Pakistan Journal of Nutrition 1 (1): 39-40, 2002
© Asian Network for Scientific Information 2002

Potential Intake of Lithium by the Inhabitants of Different Regions in Jordan

M.S.Y. Haddadin, S. Khattari Daniela Caretto, and *R.K.Robinson
Faculty of Graduate Studies, University of Jordan, Amman, Jordan
*School of Food Biosciences, University of Reading, Reading, Berkshire RG6 6AP, England

Abstract: Although it is alleged that lithium is not toxic to humans below an intake of 500 mg day^{-1}, test animals have been affected at levels as low as 50 mg kg^{-1} of feed. This study sought to establish whether fruits grown in the Jordan Valley could accumulate sufficient lithium for consumers to reach a target of 50 mg day^{-1}. The mean soil levels of extractable lithium were 13.1, 20.3 and 25.4 mg kg^{-1} in three different growing regions of the Valley, while the highest levels in citrus fruits were 51.3 mg kg^{-1} in clementines (*Citrus mitis*) and 49.4 mg kg^{-1} in the lemon (*Citrus limon*). As the latter values were on a dry weight basis, the risk of lithium toxicity would appear to be minimal but, equally important, deficiency syndromes should not be manifest either.

Key words: lithium, Jordan Valley, citrus fruits

Introduction

Lithium is widely distributed in soils around the world, and a general estimate puts the level in the earth's crust at 50-65 mg kg^{-1}. It is present in soils mainly as a component of silicates and, for this reason, sandstone soils are especially rich in lithium. By contrast, soils with excessive levels of organic matter tend to be low in lithium (3-4 mg kg^{-1}), and these differing concentrations between the soils are reflected in the levels in adjacent reservoirs. Consequently, local drinking water and, perhaps, crops subject to irrigation will contain concentrations of lithium typical of a given region.

Equally important is the fact that plants differ in their ability to accumulate lithium. Cereals and cereal-based products contain very little lithium (1 mg kg^{-1}), but most vegetables (dry weight) contain > 1 mg kg^{-1} (Anke, 1993; Bibak *et al.*, 1999); fruits like apples or lemons are cited as having around 1.4 mg kg^{-1} of lithium. The vegetative parts of plants often retain higher concentrations, and hence the level in milk tends to vary depending on the type of fodder or silage consumed. The low values in these common foods are in accord with published data on lithium intakes in Europe, with levels of 0.1 - 0.6 mg day^{-1} being recorded at different sites in Germany; as lithium is readily soluble, regional differences in the concentrations of lithium in drinking water may explain the observed variations (Anke, 1993).

However, other studies have suggested that normal intakes of lithium may reach 3.4 mg day^{-1}, but it is probable that none of these estimates take account of local factors, such as the availability of a balanced diet or, conversely, dependence on one or two locally-grown food items. Whether higher than average intakes would have any nutritional significance is not clear, for it is suggested that an intake of 500 mg day^{-1} would be needed to raise the level of blood serum lithium in humans to close to the toxic level of 1.6 meq l^{-1} (Anke, 1993). Thus, although lithium appears to be essential for the full activity of enzymes associated with both glycolysis and nitrogen metabolism, levels above the toxic threshold have been linked with a range of disorders ranging from thyroid changes to skeletal damage. The risk of this type of damage is a cause for concern mainly with patients being treated for mental disorders with daily doses of lithium in the range of 160 - 300 mg day^{-1}, but some degree of toxicity cannot be ruled out at much lower levels of intake.

Thus, studies with a range of animals have shown adverse effects at quite modest dose rates. Chickens, for example, showed reduced feed consumption, live weight gain and egg production when lithium was added to feed at the rate of 50 mg kg^{-1}, and rats fed a lithium-rich diet gave birth to lighter off-spring which, in turn, developed more slowly.

Obviously it is unwise to assume that data obtained from animal trials applies to humans but, assuming that the dry matter intake for an adult human is 500 g, then there could be scope for some populations to achieve intakes of lithium day^{-1} approaching the critical values for some animals. In practice, the risks of encountering levels of 50 mg kg^{-1} of lithium in a normal diet are extremely low but, given that litle information was available about the levels of soil lithium in the Jordan Valley which supplies the citizens of Jordan with most of their fruits and vegetables, a study was undertaken to:

assess the lithium levels in the surface soils of the Jordan Valley;

determine the lithium concentrations in the edible portions of some crops grown in the Valley; and

see if a correlation could be established between the levels of soil lithium and the concentrations in fruits reaching the consumer.

