

## Lycopene Intake by Canadian Women Is Variable, Similar Among Different Ages, But Greater Than That Reported for Women in Other Countries

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**ABSTRACT** Lycopene is an antioxidant associated with a reduced risk of chronic diseases common in women such as osteoporosis and cancer; however, no official recommendation for lycopene consumption exists, and intake data from Canadian women are limited. This study was designed to generate information about average lycopene intake in Canadian women of different ages. A cross-sectional study was conducted at St. Michael's Hospital in Toronto, Ontario, Canada. One hundred one women, between the ages of 25 and 70 years, who were not on any medications, were recruited to record their diet for 7 days. Statistical analyses were performed to compare the types of lycopene-containing foods consumed, associations between intake of lycopene and macro/micronutrients, and whether participant characteristics, such as body mass index, could predict lycopene intake. Average lycopene intake was  $6.14 \pm 5.35$  mg/day, which is higher than reported in other countries. Intake was similar among age groups but was highly variable. Raw tomatoes were the most frequently consumed source of lycopene, while participants with the highest lycopene intake consumed more cooked/processed tomato products than those with lower intake ( $P < .005$ ). Participants 25–49 years old consumed more dried/powdered tomatoes ( $P < .05$ ), pizza ( $P < .002$ ), and ketchup ( $P < .10$ ) than 50–70 year olds. Lycopene intake could not be predicted by any participant characteristics. In older participants, lycopene intake was positively correlated with intake of calcium, niacin, and vitamins A, D, and K ( $P \leq .05$ ). These findings are significant to women's health and may contribute to the establishment of nutritional and health recommendations regarding consumption of lycopene by Canadian women to prevent chronic diseases.

**KEY WORDS:** • antioxidants • carotenoids • dietary assessment • lycopene

### INTRODUCTION

THE ANTIOXIDANT LYCOPENE is a member of the carotenoid family of compounds naturally present in fruits and vegetables.<sup>1</sup> Unlike  $\beta$ -carotene, lycopene lacks provitamin A activity.<sup>2</sup> Among all carotenoids, lycopene has the highest singlet oxygen quenching ability; it is two to three times higher than  $\beta$ -carotene and 10 times higher than  $\alpha$ -tocopherol.<sup>3</sup> In the diet, the main sources of lycopene are tomatoes and tomato products.<sup>4</sup> However, it is also found in watermelons, papayas, guavas, pink grapefruits, and rosehips.<sup>5</sup> In raw tomatoes, lycopene is present predominantly in its all *trans* isomeric form. However, in cooked and processed tomatoes higher levels of the *cis* isomeric form of lycopene are present, accounting for more efficient absorption of lycopene.<sup>6</sup> Lycopene is a highly lipid-soluble chemical, and its absorption is improved when ingested with a small amount of fat.<sup>7</sup>

Oxidative stress is now recognized as an important factor in the development of several chronic diseases.<sup>8</sup> Consumption of lycopene-containing foods results in significantly decreased oxidation of lipids,<sup>9</sup> proteins, and DNA<sup>10,11</sup> in men and women of all ages, and recent studies have specifically associated lycopene intake with a decreased risk of age-related chronic diseases.<sup>12</sup> A growing body of evidence suggests that lycopene intake in women is of particular importance because of its association with a decreased risk for breast, cervical, and ovarian cancers.<sup>13</sup> We have recently shown high lycopene intake to be associated with lower bone resorption markers in postmenopausal women, suggesting a beneficial effect of lycopene on bone health.<sup>14</sup>

Although levels of lycopene in the range of 6–60 mg per day have been reported to be beneficial against chronic diseases,<sup>15</sup> no specific recommendation for its daily intake has been made. A very limited number of studies have been reported relating to the intake levels of lycopene in women,<sup>16–21</sup> with only one study addressing its intake in Canadian women.<sup>22</sup>

Therefore, the present study was conducted with the objective of assessing lycopene intake in a cohort of the Canadian female population representing different age

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groups. A total of 101 women 25–70 years old, living in the Toronto, ON, Canada area, were recruited for this study. Their food intake for a period of 7 days was recorded and analyzed for intake of lycopene and other nutrients. Subjects were grouped according to their age, and the main sources of lycopene were evaluated. Statistical analyses were carried out to determine whether lycopene intake correlated with intake of other macro- or micronutrients, caffeine, wine, liquor, or beer, age, height, weight, or smoking and/or use of medications or dietary/vitamin supplements. This article reports findings from a systematic evaluation of lycopene intake according to age in a female participant population in Canada.

