

### Key messages

- Tea is one of the most widely consumed beverages in the world. Studies in cell cultures and animal models have linked tea intake with a reduced risk of cancer.
- Overall, epidemiological studies show that drinking tea is more likely to be beneficial than harmful in terms of cancer risk, although the risk of cancer appears to be reduced only slightly. Green tea may lower the risk of colorectal cancer, but the amount of evidence for this association is limited.
- It is unclear if tea drinking is linked to oesophageal, stomach, colorectal<sup>†</sup>, prostate, breast, pancreatic, lung and kidney cancer, as studies have shown inconsistent results. However a slight trend towards risk reduction has been seen for green tea and cancers of the prostate, breast and stomach.
- The evidence does suggest there is no association between tea drinking and oral, pharyngeal, nasopharyngeal, ovarian, bladder and thyroid cancer.
- Most studies showing a benefit from tea consumption come from Asia, where mostly green tea is drunk. Studies of Europeans who drink black tea show benefits less frequently. Therefore green tea may provide greater protection against some cancers, however more human studies are needed before any conclusion can be reached.
- Cancer Council supports people drinking tea, whether it is green, black or oolong. Tea is a rich source of antioxidants, which are an important component of a healthy diet.
- Cancer Council recommends caution in the consumption of tea or other beverages at very high temperatures, due to the risk of scalding and the evidence that hot tea may increase the risk of oesophageal cancer.

### Rationale

Tea is the most widely consumed beverage in the world, after water.<sup>1</sup> It has been popular for over 4000 years.<sup>2</sup> About three billion kilograms of tea are produced and consumed yearly worldwide.<sup>3</sup> The Chinese attribute many health benefits to tea consumption, and they have used it to treat a variety of conditions for many years. However, scientific research into tea and its possible health benefits has only recently commenced.

Epidemiological studies have linked drinking tea with a reduced risk of cardiovascular disease and some cancers. These findings have been supported by a variety of studies in cell cultures and animal models. However, inconsistencies in the results of many epidemiological studies make the overall conclusion unclear.

The purpose of this position statement is to evaluate and summarise the epidemiological evidence linking tea with primary cancer prevention. It is important that Cancer Council evaluate the associations between tea and cancer risk in order to develop its messages and recommendations, especially as one of our largest fundraising events (Australia's Biggest Morning Tea) encourages members of the public to have a cup of tea to help in the quest to defeat cancer.

\* For black tea only

## Background

Tea is the brewed leaves of the *Camellia sinensis* plant. The three main types of tea are green, black and oolong, which are made via different processing methods. Green tea is made when the leaves are heated soon after they are picked. This means that the leaves have undergone minimal oxidation. Black tea is made by allowing the leaves to oxidise greatly prior to drying; hence the leaves change in colour from green to brown. Oolong tea is a result of partial oxidation i.e. the leaves are left to oxidise somewhere in between that of green and black tea.

Approximately 76% of the tea produced and consumed worldwide is black, 22% is green and less than 2% is oolong.<sup>1</sup> Green is most popular in Asian countries, while black is preferred in Europe and North America. Oolong tea is popular in China and Taiwan. Iced tea was first introduced in 1904, but the custom of drinking it remains largely American.<sup>2</sup>

