

Oxalate Content of Miner's Lettuce Irrigated with Water or Fertilizer Solutions

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Abstract

The total, soluble and insoluble oxalate contents of the small, large and cauline leaves and small and large stems of miner's lettuce (*Claytonia perfoliata*) plants which had been irrigated with tap water or a soluble fertilizer were extracted and measured using HPLC chromatography. Overall, all plant parts of miner's lettuce analyzed contained high levels of total and soluble oxalates; however plants irrigated with fertilizer contained lower levels of oxalates compared with plants irrigated with water. On a dry matter basis, the small leaves contained higher levels of total oxalate when compared to the total oxalate in the large leaves. Soluble oxalate in the leaves of plants irrigated with water ranged from 2.6 to 7.5 mg/100g dry matter (DM) and was significantly higher ($P < 0.05$) than the leaves of the fertilizer-watered plants, which ranged from 1.8 to 2.8 mg/100g DM. The soluble oxalate in the small and large stems of the fertilizer-watered plants ranged from 1.20 to 1.5 mg/100g DM and was significantly lower ($P < 0.05$) than the water-treated small and large stems, which ranged from 3.75 to 4.4 mg/100g DM. It is recommended that the leaves of miner's lettuce should be consumed in moderation.

Keywords

Miner's Lettuce, Oxalates, Fertilizer, Water Irrigation

1. Introduction

Miner's lettuce (*Claytonia perfoliata* Donn ex Willd) sometimes called winter purslane, is a group of interrelated and interbreeding plants. Typically, the plants have a pair of single leaves that are opposite each other and separated by a flowering branch. Some leaves are fused completely into a perfoliate disc known as a cauline leaf, just below the flower stalk [1]. Miner's lettuce was used as a food by many early North American set-

tlers and was popular among miners during the California gold rush as it was known for curing or averting scurvy. The leaves, stems and blossoms of miner's lettuce are rich in calcium, vitamin C and proteins [2]. Miner's lettuce is thought to have some medicinal properties. It was used as a spring tonic to restore appetite and the Native Americans used the brew as a gentle laxative. Miner's lettuce has a mild taste and is commonly mixed with other salad leaves, such as lettuce or spinach or with dry mustard, paprika, garlic, cloves etc. and used in salads or garnishes for soups [3] [4]. Cooked miner's lettuce can be used in stir fries, pasta dishes, combined with sorrel to make pesto and made into a fruity miner's lettuce smoothie with the addition of berries, pears and bananas [5].

Many green leafy vegetables contain oxalic acid in varying amounts [6]. Oxalic acid occurs as an end product of metabolism in plant tissues and can be found in the form of soluble or insoluble oxalates in the leaves. When plants that contain high levels of oxalates are consumed, the soluble oxalates can bind to calcium in other foods consumed at the same time. This formation of insoluble oxalates reduces the absorption of calcium and other minerals from the intestine [7]. While oxalic acid is a normal end product of mammalian metabolism, the consumption of additional oxalic acid may cause kidney stone formation when it is excreted in the urine [6].

Poeydomenge and Savage [8] showed that a related plant, purslane, contained high levels of oxalates in its leaves. The slight, tangy acidic taste of miner's lettuce leaves suggests that they may contain high oxalate levels but these have not been determined. Previous research has been carried out to analyze the effect of fertilizer application on the accumulation of oxalates in plant tissue. The application of nitrogen fertilizer significantly decreased the levels of total and soluble oxalates in *Hibiscus sabdariffa* [9]. However, the application of ammonia or nitrates as a fertilizer to several varieties of spinach did not have any effect on the oxalate content in the plant leaves [10]. These and other studies [11] [12] to determine the effect of fertilizer use on oxalate levels in the leaves of plants have not provided conclusive data. The purpose of this study was to determine the level of oxalates in different portions of miners' lettuce and to determine whether the application of fertilizer would change the levels of oxalate in the raw leaves.