## SUBJECTS AND METHODS

### *Experimental participants*

This protocol was approved by the research ethics board at St. Michael's Hospital, Toronto, and followed the protocol of good clinical practices. A total of 101 healthy women, 25–70 years old, were recruited mainly between the end of September to the beginning of May in the years 2003–2007 for this study. The following methods were used: advertisements in local papers/magazines and on the University of Toronto website, posters placed in local hospitals, fitness centers, and health food stores. Additionally, patients who had recently attended St. Michael's Hospital for bone mineral density measurements and had signed a form indicating their interest in osteoporosis research were contacted directly by telephone. Any women who were on medications for heart disease, high blood pressure, cholesterol or lipid lowering, diabetes, and/or osteoporosis were excluded from participating.

### *Research design*

This was a cross-sectional study. Participants were screened over the telephone to determine study eligibility. Those interested in participating came to the hospital for an appointment in which informed consent was obtained and participants were given detailed oral and written instructions on how to complete the 7-day estimated food records. In brief, participants were asked to record everything that they consumed for 7 days in typical household measures or grams/ounces if they had access to a food scale. They were also asked to record dietary/vitamin supplement information, including amount and frequency of consumption and the brand name. The participant's height, weight, and blood pressure were also taken, and information was obtained from the participants regarding menopausal status, medication and dietary/vitamin supplement use, smoking status, and intake of alcohol and caffeine.

### *Dietary analyses*

Food records were analyzed using NutriBase 5™ Clinical Edition software (version 5, released 2004, CyberSoft, Inc., Phoenix, AZ). This software generates a daily report for each participant that includes the amount of macro- and

micronutrients consumed based on their consumption of food, beverages, and dietary/vitamin supplements. Included in this output is a daily energy intake; using the average energy intake for the 7-day period, any days that were not within 30% of the average were considered unusual and were removed from the analysis. The remaining days were used to calculate the average daily intake of all of the macro- and micronutrients for each participant.

Lycopene intake is not assessed by this software and was therefore analyzed separately using the U.S. Department of Agriculture national nutrient database for lycopene as a reference which lists the content of lycopene in each food as  $\mu\text{g}/\text{measure}$ .<sup>23</sup> Using this information, the lycopene content was calculated in milligrams for each food, and an average of the total daily lycopene consumed was obtained for each participant.

### *Statistical methods*

All statistical analyses were performed using GraphPad (San Diego, CA) PRISM™ version 4 and SigmaStat® (Systat Software, San Jose, CA) statistical software version 2. Participants were stratified according to age into two groups: group 1, 25–49 years old; and group 2, 50–70 years old. Summary statistics of participant demographics, such as age and body mass index (BMI), were generated. These summary statistics are presented with mean and standard deviation (SD) values. Lycopene intake was analyzed to determine the distribution of intake, and results are presented with mean, SD, median, 25<sup>th</sup> and 75<sup>th</sup> percentiles, 95% confidence interval (CI) of the mean, and coefficient of variation. Student's *t* tests were used to compare types of lycopene-containing foods consumed among age groups and high/low intake groups.

Pearson correlation was carried out to determine the associations between intake of lycopene and the following macro- and micronutrients: carbohydrates (g), protein (g), fat (g), saturated fat (g), fiber (g), cholesterol (mg), Ca (mg), folate (g), iron (mg), iodine (g), magnesium (mg), niacin (mg), phosphorus (mg), riboflavin (mg), selenium (g), sodium (mg), thiamin (mg), zinc (mg), and vitamins A (IU), B-12 (g), C (mg), D (IU), E (IU), and K (g) (data not shown). Multiple linear regressions were performed to determine whether intake of lycopene could be predicted by the following participant characteristics: age, height (inches), weight (kg) (see Table 1), smoking, use of medications or dietary/vitamin supplements (see Table 2), and/or consumption of calories, caffeine, wine, liquor, or beer (see Table 3).