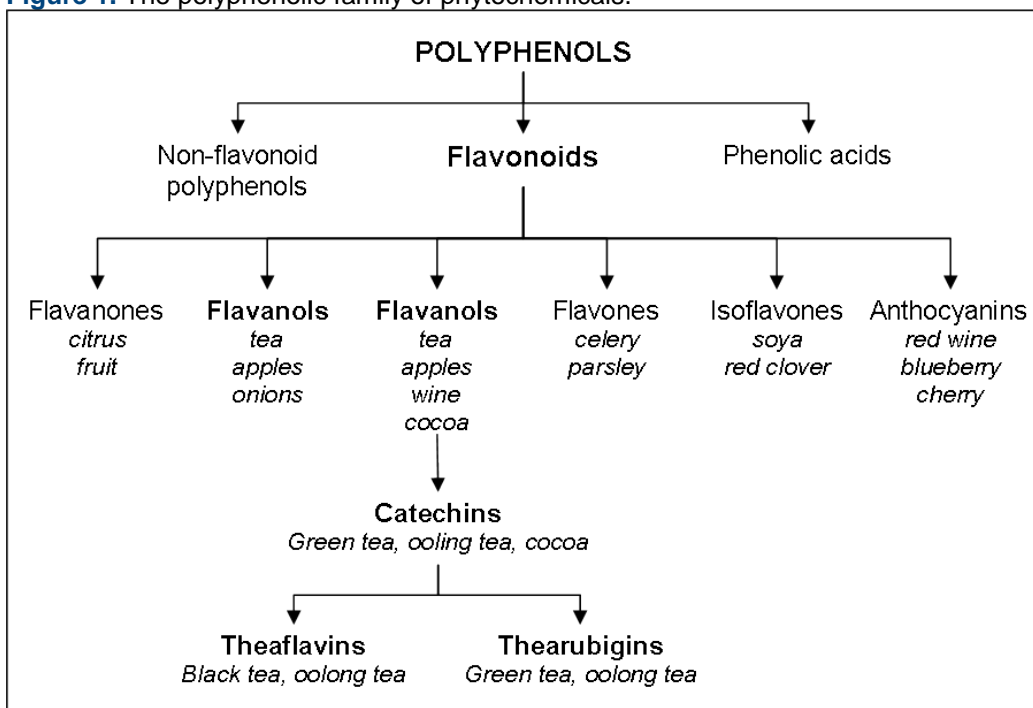
Tea is a rich source of flavonoid antioxidants from the polyphenol family (figure 1). However, the types and amounts present in tea are influenced by the variety of leaf, the growing environment, processing and manufacturing methods used (figure 2).<sup>4</sup> Major catechins in tea include epicatechin (EC), epicatechin-3-gallate (ECG), epigallocatechin (EGC) and epigallocatechin-3-gallate (EGCG).

Several clinical trials have recently demonstrated that a single dose of tea improves the plasma antioxidant capacity of healthy adults within 30 to 60 minutes after ingestion.<sup>1</sup> In general, the rise in plasma antioxidant capacity from tea peaks about one to two hours after ingestion and subsides shortly after.<sup>1</sup>

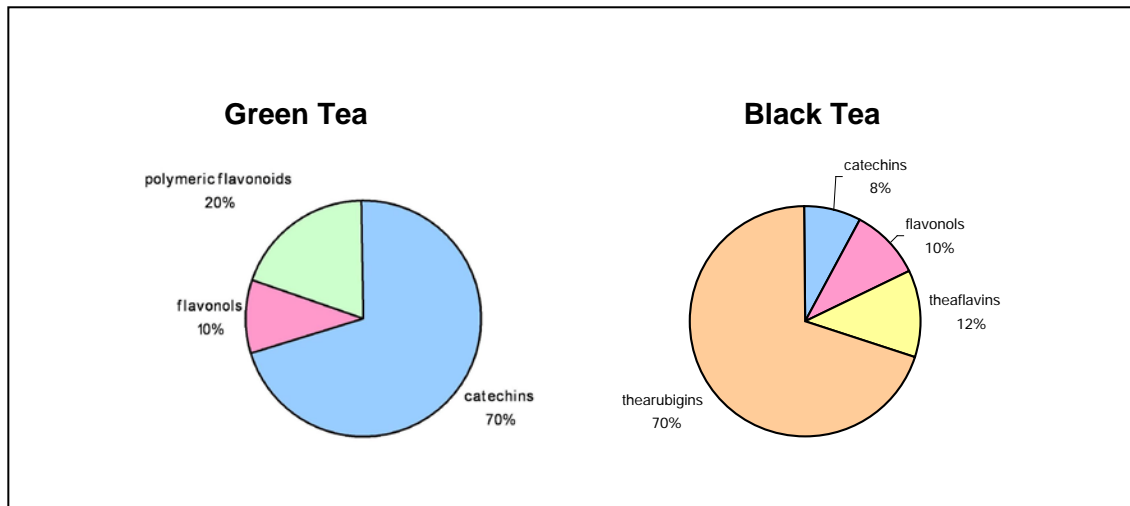
The highest concentrations of flavonoids are found in hot brewed tea (541-692 µg/mL). Less are found in instant preparations (90-100 µg/mL) and lower amounts in iced and ready-to-drink tea.<sup>1</sup> The addition of milk or water can reduce the flavonoid concentration per serving, but research shows that the addition of milk does not interfere with catechin absorption.<sup>1</sup>

Herbal teas are not true teas, as they are not made from the *Camellia sinensis* plant. Therefore they contain a variety of other antioxidants, which are determined by the particular herbal source that is used to brew the tea.

