Trace Element Composition of Common Oilseeds

Y.G. DEOSTHALE, National Institute of Nutrition, Indian Council of Medical Research, Jamai Osmania (PO), Hyderabad, 500 007 India

ABSTRACT

Nineteen varieties of groundnut (*Arachis hypogea*), 8 of mustard (*Brassica nigra*), 9 of coconut (*Cocos nucifera*), and 6 each of sesame (*Sesamum indicum*) and safflower (*Carthemum tinctorius*) were analyzed for total ash and 9 mineral nutrients. Varietal differences were significant in magnitude for zinc in sesame; for manganese, molybdenum and chromium in mustard; for calcium, iron, manganese, copper, molybdenum and chromium in groundnut; for calcium, molybdenum and chromium in safflower; and for calcium, iron, copper and molybdenum in coconut. Sesame was the richest source of most of the inorganic nutrients.

INTRODUCTION

Information on trace element content of common Indian foods is important to assess the dietary adequacy of these nutrients. Trace element composition of some important food grains like rice, wheat, sorghum and maize and the effects of milling and parboiling on the mineral content of some of these food grains have already been reported (1-4). Oilseeds such as groundnut (*Arachis hypogea*), gingeli (*Sesamum indicum*), coconut (*Cocos nucifera*), mustard (*Brassica nigra*) and safflower (*Carthemum tinctorius*) are primarily used for the extraction of edible oils. The oilseed cake or the meal obtained after extraction of oil is largely used as cattle feed or as a fertilizer. The defatted meal is a rich source of protein and, if suitably processed, has a great potential as food for human consumption. Some of these oilseeds are consumed as such and, though in small amounts, contribute to the daily intake of several nutrients. In the investigations presented here, several varieties of these oilseeds were analyzed and compared for their mineral and trace element composition.

MATERIALS AND METHODS

Nineteen varieties of groundnut grown at the Agricultural Research Station (A.R.S.), Kadri, District Anantapur (Andhra Pradesh), 6 varieties of gingeli from A.R.S. Karimnagar (Andhra Pradesh), 8 varieties of mustard from Hissar (Haryana), 6 varieties of safflower from A.R.S. Annegeri (Karnataka) and 9 varieties of coconut grown at Central Plantation Crop Research Institute, Kasargod (Kerala) were obtained. All samples were cleaned to remove grit and foreign matter, washed thoroughly with glass-distilled water to remove surface contamination and then dried in the shade. For coconut samples, the pulp was removed and dried before analysis. The samples were thoroughly dried and defatted by Soxhlet extraction using distilled diethyl ether. The defatted meals were ground to pass through a 40-mesh sieve and ashed at 500 ± 5 C. The mineral solution prepared from the ash was used for the estimation of calcium, phosphorus and iron content by official methods (5). Copper, zinc, magnesium, manganese and chromium were estimated by atomic absorption spectrophotometry (Varian Techtran Model AAS 1000). Molybdenum content of the samples was estimated by a colorimetric procedure (6).

Levels of different nutrients are expressed on dry weight basis of the whole oilseed. Varietal differences in the nutrient content were considered significant when coefficient of variation was greater than 25%. The statistical significance of the association between 2 nutrients was tested by simple coefficient of correlation.

RESULTS AND DISCUSSION

Data on mineral and trace element content (mean ± SE) of the 5 oilseed varieties are presented in Table I and only those coefficients of correlation significant statistically are presented in Table II.

Groundnut

In the 19 varieties of groundnut analyzed, variations in the calcium, iron, manganese, copper, molybdenum and chromium contents were wide and significant (c.v. 25%). Wide variations are reported to exist in the mineral and trace element composition of groundnut (7,8) and the values of different nutrients found here were within the normal ranges except for molybdenum. The mean molybdenum content of 1.66 μg/g was much lower than the range 8-30 μg/g reported by other workers (7,8). Conkerton and Ory (9) found significant differences between Spanish groundnut and Virginia groundnut for their calcium, iron, copper, manganese, sodium and zinc contents. Morris and coworkers (10) found locational differences in the mineral composition of groundnut. The varieties of groundnut analyzed here were grown under identical agroclimatic condi-

