15	16	117	27	7	15	18	10	26	22

[a]CV, coefficient of variation.

iron, total zinc, and manganese contents varied from 136 to 2178 µg, 2.9 to 6.9 mg, and 1.9 to 3.0 mg/100 g, respectively. The variation in other nutrients, such as ash, total iron, soluble zinc, phosphorus, and magnesium, was minor.

Overnight soaking (0-h germination) of groundnut kernels in water brought about a significant reduction in tannin (75%), ash (10.5%), soluble zinc (26%), and copper content, while ionizable iron content increased by 57% (Fig. 1). Increasing the germination period to 24, 48, and 72 h had no further effect on tannin, ash, and copper content. However, ionizable iron and soluble zinc contents increased by 140% and 94%, respectively, over the values of unsoaked seed (Table 2). There was a negative correlation between tannin content and ionizable iron content of ungerminated and germinated groundnut varieties (r = –0.5203).

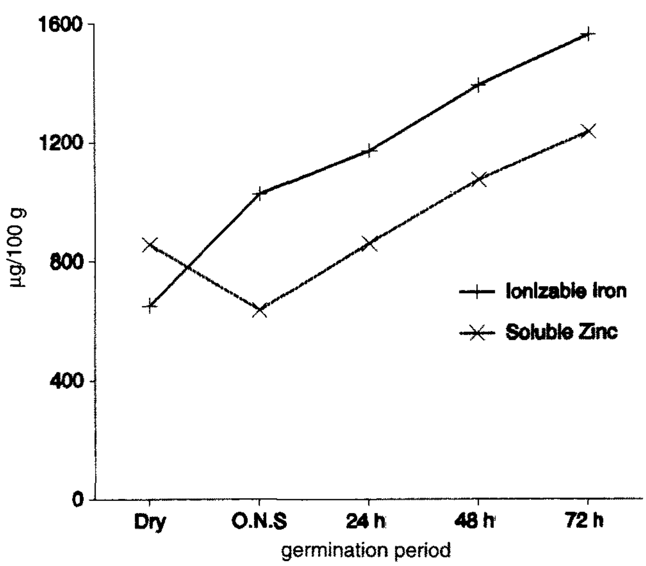

FIG. 1. Effect of germination on ionizable iron and soluble zinc content of groundnut varieties; O.N.S., overnight soaked or 0 h germination.

The decrease observed in the nutrient content during overnight soaking in water may be due to the leaching of these nutrients into soaking water. Mother liquor of water soaked overnight was collected and lyophilized, and tannin content was estimated—45–74% of groundnut tannin had leached into the soaking water. Polyphenol oxidase activity has been demonstrated in germinating wheat (15) and legumes (16). The decrease in tannin content of groundnut kernels during 0- to 24-h germination may be attributed to the induction of polyphenol oxidase in the germinating groundnut kernels.

Tannin content of groundnut kernels was lower than that of pigeonpea, green gram, black gram (17), and millets such as ragi (9), but it was higher than that observed in chickpea (17,18).

Ash content of ungerminated groundnuts ranged between 5.0 and 6.9 mg/100 g. Overnight soaking brought about a 12% decrease in ash content of the kernels. Increasing the germination period from 0 to 72 h had no further effect on ash content of the kernels.

Total iron content of groundnut varieties ranged from 5.6 to 8.0 mg/100 g. There was a slight increase in the total iron content of the kernels during overnight soaking. This may be

TABLE 2
Effect of 72-h Germination on Tannin, Mineral, and Trace Element Composition of Groundnut Varieties

Variety	Tannin (mg/100 g)	Ash (%)	Total iron (mg/100 g)	Ionizable iron (µg/100 g)	Total zinc (mg/100 g)	Soluble zinc (µg/100 g)	Total phosphorus (mg/100 g)	Phytate phosphorus (mg/100 g)	Magnesium (mg/100 g)	Manganese (mg/100 g)	Copper (mg/100 g)
PI-315608	92	4.8	6.2	3268	3.9	1774	645	418	171	1.5	1.9
PI-393527-B	61	6.2	8.1	980	5.5	1011	786	579	169	1.6	1.7
Makulu-red	74	5.8	7.6	1479	6.8	984	874	512	213	2.0	1.4
TMV-10	82	4.3	8.1	892	2.5	1229	747	443	184	2.0	2.5
ICG-404	159	5.0	4.3	1815	4.6	986	941	626	197	2.3	1.5
JL-24	78	4.2	7.5	937	4.0	1421	823	542	210	2.7	2.0
Mean ± SE	91 ± 11	5.1 ± 0.33	7.0 ± 0.60	1562 ± 372	4.6 ± 0.60	1234 ± 129	803 ± 42	520 ± 32	191 ± 8	2.0 ± 0.18	1.8 ± 0.16