**Figure 1.** The polyphenolic family of phytochemicals.<sup>4</sup>



**Figure 2.** Different antioxidant profiles in green and black tea.<sup>4</sup>



### Potential mechanisms of action

According to experimental studies, the main health benefits of tea have been linked to their antioxidative properties.<sup>1</sup> However, tea polyphenols also selectively inhibit specific enzyme activities and they can target and repair DNA aberrations.<sup>5</sup> In fact many components in tea are active and although each one has its own role, some components appear to exhibit synergistic activity.<sup>5</sup>

*In vitro* studies have shown that tea catechins can inhibit carcinogenesis at the three stages of cancer development, initiation, promotion and progression (table 1).<sup>5</sup> Some different mechanisms that may be involved include:

- Tea flavonoids have been found to inhibit hepatic cytochrome P450-dependant enzymes.<sup>1,6,7</sup> These enzymes activate procarcinogens, which are able to modify genomic DNA and induce tumour formation.<sup>5</sup>
- Phenolics from tea can prevent the formation of nitrosamines and heterocyclic amines, which are both carcinogens.<sup>5</sup>
- The catechins, EGCG and ECG, stimulate gap junctional intercellular communication.<sup>1,5</sup>
- EGCG and theaflavin-3-3'-digallate can block AP-1, which plays an important role in tumour promotion.<sup>5-7</sup>
- EGCG strongly inhibits telomerase activity, which is essential for unlocking the proliferative capacity of cancer cells.<sup>5</sup>
- Tea may induce apoptotic cell death.<sup>5-7</sup>
- EGCG can inhibit urokinase (a frequently expressed enzyme in human cancers essential for cancer growth and metastases' formation) activity by interfering with its ability to recognise its substrates.<sup>5,6</sup>

**Table 1.** Tea and tea components shown to inhibit different stages of cancer development.<sup>5</sup>

Initiation	Promotion	Progression
EGCG	EGCG	EGCG
ECG	Theaflavin-3-3'-digallate	EGC
Green tea		ECG
Black tea		Theaflavin gallate
Oolong tea		Theaflavin
		Tea polyphenols
		Tea volatiles

However many more potential mechanisms may exist and further research is needed in order to gain a better understanding of the anti-carcinogenic properties of tea in humans.

## Views on tea in cancer prevention reports

In 1991, The International Agency for Research on Cancer (IARC) stated “there is inadequate evidence for the carcinogenicity in humans of tea drinking” in their report on *Coffee, Tea, Mate, Methylxanthines and Methylglyoxal*.<sup>8</sup> They concluded “tea is not classifiable as to its carcinogenicity to humans”.

The United Kingdom Department of Health’s Committee on the Medical Aspects of Food and Nutrition Policy (COMA) published in 1998, made the following conclusions on tea:<sup>9</sup>

- *No relationship* found between the consumption of tea and pancreatic cancer, but there is a possibility of bias or confounding.
- *Insufficient evidence* exists to draw conclusions on tea consumption in relation to bladder cancer.

The World Health Organisation (WHO) report into *Diet, Nutrition and the Prevention of Chronic Diseases* published in 2003, does not specifically mention tea and its association with cancer risk.<sup>10</sup>

Guidelines by the American Cancer Society state that epidemiological studies on tea have had mixed findings, therefore tea has not been proven to reduce cancer risk in humans.<sup>11</sup>

The World Cancer Research Fund (WCRF) Report into *Food, Nutrition, Physical Activity and the Prevention of Cancer: a global perspective* published in 2007 found that the evidence was too limited in amount, consistency and quality to draw any conclusions on tea and cancer risk.<sup>12</sup> However, there was *limited suggestive* evidence that high-temperature drinks increase the risk of oesophageal cancer.<sup>12</sup>

## Epidemiological evidence

### All cancers combined

Few studies have examined the relationship between tea intake and total cancer risk. This is because if there is an effect, it is not likely to be the same for each specific cancer.<sup>13,14</sup>

The studies that do exist appear to have been started for purposes other than tea intake, hence the level of detail available on tea use is minimal.<sup>13</sup> A review which identified only three cohort studies investigating black tea intake and one cohort study investigating green tea intake shows that little can be said about the impact of tea on total cancer risk.<sup>15</sup>

### Oral, pharyngeal and nasopharyngeal cancer

None of the eight case-control studies identified in reviews on black tea consumption and oral and pharyngeal cancer report a significant association between these cancers and black tea intake, although the majority did note slightly lower risks among tea drinkers.<sup>13,16</sup> No relationship was seen between tea consumption and nasopharyngeal cancer in three case-control studies.<sup>17</sup>