Materials and Methods

Three different regions of the Jordan Valley were chosen on the basis of their location, land usage/cultivation practices and sources of water for irrigation, and these were designated as: Area (1) from South Shuna to Amman; Area (2) from Ardha to Kraima; and Area (3) from Kraima to Addassyah. In each area, farms were selected that grew citrus crops or miscellaneous vegetables, and composite soil samples (covering a depth from 0 - 30 cm) were taken from selected locations on each farm. Each sample of soil was then air-dried, passed through a sieve (2 mm openings) and oven-dried to a constant weight over 3 days at < 50°C.

The total organic matter was determined by the procedure outlined by Allison (1965) and pH in a slurry of soil in water (1 : 1, w/v). Exchangeable lithium was extracted from the soil as described by Knudsen *et al.* (1982) using 0.1 N ammonium acetate at pH 7.0. A sample of air-dried soil (10 g) was placed in a plastic bottle and 15 ml of ammonium acetate were added. The bottle was shaken for 10 min on a slow-speed 'wrist-action' shaker and then centrifuged at 12,000 rpm for 20 min to obtain a clear supernatant. This extraction procedure was repeated twice more on the same soil sample, and the supernatants were then bulked and made up to 100 ml with distilled water. After filtration through a membrane filter, the lithium concentration was derived with a Flamephotometer (AOAC, 1990). A standard curve using solutions of 0.00 - 10.0 mg l^{-1} lithium was prepared in order to calculate the concentrations of lithium in the different extracts.

The species of plant sampled are given in Table 2. A composite leaf sample was obtained from each citrus orchard (ten/species) by taking one or two fully expanded leaves from a number of trees; at the same time, one fruit was selected at random from the same trees. The leaves were subsequently washed in distilled water, air-dried for 1 day, and then oven-dried to constant weight at < 50°C. The dry leaves were ground in a Moulinex Mill (Moulinex, Paris, France) so as to pass through a 40 mesh sieve. The fruits were cut into small pieces, placed in Petri dishes and oven-dried to constant weight at < 50°C.

For digestion of the plant samples, 0.25 g of finely ground

Table 1: Average values for total available lithium (mg kgG^1) at various locations within the Areas indicated.Location Number Total Extractable Lithium

	Area 1	Area 2	Area 3
	11.2	45.0	24.4
	12.7	11.2	22.4
	10.2	19.8	18.4
	12.2	19.8	20.8
	12.7	18.3	20.3
	11.2	18.3	20.3
	11.2	19.3	23.3
	12.2	18.8	19.8
	12.7	17.7	25.8
	11.7	17.7	37.9
	12.7	23.3	40.4
	11.7	22.4	30.4
	16.2	20.8	-
	14.2	11.7	-
	16.7	-	-
	20.4	-	-
Mean	13.1	20.3	25.4

The locations cited above refer to individual farms, and where more than one soil sample was taken on a farm, the 'location' figure is a mean for all the samples for that farm.

Table 2: The species of plant tested for lithium, together with details of the number of individual plants/species examined and the origin of the test materials; all figures for lithium as mg kgG^1 of dried tissue

Plant	Origin	Range	Mean	No. of samples
Citrus mitis (clementine)	fruit	13.6-70.1	51.3	10
	leaves	58.8-205.6	143.5	10
Citrus paradisi (bomali)	fruit	13.7-25.0	20.7	10
	leaves	13.7-228.2	130.8	10
Citrus limon (lemon)	fruit	36.2-58.8	49.4	10
	leaves	70.1-171.7	134.5	10
Citrus reticulata (mandarin)	leaves	25.0-126.6	93.04	3
Corchorus olitorius (Mallow)	leaves	92.7-160.5	139.0	4
Capsicum annuum (red pepper)	leaves	194.3-318.5	256.4	2
Hibiscus esculenta (okra)	leaves		171.4	1
Sorghum bicolor	leaves		58.8	1
Trifolium alexandrinum (berseem)	leaves		183.0	1
Vitis vinifera (grape)	leaves		70.1	1

material was placed in a digestion tube along with 3 ml of concentrated sulphuric acid. The temperature of this mxixture was brought to 100°C, and the digestion process allowed to proceed for 1 hour. After cooling to 25°C, 3 ml of concentrated perchloric acid were added to the digest. The tubes were then returned to the digestion unit and, when the temperature of the liquid reached 250°C, digestion was allowed to proceed until a clear solution was obtained (~ 4 hours). The cooled digests were transferred to volumetric flasks (25 ml) and, after rinsing the tubes with deionised water, the volumes were adjusted to the mark. The total lithium concentrations in each extract were determined as before, and the same procedure was applied to sub-samples of finely-grounds fruits.

The results were analysed for L.S.D using the General Linear Models procedure of SAS as outlined by Steel and Torrie (1980).