## RESULTS

In total, 101 recruited participants completed the study. The average lycopene intake for these participants was  $6.14 \pm 5.35$  mg/day, which is higher than the reported values of 1.1–5.6 mg/day in the United States<sup>18,19,22</sup> and 1.64–5.01 mg/day throughout Europe.<sup>16</sup> Some studies do report intakes as high as 7–11 mg/day; however, these are limited to the older population (ages 50 and above).<sup>17,20</sup> In this population of participants, 20.8% had negligible lycopene

TABLE 1. SUMMARY STATISTICS FOR STUDY PARTICIPANTS STRATIFIED INTO TWO GROUPS ACCORDING TO AGE

Parameter of interest	Participant group			
	Group 1 (25–49 years old)		Group 2 (50–79 years old)	
	Mean ± SD	Range	Mean ± SD	Range
Number	29		72	
Age (years)	32.76 ± 7.51	25–49	56.01 ± 3.30	50–67
BMI (kg/m <sup>2</sup> )	24.17 ± 4.82	16.9–37.3	25.26 ± 4.35	18.0–41.4
Weight (kg)	64.85 ± 12.10	45.3–92.6	65.44 ± 15.21	44.1–106.0
Height (inches)	64.12 ± 3.18	52.3–69.5	63.63 ± 2.84	56.0–68.5
Pulse rate (beats/minute)	71.64 ± 13.46	47–106	73.36 ± 9.91	52–98
Blood pressure (mm Hg)				
Systolic	117.8 ± 12.18	90–141	120.1 ± 15.87	88–153
Diastolic	73.35 ± 8.66	60–97	76.83 ± 10.11	55–96

intake (consumed <1.0 mg/day), and only 8.9% consumed greater than 15 mg/day (data not shown).

Summary statistics for participants are given in Tables 1 and 2. Table 1 shows the average age of the participants, as well as their average height, weight, BMI, pulse rate, and blood pressure, which were taken to assess the overall health of this participant population. Overall, the groups of participants had normal pulse rate and blood pressure for their respective ages. The BMI for group 1 was in the healthy range, while for the older group 2, the average BMI was a little higher, in the overweight range, but this was not statistically different from the younger group. Participants were asked about their smoking and menopausal status as well as their intake of dietary/vitamin supplements and medications to obtain further information on the general health status of the participant population. In both age groups, the majority of participants were non-smokers and

did not take any medications (Table 2). However, dietary/vitamin supplement intake was quite common, with more than 50% of the participants in each group consuming supplements daily or occasionally (Table 2). In group 1, 13.8% of participants were menopausal, whereas 27.8% of participants were menopausal in group 2. The parameters presented in Table 3 yielded further information on the population of participants in this study and were used in regression analyses to determine if they could predict lycopene intake in either age group (see below).

Table 4 shows the statistical data for lycopene intake for these two groups. The data are skewed, as is demonstrated by the high SDs for both age groups. However, the distribution of lycopene intake is quite similar between the age groups, as can be seen by the percentile distribution and coefficients of variation.

Figure 1 shows the average consumption per week for lycopene-containing foods among participants 25–49 and 50–70 years old. The type of lycopene-containing food that was consumed most often in this population, for both age groups, was raw tomatoes (consumed approximately twice a week by each age group). Participants 25–49 years old

TABLE 2. PERCENTAGE OF STUDY PARTICIPANTS IN EACH AGE GROUP WHO SMOKE CIGARETTES, CONSUME VITAMINS OR MEDICATIONS, AND ARE MENOPAUSAL