TABLE I

Mineral and Trace Element Composition of Some Oilseeds[a]

	Sesame	Mustard	Groundnut	Safflower	Coconut
No. of varieties	6	8	19	6	9
Ash (g %)	6.6 ± 0.02	4.7 ± 0.21	3.3 ± 0.09	2.1 ± 0.15	2.1 ± 0.09
Phosphorus (mg/100 g)	872 ± 35	767 ± 41	500 ± 8	367 ± 10	193 ± 10
Calcium (mg/100 g)	1232 ± 28	318 ± 25	77 ± 6	214 ± 28	24 ± 4
Magnesium (mg/100 g)	521 ± 42	273 ± 18	259 ± 4	241 ± 18	164 ± 6
Iron (mg/100 g)	9.3 ± 0.43	7.9 ± 0.34	2.5 ± 0.23	4.6 ± 0.13	7.8 ± 0.91
Zinc (μg/g)	122 ± 21	48 ± 3.7	39 ± 1.6	52 ± 3.3	50 ± 1.8
Manganese (μg/g)	13.2 ± 0.26	25.6 ± 4.09	11.0 ± 0.76	11.0 ± 0.78	62.4 ± 3.28
Copper (μg/g)	22.9 ± 1.70	8.3 ± 0.44	9.0 ± 0.53	15.8 ± 1.54	10.0 ± 0.91
Molybdenum (μg/g)	2.04 ± 0.068	0.89 ± 0.105	1.66 ± 0.173	0.54 ± 0.08	0.21 ± 0.028
Chromium (μg/g)	0.87 ± 0.052	0.63 ± 0.058	0.48 ± 6.031	0.45 ± 0.060	—

[a]All values are mean ± SEM for dry weight of the sample.

TABLE II

Significant Correlations between Nutrients in Different Oilseeds

Groundnut (19)[a]		Mustard (8)		Safflower (6)		Sesame (6)		Coconut (9)	
Correlation between	r	Correlation between	r	Correlation between	r	Correlation between	r	Correlation between	r
P and Ca	0.707^{e}	Ash and P	0.695^{b}	Ash and P	0.907^{d}	Ash and Zn	0.837^{b}	P and Mg	0.697^{b}
P and Mn	-0.453^{b}	Ash and Zn	0.916^{e}	Ash and Fe	0.864^{c}	P and Mg	0.758^{b}	P and Zn	0.682^{b}
Ca and Fe	-0.505^{b}	P and Mg	0.934^{e}	P and Mg	0.835^{c}	Ca and Cr	-0.847^{c}	Mg and Fe	-0.784^{c}
Ca and Zn	0.675^{d}	P and Zn	0.775^{c}	Mg and Mn	0.805^{b}	Zn and Cu	0.855^{c}		
Ca and Mn	-0.713^{e}	P and Mo	0.739^{b}	Mg and Cu	0.775^{b}				
Ca and Cu	0.578^{d}	Mg and Fe	0.679^{b}	Zn and Cu	0.925^{d}				
Ca and Mo	0.596^{d}	Fe and Zn	0.745^{b}						
Fe and Zn	-0.657^{d}	Fe and Mn	0.736^{b}						
Fe and Mn	0.632^{d}	Fe and Cr	0.769^{c}						
Fe and Cu	-0.632^{d}	Mn and Cu	0.761^{c}						
Zn and Mn	-0.645^{d}	Mn and Cr	0.742^{b}						
Zn and Cu	0.865^{e}	Cu and Cr	0.737^{b}						
Mn and Cu	-0.642^{d}								
Mn and Mo	-0.548^{c}								

[a]Number of samples analyzed in parentheses.
[b]Significant at the 5% level.
[c]Significant at the 2% level.
[d]Significant at the 1% level.
[e]Significant at the 0.1% level.

tions and the large variations in the mineral and trace element content are therefore largely attributable to genetic factors.

In these varieties of groundnut, a highly significant inverse correlation existed between calcium and manganese content. Further, phosphorus, molybdenum, copper and zinc were significantly correlated, positively with calcium and negatively with manganese. The level of iron, which was directly correlated with manganese, was inversely proportional to calcium, copper and zinc content. Correlation between copper and zinc was positive and significant statistically.

