

Organic Diets Reduce Exposure to Organophosphate Pesticides

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Abstract

To determine whether consuming a largely organic diet reduces organophosphate (OP) pesticide exposure in adults, a prospective, randomised, single-blinded, crossover, biomonitoring study was performed. The study involved 13 Australian adults who consumed a largely (>80%) organic diet or a largely conventional diet for 7 days and were then crossed over to the alternate diet for a further 7 days. Urinary levels of six dialkylphosphate (DAP) metabolites produced from OP pesticides, were analysed in first-morning voids collected on day 8 of each phase using GC-MS/MS. The consumption of organic food for 7 days resulted in a statistically significant reduction in urinary OP metabolites. The mean total DAP results in the organic phase were 89% lower than in the conventional phase (M=0.032 and 0.294 respectively, p=.013) and there was a 96% reduction in urinary dimethyl DAPs (M=0.011 and 0.252 respectively, p=.005). Large scale studies are now required to confirm these results and determine their clinical relevance.

Introduction

A key factor driving organic food consumption is the belief that organic food is healthier than conventionally grown food because it contains fewer pesticide residues (Oates et al. 2012). While there is increasing evidence of adverse health effects from pesticides (Sanborn et al. 2012), studies demonstrating clear harm as a result of dietary pesticide exposure are lacking, as are studies investigating the ability of organic diets to mitigate such harm. Organophosphate pesticides (OP) are of particular concern because of their prevalence of use, high detection rates in the general population (Barr et al. 2004, Babina et al. 2012), and associations with negative effects on human health even at low doses (Bouchard et al. 2010, Bouchard et al. 2011, Ross et al. 2013). A few studies have demonstrated reduced OP metabolites in the urine of children eating mostly organic diets (Curl et al. 2003, Lu et al. 2006) but children are disproportionately exposed to pesticides due to differences in body weight, behaviour and metabolism (NRC 1993, Huen et al. 2009).

Material and methods

A prospective, randomised, single-blinded, crossover, biomonitoring study was performed to determine whether consumption of a mostly organic diet for 7 days would reduce urinary dialkylphosphate (DAP) metabolites (markers of OP pesticide exposure) in Australian adults. The study involved thirteen Australian adults who consumed a largely (>80%) organic diet or a largely conventional diet for 7 days and were then crossed over to the alternate diet for a further 7 days.

Following ethics approval from RMIT University's Human Research Ethics Committee, prospective participants were screened by telephone to confirm their eligibility for the study and randomly assigned to either a largely organic or conventional diet for 7 days. They were asked to complete a food intake survey during each period, and on day 8, provide a first morning urine sample and complete an additional survey to record other factors that may affect pesticide exposure, such as non-dietary pesticides and food preparation behaviours. After day 8 participants were then crossed over and directed to undertake the alternate diet for a 7-day period and then provide a second urine sample and completed survey. Prior to commencement, all participants were provided with copies of necessary documents and equipment including clear written instructions on how to complete documents and collect urine samples. All documents and specimen containers were coded to protect the participants' identity and to blind laboratory technicians to the phase allocation of participants' urine samples.

Urinary levels of six DAP metabolites (Dimethylphosphate [DMP], Diethylphosphate [DEP], Dimethylthiophosphate [DMTP], Diethylthiophosphate [DETP], and Dimethyldithiophosphate [DMDTP] and Diethyldithiophosphate [DEDTP]), were analysed in first-morning voids collected on day 8 of each phase

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using gas chromatography tandem mass spectrometry (GC-MS/MS). Samples were transported to the AsureQuality Wellington (NZ) laboratory and remained frozen (-18°C) or cold (4°C) prior to analysis. The limits of detection were 0.11-0.51 µg/L and results were creatinine corrected to account for the effects of urine dilution or concentration in spot samples.

Data analysis was conducted using SPSS for Windows statistical software (version 18). As the distributions of the metabolite levels were not normal, the non-parametric Wilcoxon matched pairs signed-ranks test was used for paired samples to determine whether there were significant differences between phases.

Results

The majority of participants were female (69%) with a mean age of 42 years (SD=10 years). They lived in urban and periurban (suburban or semi-rural with no nearby agriculture) areas, although some travelled to rural areas during the study period.

Participants consumed an average of 93% of their food servings from organic produce in the organic phase (this included 83% certified organic produce) and 96% conventional produce during the conventional phase. The overall number of food servings in each phase was very similar, and the average number of servings from each food category was similar, with the exception that participants consumed significantly less animal protein during the organic compared to the conventional phase (-36%, $p=.006$).