Parameter	Percentage	
	Group 1 (25–49 years old)	Group 2 (50–79 years old)
	Smokers	
Never	75.9	66.7
Current	13.8	9.7
Previous/social	10.3	23.6
Supplement use		
None	44.8	31.9
Occasional	13.8	4.2
Daily	41.4	63.9
Medication		
None	69.0	65.3
Birth control	27.6	0.0
Hormone replacement	0.0	8.3
Other	3.4	26.4
Menopausal status		
Premenopausal	86.2	2.8
Menopausal (≤2 years)	13.8	27.8
Postmenopausal (>2 years)	0.0	69.4

TABLE 3. CONSUMPTION OF LYCOPENE, CALORIES, CAFFEINE, AND ALCOHOLIC BEVERAGES FOR EACH GROUP OF STUDY PARTICIPANTS

Product consumed	Mean ± SD values	
	Group 1 (25–49 years old)	Group 2 (50–79 years old)
	Lycopene (mg/day)	5.92 ± 5.18
Calories (kcal/day)	1,783 ± 502.4	1,870 ± 668.2
Coffee, tea (black and green) and caffeinated soda (cups/day)	1.29 ± 1.16	2.49 ± 1.77
Wine (servings/week) <sup>a</sup>	1.48 ± 2.16	2.32 ± 3.30
Liquor (servings/week) <sup>b</sup>	0.64 ± 1.76	0.22 ± 0.98
Beer (servings/week) <sup>c</sup>	0.12 ± 0.56	0.49 ± 1.55

<sup>a</sup>One serving = 6 oz = 177 g.

<sup>b</sup>One serving = 1.5 fl oz = 42 g.

<sup>c</sup>One serving = 341 mL bottle = 343 g.

TABLE 4. SUMMARY STATISTICS OF LYCOPENE INTAKE FOR EACH AGE GROUP OF STUDY PARTICIPANTS

Lycopene intake (mg/day)	Age of participants (years)	
	25–49 (n = 29)	50–79 (n = 72)
Mean ± SD	5.92 ± 5.18	6.23 ± 5.45
25 <sup>th</sup> percentile	1.065	2.055
Median	5.010	5.015
75 <sup>th</sup> percentile	8.980	8.115
Maximum	21.70	21.43
95% CI of mean	(3.95, 7.89)	(4.94, 7.51)
Coefficient of variation (%)	87.43	87.60

consumed significantly more dried tomatoes/tomato powder ( $P < .05$ ), pizza ( $P < .002$ ), and ketchup (marginally significant,  $P < .10$ ) than participants 50–70 years old, while participants 50–70 years old consumed on average more tomato juice (effect not significant) than the younger participants. In addition, participants 50–70 years old tended to consume at least twice as much lycopene from raw food sources, including pink grapefruit, red pepper, and papaya/guava/blood orange (effect not significant).

Statistical analysis was performed to determine whether daily lycopene intake correlated with daily intake of macro- and micronutrients or whether lycopene intake could be predicted by other participant characteristics (such as BMI, listed in Subjects and Methods above). These types of as-

sociations were not significant among participants 25–49 years old. However, in participants 50–70 years old, lycopene intake was positively correlated with intake of calcium ( $r = 0.2316$ ,  $P = .05$ ), niacin ( $r = 0.3149$ ,  $P < .01$ ), and vitamins A ( $r = 0.2649$ ,  $P < .05$ ), D ( $r = 0.2660$ ,  $P < .05$ ), and K ( $r = 0.4280$ ,  $P < .001$ ) (data not shown).

Table 5 presents data on the average lycopene intake within each age group. For participants 25–49 years old (group 1), those with low lycopene intake (according to quartiles) had an average intake of  $0.69 \pm 0.19$  mg/day (Table 5) and did not consume lycopene foods on a daily basis. A comparison between types of lycopene-containing foods consumed among these participants showed that there was no significant difference between consumption of raw or cooked/processed lycopene-containing foods, and intake levels of both were low ( $0.57 \pm 0.53$  and  $0.86 \pm 0.69$  servings per week, respectively). Participants in this age group with a high lycopene intake (according to quartiles) had an average intake of  $13.01 \pm 4.4$  mg/day (Table 5); 100% of these participants consumed lycopene-containing foods on a daily basis. A comparison between types of lycopene-containing foods consumed among these participants showed that consumption of cooked/processed lycopene-containing foods ( $6.57 \pm 2.57$  servings per week) was significantly higher than consumption of raw foods ( $1.71 \pm 1.80$  servings per week) ( $P < .005$ ). When compared to participants of the same age who were considered to have a low lycopene intake there was no significant difference in the