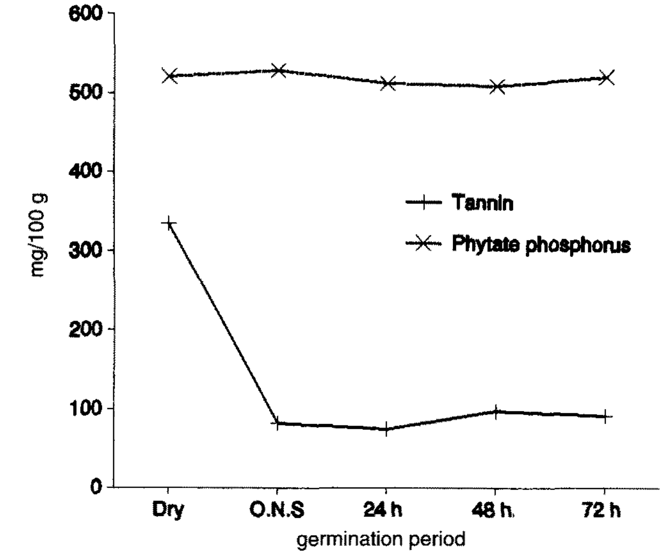

FIG. 2. Effect of germination on tannin and phytate phosphorus content of groundnut varieties. See Figure 1 for abbreviation.

due to the loss of total solids observed during this period. Ionizable iron was used as a valid measure of bioavailability of iron from foods of plant origin. There was a wide variation in ionizable iron (136–2178 μg/100 g) content of ungerminated groundnut kernels, with a coefficient of variation (CV) of 117%. Overnight soaking in water resulted in a 57% increase in ionizable iron content. As the germination period increased to 24, 48, and 72 h, ionizable iron content also increased to 80, 114, and 138%, respectively. Groundnut kernels with the lowest tannin content (100 g/100 g) had the highest ionizable iron content (2178 μg/100 g), while the variety with the highest tannin content (628 mg/100 g) had the lowest ionizable iron content (136 μg/100 g). There was a negative correlation ($r = -0.5203$) between tannin and ionizable iron contents. Udayasekhara Rao and Deosthale (9) and Prabhavathi and Narasinga Rao (19) observed similar correlations with respect to ragi and legumes. Tannins are known to interfere in iron absorption in humans (8).

Considerable variation in the total zinc content of groundnut varieties was observed (2.9 to 6.9 mg/100 g, with a CV of 27%). Germination of the kernels brought about a 10% decrease in total zinc content. Soluble zinc, the bioavailable form, constituted 18% of total zinc in ungerminated kernels, and its concentration increased gradually as the germination period increased from 0 to 72 to 31%. There was a 50% increase in soluble zinc content at the end of 72-h germination over that of raw kernels (Fig. 1). Soluble zinc as percent of total zinc increased from 45 to 88% at the end of 72 h of germination in ragi varieties (9).

Total phosphorus content of groundnut varieties varied from 616 to 969 mg/100 g. Overnight soaking brought about a negligible decrease (5%) in the total phosphorus content of the groundnut kernels. Increasing the germination period had no further effect on the phosphorus content of the kernels.

Phytate phosphorus content of groundnuts varied between 395 and 623 mg/100 g. Phytate phosphorus constituted around 60% of the total phosphorus content. Germination had no significant effect on phytate phosphorus content of the kernels (Fig. 2). Decreased phytate phosphorus content was reported in germinating pulses (19–21) and in ragi (9). Because phytate phosphorus constitutes the storage form of phosphorus in seeds, it might have been hydrolyzed to meet the increasing demands of the germinating seeds.

Wide variations were observed in manganese (26% CV) and copper (22% CV) content of groundnut varieties. Overnight soaking of the kernels resulted in a 20% decrease in their copper content. There was no further change in copper content as the germination period was increased to 72 h. For magnesium and manganese, germination has a marginal effect on their concentrations.

Table 3 gives the analysis of variance data on tannin, ionizable iron, and soluble zinc. The germination period was taken as a covariate. The results indicated that the germination period has a significant effect on all three parameters studied. However, varietal differences were significant with respect to ionizable iron content only.