Among the 5 oilseeds, groundnut was the poorest source of iron.

Mustard

The 8 varieties of mustard showed varietal differences only for manganese, molybdenum and chromium content. Elson and coworkers (11) have studied copper, zinc, calcium and lead content of meal, oil and whole seed of rapeseed and found that the trace metal content of the seed was not influenced by location; in addition, the variety appeared to affect the levels of different metals. Appelqvist (12) reported some data of the inorganic nutrient content of rapeseed. Phosphorus, magnesium, zinc and manganese contents of mustard observed here were comparable to those of rapeseed. However, the calcium content of rapeseed was about 1.5 times higher than that of mustard. On the other hand, the copper content of mustard was 2 times higher than that of rapeseed.

The phosphorus content of the mustard varieties was positively and significantly correlated with total ash, magnesium, zinc and molybdenum content. Similarly, iron was significantly correlated with zinc, magnesium, manganese and chromium. The correlation of copper with chromium and manganese and that of zinc with total ash were positive and significant. Compared to groundnut, safflower and coconut, the levels of most of the inorganic nutrients were found to be higher in mustard seeds and, next to sesame, mustard was the richest source of mineral elements.

Sesame

In the 6 sesame varieties analyzed here varietal differences were significant only for zinc content. The levels of calcium and phosphorus were slightly higher than those reported for 7 varieties grown in Central America (13), but the iron contents were comparable in the two. Data presented by Johnson and coworkers (14) have shown differences in calcium content of Sudanese white and Indian black sesame. It has further been shown that ca. 60-80% of calcium is lost during dehulling of the sesame seed. The oxalic acid content, which is high in the sesame seeds, is lost by only ca. 30-50%. The hull or pericarp constitutes ca. 15-20% of the weight of the sesame seed and over 80% of the seed calcium is present in this portion (15). On the other hand, almost all of the phosphorus of the whole seed is located in the oily kernel of sesame, and magnesium phytate complex accounts for most of this phosphorus (16).

In the 6 sesame varieties, significant inverse correlations were observed between zinc and copper and between calcium and chromium. The significant positive correlations observed were those between zinc and total ash and between phosphorus and magnesium.

Data presented here show that sesame is an exceptionally rich source of all the inorganic nutrients except, perhaps, for manganese. High content of the fibrous hull in the seed and high levels of oxalate and phytate may have an adverse effect on the bioavailability of these nutrients.

Safflower

In the safflower varieties, variations in calcium, molybdenum and chromium content were significant in magnitude. Compared to coconut and groundnut, this oilseed was found to be richer in calcium, zinc and copper content. Safflower seed is composed of a kernel which is surrounded by a thick fibrous hull. The relative proportion of the hull varies from 25 to 70% of the whole seed and this is a varietal character (17). Hull contains few nutrients, and large variations in the relative proportion of the hull in the safflower seed perhaps partly explain the differences in the nutrient composition of the seed. The protein and fiber content of whole seed is affected by climate, manner of farming and type of soil.

Statistically significant correlations observed were those of phosphorus with total ash and magnesium and iron with total ash. The bitter taste of safflower kernel due to the presence of some alkaloids limits its use, especially of the oil meal, as a food or feed. Special efforts are therefore needed to suitably process this seed or cake to make it acceptable.

Coconut

Significant variations were observed in the calcium, iron, molybdenum and copper content of the 9 coconut varieties. Curtin (18) reported some data on mineral and trace element compositions of coconut oil meals. Comparison of these data with those observed here after converting the level of each nutrient to a fat-free basis indicated that the values for phosphorus and iron content were similar to those reported by Curtin. However, magnesium content of the coconut varieties analyzed here was almost double and manganese content was about 5 times higher. On the other hand, calcium and copper contents were lower than the values reported for Philippine coconuts. Compared to other oilseeds, manganese content of the coconut was 2-5 times higher but it was the poorest source of calcium, phosphorus, magnesium and molybdenum.