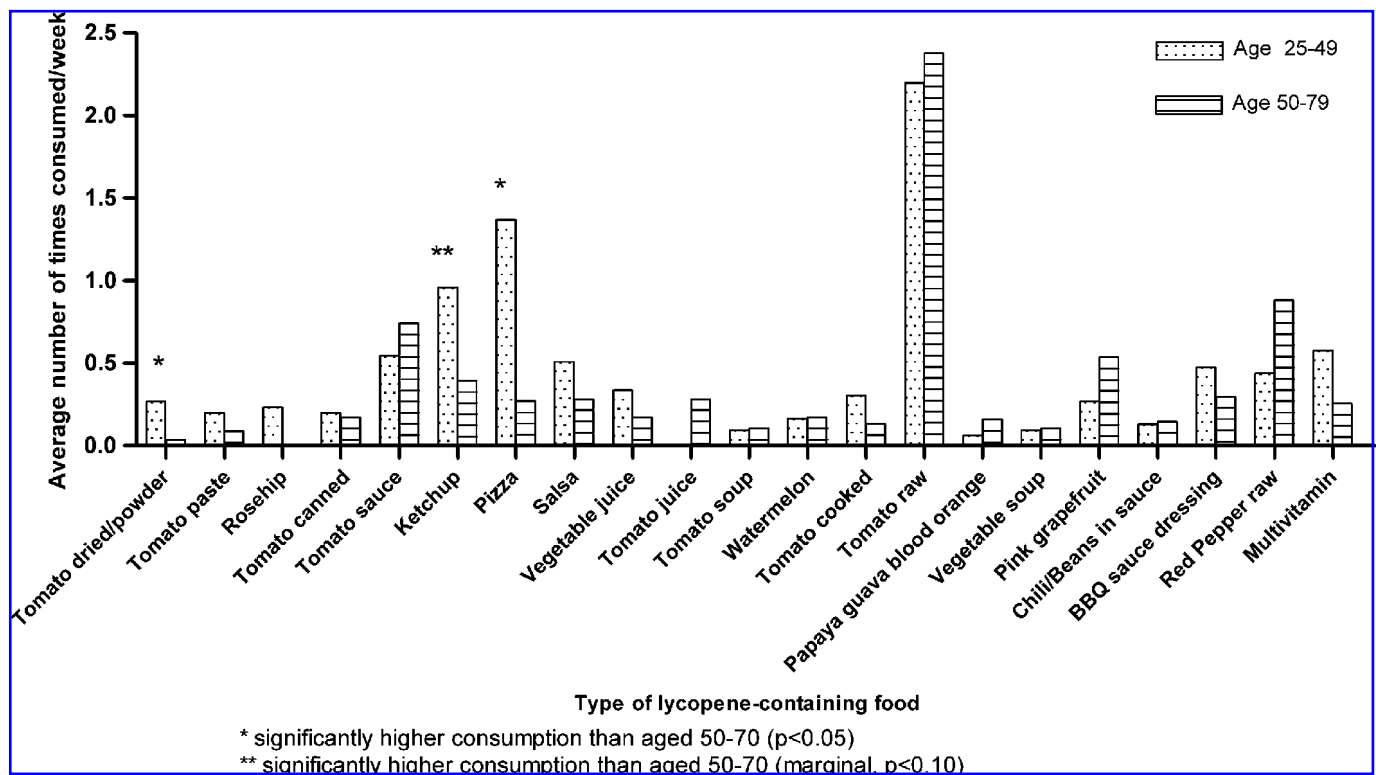


FIG. 1. Frequency of lycopene consumption by the participants for a 1-week period, showing all sources of lycopene consumed. Data shown are grouped according to participant age. The types of lycopene-containing foods are listed, from left to right, from highest to lowest concentration of lycopene in  $\mu\text{g/g}$ .