A total of 13 matched samples were available for comparison. Differences in mean urinary DMP and DMTP levels were statistically significant between the conventional and organic phases and there was a trend towards significance for differences in DMDTP (Table 1). None of the diethyl DAPs (DEP, DETP or DEDTP) differed significantly between phases. DMP returned no quantifiable results in the organic phase and overall there were only three quantifiable detections for any of the dimethyl DAPs during the organic phase.

Table 1. DAP Results for Individual Metabolites (Creatinine Corrected µg/ g) N=13

Metabolite	Mean(SD) µg/ g		Sig ^a	Maximum µg/ g		Frequency of quantifiable detections (%)	
	Con	Org		Con	Org	Con	Org
DMP	3.9(6.7)	ND(-)	.028*	23	ND	38	0
DEP	4.8(4.5)	2.8(2.6)	.221	12	7.4	62	46
DMTP	29(48)	0.98(2.3)	.005*	160	8.5	92	15
DETP	1.8(3.4)	0.56(0.97)	.263	10	3.6	54	38
DMDTP	2.3(3.9)	0.35(1.0)	.051 ^b	14	3.7	54	8
DEDTP	0.12(1.2)	0.068(0.046)	.144	0.33	NQ	23	0

Note: Results reported to two significant figures; Con – Conventional Phase; Org – Organic Phase; ND = Not Detectable, levels below the LOD; NQ = Not Quantifiable, levels greater than or equal to the LOD but less than the LOQ

^aSignificance of the difference between the conventional and organic phase; ^bTrend towards significance

* $p<.05$ (Wilcoxon Signed-Ranks Test)

As with a previous study conducted in children (Curl et al. 2003) total molar metabolite quantities ($\mu\text{mol/ g}$) were determined for each participant. To calculate the total DAPs (ΣDAP), total dimethyl DAPs (ΣMP) and total diethyl DAPs (ΣEP), the individual DAP result ($\mu\text{g/ g}$) was divided by its molecular weight (g/ mol) before being added together. DEDTP was not included in the calculations due to the extremely low frequency of detection and because it had not been used in the aforementioned study.

Both total DAPs and total dimethyl DAPs were significantly lower in the organic phase than the conventional phase (Table 2). The mean total DAP results in the organic phase were 89% lower than in the conventional phase and the total dimethyl DAPs were 96% lower. There was also a non-significant 49% reduction in the mean total diethyl DAP levels.

Table 2. Results for Summed DAP Metabolites ($\mu\text{g/ g}$) N=13

Summed Metabolites	Mean(SD) $\mu\text{mol/ g}$		Sig	Minimum $\mu\text{mol/ g}$		Maximum $\mu\text{mol/ g}$	
	Con	Org		Con	Org	Con	Org
ΣDAP	0.29(0.44)	0.032(0.038)	.013*	0.014	0.0053	1.5	0.14
ΣMP	0.25(0.40)	0.011(0.023)	.005*	0.0066	0.0031	1.32	0.086
ΣEP	0.42(0.038)	0.21(0.020)	.170(NS)	0.0070	0.0021	0.14	0.059

Note: Results reported to two significant figures; Con – Conventional Phase; Org – Organic Phase

* $p < .05$ (Wilcoxon Signed-Ranks Test)

For the purpose of determining central tendency and dispersion (variability) numerical figures are required so assumptions were made to deal with non-detectable (ND) and non-quantifiable (NQ) results. These dose estimation methods, the choice of nonparametric tests for statistical analysis and the use of creatinine correction did not appear to influence the direction of the findings.

Discussion

The consumption of a largely organic diet resulted in a statistically significant reduction in organophosphate pesticide exposure. These findings are consistent with a previous study of DAPs in children aged 2-5 years (Curl et al. 2003) despite differences in exposure and metabolism between children and adults. Children consuming organic fruit, vegetables and juice had significantly lower levels of urinary ΣMP than those consuming conventional produce ($p = .0003$) but ΣEP did not differ significantly across the two groups ($p = .13$).

The sample size was small and pesticide use and food availability differ from region to region. At this time no reference doses exist to indicate the level at which a specific DAP or combination of DAPs may incur risk (Sudakin and Stone 2011) so deriving meaning from the results that is relevant to consumers is difficult. Larger studies across geographical locations are required to corroborate the findings and determine their clinical relevance. Future research should investigate the relationship between exposure and well-chosen health outcomes.

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