The studies presented here indicate overnight soaking of groundnut kernels brought about losses in tannin, ash, minerals, and trace elements, with the exception of iron. Ionizable iron increased during the same period. Increasing the germination period from 0 to 72 h caused a rise in soluble zinc, and ionizable iron. Germination of groundnuts was found to be beneficial as it decreased the antinutritional tannin, whereas

TABLE 3
Analysis of Variance Table for Tannin, Ionizable Iron, and Soluble Zinc by Varietal and Germination Period Differentials[a]

		Tannin			Ionizable iron			Soluble zinc		
Source of variation	d.f.	MSS	"F" ratio	Level of significance	MSS	"F" ratio	Level of significance	MSS	"F" ratio	Level of significance
Varieties	5	13808.5	1.1	0.373	4012973.9	103.9	0.000	182880.4	2.0	0.114
Germination period (covariate)	1	132446.0	10.8	0.003	2899601.7	75.1	0.000	843483.3	9.3	0.006
Error	23	12223.3			38631.2			90735.0		
Total	29	16642.2			822516.9			132579.0		

[a]d.f., Degrees of freedom; MSS, mean sum of squares; "F" ratio, Fisher's ratio.

the bioavailable forms of iron and zinc increased significantly (Table 3). Malted white ragi flour had better nutritional quality as judged by protein efficiency ratio and net protein utilization than did unmalted white ragi (22). As iron deficiency anemia and protein–energy malnutrition are prevalent among children belonging to low socioeconomic groups, germination may therefore be considered a simple process wherein iron and zinc bioavailability, as well as protein quality, can be enhanced to combat iron deficiency anemia and protein–energy malnutrition in these children.

ACKNOWLEDGMENTS

I would like to thank Dr. Vinodini Reddy, Director, National Institute of Nutrition, Hyderabad, for her interest in the work, M.P. Ramulu for his technical help, and Dr. N. Balakrishna for statistical analysis of the data.

REFERENCES

1. Gopalan, C., B.V. Ramasastri and S.C. Balasubramanian, *Nutritive Value of Indian Foods*, National Institute of Nutrition, ICMR, Hyderabad, 1971.
2. *The Wealth of India. Raw materials*, Vol. 1. CSIR, New Delhi, 1948, p. 90.
3. Srikantia, S.G., and C. Gopalan, *Ind. J. Med. Res. 48*:637 (1960).
4. Griffiths, D.W., and G. Moselay, *J. Sci. Food Agric. 31*:255 (1980).
5. Geeta, R., T.K. Virupakshka and M. Sadaksharaswamy, *J. Agric. Food Chem. 25*:1101 (1977).
6. Brandtzaeg, B., N.G. Malleshi, U. Svanberg and H.S.B. Desikachar, *J. Trop. Paedi. 27*:184 (1981).
7. *Am. J. Clin. Nutr. 35*:1442 (1982).
8. Destler, P.B., S.R. Lynch, R.W. Charlton, J.D. Torrance, T.H. Bothwell, P.B. Walker and F. Hayet, *Gut. 16*:193 (1975).
9. Udayasekhara Rao, P., and Y.G. Deosthale, *Plant Foods Hum. Nutr. 38*:35 (1988).
10. Price, M.L., S.V. Scoyoc and L.G. Butler, *J. Agric. Food Chem. 26*:1214 (1978).
11. *Official Methods of Analysis*, 11th edn., Washington, D.C., Association of Official Analytical Chemists, 1970.
12. Makower, R.V., *Cereal Chem. 47*:288 (1970).
13. Narasinga Rao, B.S., and T. Prabhavathi, *Am. J. Clinc. Nutr. 31*:169 (1978).
14. Mrunalini, D.P., Essential Trace Element Profile and Zinc Availability in Indian Foods and Diets, Ph.D. Thesis, M.S. University of Baroda, 1983.
15. Kruger, J.E., *Cereal Chem. 53*:201 (1976).
16. Udayasekhara Rao, P., and Y.G. Deosthale, *J. Food Sci. 52*:1549 (1987).
17. Udayasekhara Rao, P., and Y.G. Deosthale, *J. Sci. Food Agric. 33*:1013 (1982).
18. Narasinga Rao, B.S., and T. Prabhavathi, *Ibid. 33*:89 (1982).
19. Prabhavathi, T., and B.S. Narasinga Rao, *Ibid. 30*:597 (1979).
20. Janabai, G., R. Parvatham and K. Santhini, *Ind. J. Nutr. Dietet. 18*:87 (1981).
21. Udayasekhara Rao, P., and Y.G. Deosthale, *J. Food Sci. Techn. 20*:195 (1983).
22. Udayasekhara Rao, P., *Food Chem. 51*:433 (1994).

[Received April 8, 1994; accepted January 2, 1995]