TABLE 5. CONSUMPTION OF LYCOPENE FOR THE LOWEST AND HIGHEST QUANTILES OF INTAKE, SHOWING NUMBER OF SERVINGS OF RAW OR COOKED/PROCESSED LYCOPENE FOODS FOR EACH AGE GROUP

<i>Intake of lycopene (mean ± SD)</i>	<i>Lowest quartile of intake</i>		<i>Highest quartile of intake</i>	
	<i>Group 1 (25–49 years)</i>	<i>Group 2 (50–79 years)</i>	<i>Group 1 (25–49 years)</i>	<i>Group 2 (50–79 years)</i>
Average lycopene intake (mg/day)	0.69 ± 0.19	0.59 ± 0.65	13.01 ± 4.4	14.14 ± 3.95
Number of servings raw lycopene foods per week*	0.57 ± 0.53	1.33 ± 1.50 <sup>a</sup>	1.71 ± 1.80	4.44 ± 3.37 <sup>b</sup>
Number of servings of cooked/processed lycopene foods per week <sup>†</sup>	0.86 ± 0.69 <sup>c</sup>	0.28 ± 0.46	6.57 ± 2.57 <sup>d,e</sup>	5.94 ± 2.34 <sup>d</sup>

\*Includes raw tomatoes, pink grapefruit, watermelon, and papaya.

<sup>†</sup>Includes cooked tomatoes, ketchup, tomato juice/sauce, etc.

<sup>a</sup>Significantly higher consumption than cooked/processed foods in same age/quartile group ( $P < .01$ ).

<sup>b</sup>Significantly higher consumption than in lowest quartile group of same age ( $P < .005$ ).

<sup>c</sup>Significantly higher consumption cooked/processed foods than group 2, low quartile of intake ( $P < .05$ ).

<sup>d</sup>Significantly higher consumption than in lowest quartile group of same age ( $P < .0001$ ).

<sup>e</sup>Significantly higher consumption than raw foods in same age/quartile group ( $P < .005$ ).

number of servings of raw lycopene foods; however, those with a high intake consumed a significantly higher number of servings of cooked/processed lycopene foods than those with a low intake ( $P < .0001$ ) (Table 5).

For participants 50–70 years old (group 2) those with low lycopene intake (according to quartiles) had an average intake of  $0.59 \pm 0.65$  mg/day (Table 5); only 5% of these participants consumed lycopene-containing foods on a daily basis. A comparison between types of lycopene-containing foods consumed among these participants showed that consumption of raw lycopene-containing foods ( $1.33 \pm 1.50$  servings per week) was significantly higher than that of cooked/processed lycopene-containing foods ( $0.28 \pm 0.46$  servings per week) ( $P < .01$ ). Participants in this age group with a high lycopene intake had an average intake of  $14.14 \pm 3.95$  mg/day (Table 5); 94% of these participants consumed lycopene-containing foods on a daily basis. A comparison between types of lycopene-containing foods consumed among these participants showed that consumption of both raw and cooked/processed lycopene-containing foods was high ( $4.44 \pm 3.37$  and  $5.94 \pm 2.34$  servings per week, respectively). In this age group there was no significant difference between consumption of either raw or cooked/processed lycopene-containing foods for high-intake participants. Compared to participants of the same age who were considered to have a low lycopene intake, those with high lycopene intake consumed significantly more servings per week of both raw ( $P < .005$ ) and cooked/processed lycopene-containing foods ( $P < .0001$ ).