2. Materials and Methods

2.1. Source of Materials and Preparation

Miner's lettuce seeds (*Claytonia perfoliata* Donn ex Willd Syn. *Montiaperfoliata*) were purchased from Kings Seeds (Katikati, Bay of Plenty, NZ). The seeds were sown in a standard three-month growing potting mix (80% bark, 20% pumice, Scotts Osmocote® controlled release NPK fertilizers containing trace elements and lime as soil nutrients) on the 30th August 2015. The seedlings were planted out on 12th September in a greenhouse maintained between 15°C and 25°C at the Horticulture Research Area, Lincoln University, Canterbury, NZ (43°38'43"S, 172°27'43"E), 10 meters above sea level. One group of plants was irrigated with tap water while another group was irrigated with di-

luted liquid High NK™ liquid fertilizers (PGG Wrightson, Christchurch, New Zealand). The fertilizers contained NPK (16-5.5-13, with trace elements, the solution contained 13.7% potassium nitrate). Five hundred mL of concentrated fertilizer was diluted into 20 L of tap water before application. Approximately 10 g of leaves, stems and flowers were harvested on the 15th December 2015 when the plants had reached a height of 100 mm. The leaves (large, small and cauline), stems (large and small) and flowers were cut into 1 - 2 mm pieces with a stainless steel knife prior to sampling.

2.2. Dry Matter

The dry matter (DM) contents of each sample of the leaves and stems were determined by drying in an oven (Watvic, Watson Victor Ltd., New Zealand) to a constant weight at 105°C [13].

2.3. Extraction and Determination of Total and Soluble Oxalic Acids

The extraction of total and soluble oxalates from the fresh leaves and stems of miner's lettuce were carried out using the methods outlined by Vanhanen and Savage [14]. The insoluble oxalate content of each sample was calculated by difference between the total and the soluble oxalate contents [15].

2.4. Statistical Analysis

All calculations were performed using Excel 2013 and statistical analysis was carried out using GenStat, Release 15.1 for Windows 7 (VSN International Ltd., Hemel Hempstead, Hertfordshire, UK) to determine the accumulated analysis of variance. All analyses were carried out in triplicate and the results presented as mean ± standard error (SE).

3. Results and Discussion

The shape of the leaves and the arrangement of the cauline leaves of miner's lettuce growing in this experiment confirm that the cultivar used in this study was *Claytonia perfoliata* subsp *perfoliata* [16]. Analysis of oxalate content found in different plant fractions of miner's lettuce irrigated with water or fertilizer solutions was carried out to compare the distribution of oxalates in each of the edible plant parts. The mean values of total, soluble and insoluble oxalate content of each of the edible plant parts are shown in **Table 1**.

3.1. Leaves

The dry matter contents (**Table 1**) of all the plant parts were higher in the fertilizer-watered plants compared to the tap water irrigated plants. The water-fed leaves showed that very high percentages of soluble oxalate were present compared with the total oxalate in the large leaves (93.0%), cauline leaves (83.3%), with moderate levels in the smaller leaves (38.9%). However, the soluble oxalate level in the fertilizer-watered miner's lettuce were relatively lower with all three; small, large and cauline leaves and ranged between 46.7% to 67% of the total oxalate content of these leaves.

Table 1. Percentage of dry matter, total, soluble and insoluble oxalates (g/100g DM) of fresh leaves, stems and flowers of miner's lettuce irrigated with tap water or soluble fertilizer (values in brackets are % soluble oxalate of total oxalate content).

Plant treatment	Dry matter (%)		Total oxalate		Soluble oxalate		Insoluble oxalate	
	Tap water	Fertilizer solution	Tap water	Fertilizer solution	Tap water	Fertiliser solution	Tap water	Fertilizer solution
Leaves								
Small	5.26	8.20	10.71 ± 0.06	5.23 ± 0.03	4.17 ± 0.00 (38.9)	2.44 ± 0.01 (46.7)	6.54 ± 0.06	2.79 ± 0.02
Large	6.99	8.19	8.04 ± 0.01	4.70 ± 0.02	7.48 ± 0.06 (93.0)	2.78 ± 0.01 (59.1)	0.56 ± 0.05	1.92 ± 0.01
Cauline	9.28	10.35	3.06 ± 0.01	2.61 ± 0.01	2.55 ± 0.03 (83.3)	1.75 ± 0.01 (67.0)	0.51 ± 0.02	0.86 ± 0.01
Stems								
Small	5.08	5.21	6.02 ± 0.06	2.62 ± 0.03	3.75 ± 0.01 (62.3)	1.46 ± 0.00 (55.7)	2.27 ± 0.05	1.16 ± 0.03
Large	6.25	6.68	5.03 ± 0.06	1.77 ± 0.01	4.41 ± 0.03 (87.7)	1.20 ± 0.01 (67.8)	0.62 ± 0.03	0.57 ± 0.00
Flowers	10.32	12.15	2.30 ± 0.00	2.39 ± 0.01	2.27 ± 0.00 (98.7)	2.21 ± 0.01 (92.5)	0.02 ± 0.00	0.18 ± 0.00
Analysis of variance			df	Total	Soluble	Insoluble		
Plant part			4	***	***	***		
Treatment			1	***	***	ns		
Plant part × treatment			5	***	***	*		
LSD plant part (5%)				0.92	0.65	1.05		
LSD treatment (5%)				0.53	0.38	0.61		
LSD plant part × treatment (5%)				1.30	0.92	1.48		