In the coconut varieties here, magnesium and zinc were significantly and positively correlated with phosphorus. Iron was inversely correlated with magnesium.

Data presented here show that oilseeds are a rich source of not only minerals such as calcium, iron and magnesium but also of trace elements such as copper, zinc, manganese and chromium. Compared to cereals, millets and pulses, their copper and chromium contents are significantly higher. These oilseeds, especially safflower, mustard and sesame, contain high proportions of fibrous hull and their phosphorus is mostly present in the form of phytate (19). Both components are known to limit the bioavailability of the metal ions. Feeding trials with rapeseed meal result in severe zinc deficiency, which has been attributed to high phytate of the rapeseed meal (20,21). Presence of high tannin, especially in the skin of the groundnut (8), bitter principles in safflower kernel (22), toxic thioglucosinolates in mustard seeds (23,24), and high oxalic acid content of sesame (14) are some of the factors which may affect the efficient utilization of these oilseeds and perhaps more so of their meals after oil extraction. Since protein is the most important nutrient present in very high amounts in these oilseed meals, methods are being developed to prepare protein isolates and various other products for diverse end uses. By suitable technology, the oilseed meal, the major by-product of the edible oil industry, can be a food rich in major, as well as minor, nutrients.

ACKNOWLEDGMENT

Thanks to P.G. Tulpule, Director, for his keen interest in these studies and M.P.C. Vijaya Raj, for technical assistance.

REFERENCES

1. Deosthale, Y.G., D.S. Shankara Rao and B. Belavady, J. Sci. Food Agric. 30:40 (1979).
2. Shankara Rao, D.S., and Y.G. Deosthale, J. Plant Foods (in press).
3. Deosthale, Y.G., and B. Belavady, Indian J. Nutr. Dietet. 15:302 (1978).
4. Deosthale, Y.G., Curr. Sci. 48:54 (1979).
5. "Official Methods of Analysis," 9th Edn., Association of Official Agricultural Chemists, Washington, DC, 1960, p. 283.
6. Sandell, E.B., "Colorimetric Determination of Traces of Metals," 3rd Edn., Wiley Interscience Publishers Inc., New York, NY, 1959, p. 460.
7. Seshadri, C.R., "Groundnut," Indian Central Oilseeds Committee, Hyderabad, India, 1962, p. 244.
8. Rosen, G.D., "Processed Plant Protein Foodstuffs," edited by A.M. Altschul, Academic Press Inc., New York, NY, 1958, p. 419.
9. Conkerton, E.J., and R.L. Ory, JAOCS 53:574 (1976).
10. Morris, N.M., E.J. Conkerton, B. Picolo and R.L. Ory, J. Agric. Food Chem. 26:1028 (1978).
11. Elson, C.M., D.L. Hynes and P.A. MacNeil, JAOCS 56:998 (1979).
12. Appelqvist, L.A., "Rapeseed," edited by L.A. Appelqvist and R.A. Ohlson, Elsevier Publishing Co., London, 1972, p. 123.
13. De Zaghi, S., and R. Bressani, R. Turrialba. 18:391 (1969).
14. Johnson, L.A., T.M. Suleiman and E.W. Lusas, JAOCS 56:463 (1979).
15. Joshi, A.B., "Sesame," Indian Central Oilseeds Committee, Hyderabad, India, 1961, p. 16.
16. O'dell, B.L., and A. deBoland, J. Agric. Food Chem. 24:804 (1976).
17. Kneeland, J.A., "Processed Plant Protein Foodstuffs," edited by A.M. Altschul, Academic Press Inc., New York, NY, 1958, p. 620.
18. Curtin, L.V., Ibid., p. 645.
19. Erdman, J.W., Jr., JAOCS 56:736 (1979).
20. McLaughan, J.M., J.L. Beare-Rogers, J.D. Jones and B.G. Shah, Nutr. Report Int. 15:331 (1977).
21. Jones, J.D., JAOCS 56:716 (1979).
22. Betschart, A.A., Ibid. 56:455 (1979).
23. Ohlson, R., and K. Anjou, Ibid. 56:431 (1979).
24. Rutkowski, A., Ibid. 56:475 (1979).

[Received June 16, 1980]