To determine differences in age for those considered to have both low and high lycopene intake (according to quartiles), group 1 (25–49 years old) was compared to group 2 (50–70 years old). There were no significant differences between average daily intake for those with low lycopene intake ( $0.69 \pm 0.19$  for group 1,  $0.59 \pm 0.65$  for group 2) or for those with high lycopene intake ( $13.01 \pm 4.4$  for group 1,  $14.14 \pm 3.95$  for group 2) (Table 5). For participants with a low lycopene intake, group 1 consumed significantly more cooked/processed lycopene-containing foods than group 2 ( $P < .05$ ), whereas group 2 tended to consume more raw lycopene-containing foods (effect not significant). For par-

ticipants with a high lycopene intake, consumption of cooked/processed lycopene-containing foods was similar between age groups, whereas the older group consumed more raw lycopene foods (marginally significant,  $P = .06$ ).

## DISCUSSION

The importance of this study is that it presents information about previously under-reported lycopene intake by Canadian women of different age groups. Our findings showed that: (1) participants had an average lycopene intake of  $6.14 \pm 5.35$  mg/day, which is similar to previously reported results on lycopene intake in Canadian women<sup>22</sup> and higher than women in other countries in North America and Europe; (2) lycopene intake is highly variable among Canadian women, as demonstrated by the wide SD of the intake, but is similar among age groups; (3) in both age groups, the most frequently consumed lycopene-containing food is raw tomatoes, and participants with the highest intake of lycopene consumed significantly higher cooked/processed tomato products than those with lower lycopene intake; (4) participants 25–49 years old consume significantly more pizza, ketchup, and dried tomato/tomato powder than participants 50–70 years old, who tend to consume more tomato sauce and raw lycopene foods; and (5) there is no association between lycopene intake and age, height, weight, smoking, and/or use of medications or dietary/vitamin supplements in either age group. However, in older participants, 50–70 years old, lycopene intake was positively correlated with intake of calcium, niacin, and vitamins A, D, and K.

These findings are significant because they provide important information on lycopene consumption in Canadian women. Health benefits of lycopene include risk reduction of diseases important in women's health<sup>12–14</sup>; therefore, the information presented here may be useful for promoting the establishment of recommendations regarding lycopene intake in the female population.

In the present study, the average lycopene intake of the population participants was  $5.92 \pm 5.18$  mg/day for women 25–49 years old and  $6.23 \pm 5.45$  mg/day for women 50–70 years old. This is similar to the only other Canadian study

that examined lycopene intake in approximately the same age groups of women, where average intakes of  $5.55 \pm 10.41$  mg/day were reported for younger women and those of  $5.26 \pm 9.77$  mg/day were reported for older women.<sup>22</sup> The previous Canadian study reported intakes from five different geographical areas in Canada, whereas the participant population in the present study was taken only from Toronto. Indeed, a few American studies report that geographical area affects lycopene intake,<sup>24,25</sup> which may be attributed to food choices and/or availability.

American studies, with similar age groups, report average intakes with ranges of 1.1–5.6 mg/day.<sup>18,19,21,22</sup> These previous studies used 24-hour recall or food frequency questionnaires to report lycopene intake, which tend to introduce more error because participants may not accurately remember intake of specific foods.<sup>24</sup> A strength of our study is that estimated dietary records were used, which have previously been shown to be an accurate method of assessment due to strong correlations between intake and serum concentrations of lycopene.<sup>14</sup>

In terms of beneficial effects of lycopene consumption, this average intake of lycopene may seem low, considering most intervention trials supplement participants with at least 15 mg/day of lycopene and when “therapeutic” levels are considered to be as high as 60 mg/day.<sup>15</sup> However, population studies show that actual lycopene intakes are much lower than what is supplied in intervention studies.<sup>17,18,21</sup> In fact, in North America, approximately 50% of the population consume less than 2 mg/day.<sup>12</sup> Furthermore, in the Italian population, which frequently consumes lycopene-rich foods, and lycopene is the most commonly consumed carotenoid, a recent study reported that the average lycopene intake was only 7.4 mg/day.<sup>26</sup> Overall, these intake levels and those previously reported in Canada<sup>22</sup> tend to be higher than those of other European countries such as Spain, Ireland, France, the Netherlands, and the United Kingdom, where average daily intake is reported as 1.64, 4.43, 4.75, 4.86, and 5.01 mg/day, respectively.<sup>16</sup>