### Oesophageal cancer

Tea consumption was previously linked to a higher incidence of oesophageal cancer, however recent studies do not confirm this.<sup>18</sup> Results for green tea and oesophageal cancer are mixed, with both positive and negative findings.<sup>19</sup>

It appears that the development of oesophageal cancer may be related to the high temperature at which the drink is consumed, rather than the nature of the drink.<sup>1,18</sup> In fact, the majority of case-control studies indicate a consistent association between food and beverage temperature and oesophageal cancer.<sup>19</sup> Studies suggest that the hotter the tea or beverage, the greater the risk.<sup>19</sup>

In case-control studies, consumption of very hot tea (55-67°C) has been positively associated with oesophageal cancers.<sup>13,15,17,18</sup> This may be due to enhanced cell proliferation in response to cell death from scalding of the oesophageal mucosa.<sup>18</sup> However, a number of case-control studies found no relationship between tea consumption at normal temperatures (37-45°C) and oesophageal cancer.<sup>17,18</sup>

## Stomach cancer

The effects of tea on stomach cancer appear to be conflicting, with inconsistent results seen for both green and black tea.<sup>16-19</sup> However most studies indicate there is no significant relationship.<sup>15,17</sup>

Results from case-control studies indicate that tea, especially green, may reduce the risk of stomach cancer.<sup>15,20</sup> Prospective studies indicate no inverse association is present between green tea and stomach cancer risk.<sup>20,21</sup>

## Colorectal cancer

The results of studies on colorectal cancer and tea intake are inconsistent. However, most show there is no association between tea intake and colorectal cancer.<sup>13,17,22,23</sup> Interestingly, one review reports that a negative association may be stronger in studies of rectal cancer than colon cancer.<sup>24</sup>

For green tea specifically, the literature does suggest there may be a protective effect on the development of colorectal cancer.<sup>14,15,19</sup> In particular, several studies from Japan and China have shown a protective effect of green tea on colorectal cancer.<sup>1</sup>

Pooled results from a recent meta-analysis (table 2) show that a high green tea intake is associated with a reduced risk of colorectal and colon cancer (but not rectal on its own), however this was observed only in case-control studies.<sup>25</sup> The analysis also showed a non-significant reduction in colorectal cancer risk in women with high intake of green tea, but this was not seen for men.<sup>25</sup>

Nonetheless, the authors conclude that there is insufficient information to provide a definitive assessment on the relationship between green tea intake and colorectal cancer risk,<sup>25</sup> and a systematic literature review conducted in 2004 found there was no clear evidence to support the suggestion that green tea plays a role in the prevention of colorectal cancer.<sup>26</sup>

**Table 2.** Green tea intake and colorectal cancer risk.<sup>25</sup>

Green tea	Colorectal cancer			Colon cancer			Rectal cancer		
	Summary odds ratio	95% confidence interval	Number of studies	Summary odds ratio	95% confidence interval	Number of studies	Summary odds ratio	95% confidence interval	Number of studies
All studies	0.82	0.69-0.98	8	0.86	0.73-1.00	6	0.99	0.71-1.37	6
Cohorts	0.97	0.82-1.16	4	0.99	0.79-1.24	3	0.99	0.57-1.73	3
Case-controls	0.74	0.63-0.86	4	0.74	0.60-0.93	3	0.98	0.61-1.60	3
Women	0.52	0.25-1.05	not specified	-	-	-	-	-	-
Men	0.89	0.73-1.08	not specified	-	-	-	-	-	-

For black tea, a small number of studies indicate there might be an increased risk of colon or rectal cancer associated with regular use, whereas some studies have found no association.<sup>1,14,15</sup>

Pooled results from the same meta-analysis (table 3) show that there is no association between colorectal cancer and black tea consumption, but the risk is higher in Japanese rather than Western populations.<sup>25</sup> In Western populations, results for women indicated a statistically significant protective effect of black tea on colorectal cancer risk, but no such association was seen in men.<sup>25</sup>

**Table 3.** Black tea intake and colorectal cancer risk.<sup>25</sup>

Black tea	Colorectal cancer			Colon cancer			Rectal cancer		
	Summary odds ratio	95% confidence interval	Number of studies	Summary odds ratio	95% confidence interval	Number of studies	Summary odds ratio	95% confidence interval	Number of studies
All studies	0.99	0.87-1.13	20	1.02	0.88-1.18	12	0.91	0.73-1.12	10
Cohorts	1.02	0.78-1.34	7	0.93	0.67-1.30	6	0.96	0.74-1.24	5
Case-controls	0.98	0.84-1.15	13	1.13	1.02-1.24	6	0.86	0.62-1.19	5
Japanese	1.62	1.22-2.14	not specified	-	-	-	-	-	-
Western	0.93	0.82-1.06	not specified	-	-	-	-	-	-
Western women	0.82	0.70-0.95	not specified	-	-	-	-	-	-
Western men	1.15	0.89-1.50	not specified	-	-	-	-	-	-