Results and Discussion

Soils on the all the farms were calcareous with high pH. In the first Area (16 samples), the pH ranged from 7.5 - 8.1, in the second Area (14 samples) the lowest pH was 7.6 and the highest 8.0, while in the third Area (12 samples) the pH ranged from 7.5 to 7.8. The similarity in pH values suggests that there should be no effect of pH on the general status of lithium in the different soils. The total organic matter contents were low at 0.22 - 2.50 g kgG^1 in Area (1), 0.65 - 2.50 g kgG^1 in Area (2) and 0.95 - 2.70 g kgG^1 in Area (3). Overall, the results for pH and organic matter tend to mirror the values reported by Khattari (1990), and hence it seems likely that the sites selected for the analysis of lithium were typical of the regions in question. However, the low level of organic matter could be relevant in this context, because it is 'peaty' soils that tend to have low levels of lithium.

The values in Table 1 show that the lithium concentrations in the Jordanian soils ranged from 10.2 to 44.9 mg kgG^1, and these high values reflect the nature of the parent rock which is rich in alkaline elements; these elements, in turn, accumulate in the arid soil due to the lack of leaching. The comparison between Areas is of interest as well, as there is a clear gradient from the south (Area 1) to the north (Area 3) of the Jordan Valley. Statistical analysis of the data showed a significant correlation between location and total amount of extractable lithium ($P < 0.05$).

The concentrations of lithium in the different species of plant are shown in Table 2, and some of the values were extremely high compared with the figures (~ 1.4 mg kgG^1 of dry matter) reported by Anke *et al.* (1993) for fruits from the citrus family. Thus, assuming that the clementine has a moisture content of 87.5% (Holland *et al.*, 1991), then a rough conversion of the dry weight value to a wet weight figure gives a mean value for lithium of 0.63 mg *per* fruit. Given that a consumer could easily eat two or three clementines at one sitting, a lithium intake of ~ 2.0 mg could easily arise just from 'snacking'; a glass of lemon juice would further add to the intake.

The vegetative tissues retained, as expected, much higher levels of lithium, and it was unfortunate that no vegetative crops were available for analysis; none of the leaves studied are eaten. It may be, of course, that accumulation in the leaves is typical only of certain genera, for it has been suggested that the accumulation of lithium in leaves of citrus trees is a mechanism for removal from the body of the tree. However, in soils with little leaching, it may be that much of the lithium is simply taken-up again during the subsequent growing season, and this potential for recycling might explain why the levels of lithium in plants growing in Area 1 were similar to those in Area 3 (data not shown). Certainly some correlation might have been expected between the concentrations in the soils and the levels found in the plants, but no such connection could be established. Equally curious was the apparent absence of lithium damage to the citrus trees, because Aldrich *et al.* (1951) suggested that leaf damage could be initiated at concentrations as low as 1 - 4 mg kgG^1 of fresh tissue; the reasons for this apparent contrast were not investigated.

Conclusion: The high silicate content of soils in the Jordan Valley means that lithium is readily available to plants and, as a consequence, quite high levels build-up in the vegetative tissues of a number of plants. Much lower levels accumulated in the edible portions of citrus crops and, although the levels were higher than those reported by other workers, there appeared to be little hazard for the average consumer of citrus fruits.

References

Aldrich, D.G., A.P. Vanselow and G.R. Bradford, 1951. Lithium toxicity in citrus. Soil Science, 71: 291-295.

Allison, L.E., 1965. Organic carbon. In Methods of Soil Analysis, ed. C.A.Black, pp:1035-1048. Wisconsin: American Society of Agronomy.

Anke, M., 1993. Lithium. In Encyclopaedia of Food Science, Food Technology and Nutrition. eds. R. Macrae, R.K.Robinson & M.Sadler, pp: 2779-2782. London: Academic Press.

AOAC., 1990. Official Methods of Analysis. Volume 1, 15th. Edition AOAC, Arlington, USA.

Bibak, A., S. Sturup, L. Knudsen and V. Gundersen, 1999. Concentrations of 63 Elements in Cabbage and Sprouts in Denmark. Commun. Soil Sci. Plant Anal., 30: 2409-2418.

Holland, B., A.A. Welch, I.D. Unwin, D.H. Buss, A.A. Paul and D.A.T. Southgate, 1991. McCance and Widdowson's The Composition of Foods. The Royal Society of Chemistry, London.

Khattari, S.K., 1990. Heavy metals in soils of the Jordan Valley.Dirasat, 17B: 35-48.

Knudsen, D., G.A. Peterson and P.F. Pratt, 1982 . Lithium, sodium and potassium. In: Methods of Soil Analysis. Ed. Page, A.L. Soil Science Society of America, Madison, Wisconsin.

Steel, G.D. and J.M. Torrie, 1980. Principles and Procedures of Statistics. Tokyo: McGraw-Hill Book Company.