Comparison of lycopene intake for the two age groups demonstrated that the intake of lycopene was highly variable for both age groups (see SDs, Table 3), indicating a wide difference in lycopene consumption among Canadian women. These observations are consistent with previously reported results and may be because of the fact that lycopene is only found in a select group of foods.<sup>22</sup> Some studies suggest that lycopene intake is much lower in the older population.<sup>16</sup> We did not find a significant difference in lycopene intake between the two age groups (Table 3), which is similar to previously reported Canadian results.<sup>22</sup>

In our study, the most frequently consumed type of lycopene-containing food was raw tomatoes (Fig. 1). Similar findings are reported for the United States,<sup>24</sup> France, Spain, and the United Kingdom,<sup>16</sup> whereas in Ireland and the Netherlands, processed tomato products tended to be more frequently consumed.<sup>16</sup> The only other study to report lycopene intake in a female population in Canada showed that cooked/processed tomato products were more frequently consumed, such as tomato sauce.<sup>22</sup> It may be that this dis-

crepancy is caused by seasonal variation in lycopene consumption by participants in these Canadian studies. However, reports suggest that the effect of seasonal variation on lycopene intake tends to be minor<sup>16</sup> and primarily occurs in the summer months, when the consumption of watermelon and raw tomatoes might be increased because of availability.<sup>27</sup>

Our finding that younger participants consumed significantly more pizza, ketchup, and dried/powdered tomatoes than older participants (Fig. 1) is consistent with previous reports.<sup>24</sup> This may be because of the perception among the older age group that products such as pizza and ketchup are associated with higher energy, fat, and salt intake and are to be consumed less frequently. This is demonstrated in this population; young participants consumed more servings of cooked/processed lycopene foods than older participants, whereas older participants consumed more servings of raw lycopene foods (Table 5 and Fig. 1). In both age groups, participants with the highest quartile of lycopene intake consumed significantly more cooked/processed lycopene foods than participants in the low quartile of intake. This is to be expected because cooked/processed lycopene-containing foods are higher in lycopene concentration than raw lycopene-containing foods.<sup>6</sup> Cooking or processing of tomato products enhances bioavailability of lycopene not only because it results in the release of lycopene from its food matrix into the lipid component of the food,<sup>28</sup> but because it causes isomerization to the *cis* form, which results in better absorption of lycopene.<sup>13</sup>

Although no association between lycopene intake and age, height, weight, smoking, and/or use of medications or dietary/vitamin supplements was found in the present study, other studies that looked at serum lycopene and not lycopene intake<sup>24</sup> found an association. However, because previous studies, including ours,<sup>14</sup> found a strong correlation between lycopene intake and serum lycopene,<sup>10,11,14,29</sup> this discrepancy is unclear at present.

The correlation between lycopene and vitamin A intake in older participants is to be expected because many foods high in lycopene are also high in vitamin A. On the other hand, the absence of correlation between lycopene intake and micronutrients in the younger group may be because participants in the younger group tended to have a more varied diet, choosing different foods for each meal and more day-to-day variety, whereas older participants in this population tended to have the same meal for breakfast and lunch at least three to four times per week (data not shown).

The study described here provides important information on intake of lycopene among Canadian women using a 7-day estimated food record. Prior to our study, information of average lycopene intake in Canadian women has been limited.<sup>22</sup> In summary, these results show that lycopene intake is similar among different age groups of women, although the types of lycopene-containing foods consumed differ. Compared to populations in America and parts of Europe, Canadian women in this study tend to have a higher lycopene intake, which could be explained by a wide variety of lycopene-containing foods, particularly tomatoes and tomato products, that are consumed on a fairly regular basis.

This study contributes valuable information about lycopene consumption and its association with other nutrients among Canadian women of different ages. This information is important in formulating nutrient and health recommendations for the prevention of chronic diseases prevalent in women's health, which can lead to maintaining an excellent quality of life.

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### AUTHOR DISCLOSURE STATEMENT

No competing financial interests exist for any of the authors.

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