Significance: ns, not significant; *** $P < 0.001$; * $P < 0.05$; LSD: least significant difference.

3.2. Stems

On a dry matter basis water-irrigated small (62.3%) and large (87.7%) stems contained a higher percentage of soluble oxalate compared to the total oxalate content of the stems. In contrast, lower levels of solubleoxalate, ranging between 55.7% and 67.8% of the total oxalate content, were found in the fertilizer-irrigated small and large stems. Overall, large leaves harvested from the water-irrigated plants contained higher levels ($P < 0.05$) of total oxalates when compared to leaves harvested from fertilizer-watered plants on a fresh matter and a dry matter basis.

3.3. Flowers

On a dry matter basis flowers contained the highest levels of oxalate when compared to the stems and leaves. The soluble oxalate content of the flowers irrigated with water was 98.7%, and 92.5% in fertilizer-watered flowers when compared to the total oxalate content.

4. Discussion

Most parts of the plant contained high levels of oxalate. It is remarkable to note that the smaller leaves harvested from tap water irrigated plants contained 10.7% total oxalate on a DM basis, while the leaves harvested from plants irrigated with fertilizer contained 5.2% total oxalate on a DM basis. In contrast, the water-irrigated large leaves contained 8.0% total oxalate on a DM basis and the fertilizer-watered large leaves contained 4.7% on a DM basis. The small and large miner's lettuce leaves, irrigated with fertilizer resulted in approximately 47% reduction in the total oxalate on a DM basis when compared to the leaves harvested from the water-irrigated plants. Overall the irrigation of the plants with nitrate fertilizer significantly reduced the oxalate contents of all parts of the plants which confirm the observation on the response of *Hibiscus sabdariffa* [17].

Statistical analysis (**Table 1**) of the total and soluble oxalate contents between the plant parts of miner's lettuce irrigated with both water and fertilizer solutions were significantly different at $P < 0.001$. Interactions between the type of treatment and plant parts were also significantly different ($P < 0.001$) for the total and soluble oxalate contents of the leaves and stems and the insoluble oxalate between the leaves and stems were only significantly different ($P < 0.05$). It is interesting to note that the overall % of soluble oxalate compared to the total oxalate for the leaves and stems was 77.3% for the water irrigated plants compared to 64.8% for all the plant parts sampled from the plants irrigated with fertilizer solution. There is also a significant increase in the proportion of soluble oxalate in the large leaves compared to the small leaves for both of the treatments. The leaves are the most commonly eaten part of miner's lettuce and they contain high levels of oxalate, comparable to many oxalate-rich foods such as spinach, Swiss chard, beetroot and rhubarb [6]. Small and large stems and flowers of miner's lettuce are less likely to be eaten but they contain high levels of oxalate (2% to 6% of the total DM). The consumption of 100 g of the fresh leaves of miner's lettuce would contribute 562.9 mg of total oxalate to the diet and this would constitute a significant part of the normal daily intake of oxalate for omnivores, which ranges from 70 to 930 mg/day, but for vegetarians, this range increased from 80 to 2000 mg/day [18].

5. Conclusion

The oxalate contents of all parts of miner's lettuce were high and comparable to the oxalate levels present in spinach, which is well known to contain high levels of oxalates. Although miner's lettuce is used as an occasional salad addition its use is at present limited to small regions in North America. There have been some comments on various websites and in cook books about its tart taste, which would suggest that the plant contains high levels of plant acids. As miner's lettuce is in the same genus as purslane, a plant that is well known to contain high levels of oxalates, it is surprising that no detailed analysis had been conducted to determine the levels in miner's lettuce. It is fortunate that miner's lettuce appears to be added as a minor constituent to salads and not consumed as a main part of a diet. If this plant became more widely used as a regular

part of a diet, in the form of pesto and other products, it could lead to an excessive consumption of oxalate with potentially significant effects on the body.

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