### Prostate cancer

Few studies have been conducted on the association between prostate cancer and tea drinking. The limited number of studies available show inconsistent results, with most indicating no association is present, although a small number of studies do suggest an inverse association between tea and prostate cancer risk.<sup>1,15,18,27</sup>

Evidence seems to support a potential link between green tea and the prevention of prostate cancer,<sup>28-30</sup> although the number of epidemiological studies on green tea consumption and prostate cancer risk is too small for a conclusion to be reached.<sup>15</sup>

### Breast cancer

The majority of studies show that there is no relationship between tea consumption and breast cancer risk, although there are inconsistent results.<sup>1,13,15,17</sup>

For green tea specifically, one recent meta-analysis found that while cohort studies found no association with breast cancer risk, the pooled result for all studies showed a reduced risk for breast cancer (table 4).<sup>31</sup> However, a second meta-analysis showed no association between both cohort and case-control studies and breast cancer risk (table 4).<sup>32</sup> Therefore, the pooled analyses do not definitively support the use of green tea in primary prevention of breast cancer, however case-control studies show a slight trend toward risk reduction.

**Table 4.** Green tea intake and breast cancer risk.<sup>31,32</sup>

Green tea	Breast cancer					
	<i>Sun et al.</i> <sup>31</sup>			<i>Seely et al.</i> <sup>32</sup>		
	Summary odds ratio	95% confidence interval	Number of studies	Summary odds ratio	95% confidence interval	Number of studies
All studies	0.78	0.61-0.98	4	-	-	-
Cohorts	0.85	0.66-1.09	3	0.89	0.71-1.1	3
Case-controls	-	-	-	0.44	0.14-1.31	2

Nearly all studies indicate the greatest risk reduction is at consumption levels equal to or more than five cups/day.<sup>32</sup> Therefore, any protective effect is most likely to result from green tea at consumption levels greater than or equal to five cups/day.<sup>32</sup>

For black tea and breast cancer risk, the pooled result from a meta-analysis for all studies showed there was no association (table 5).<sup>31</sup> However, the pooled result for cohort studies showed a modest increase, while that from case-control studies showed a modest decrease in risk of breast cancer associated with high black tea intake.<sup>31</sup>

**Table 5.** Black tea intake and breast cancer risk.<sup>31</sup>

Black tea	Breast cancer		
	Summary odds ratio	95% confidence interval	Number of studies
All studies	0.98	0.88-1.09	13
Cohorts	1.15	1.02-1.31	5
Case-controls	0.91	0.84-0.98	8

### Other female reproductive tract cancers

Few studies have investigated the link between tea intake and other cancers of the female reproductive tract. One review suggests that tea consumption does not increase the risk of ovarian cancer.<sup>33</sup> Another indicates that while evidence from *in vitro* and animal studies suggests that components in tea are associated with a reduced risk of ovarian cancer, most epidemiological studies show that tea is not linked with ovarian cancer.<sup>34</sup> However, one study from China showed that the risk of epithelial ovarian cancer significantly declined with increasing consumption level and years of green tea drinking.<sup>34</sup>

Another review references two studies that suggest there is a negative association between tea consumption and cancer of the uterus, however more studies are required to draw a final conclusion.<sup>17</sup>

### Pancreatic cancer

Most studies indicate there is no association between tea intake and pancreatic cancer.<sup>17</sup> For black tea consumption, most cohort studies showed no significant association with the risk of pancreatic cancer, while results from case-control studies are inconsistent.<sup>13,15</sup> Results for green tea and pancreatic cancer risk are inconsistent.<sup>19</sup>

### Liver cancer

Few studies have examined the relationship between tea intake and liver cancer risk. Most show that there is no relationship between tea consumption and liver cancer risk, however more research is needed before a conclusion can be reached.<sup>17</sup>

### Lung cancer

Results from studies on lung cancer and tea drinking are mixed.<sup>14,17,19</sup> Some show a positive association between tea intake and lung cancer risk, but this is not always significant and is likely to be due to other confounding factors.<sup>13,17</sup>

A more recent study has shown the risk of lung cancer is reduced with two or more cups of black tea/day,<sup>1</sup> while two reviews found that three out of four cohort and case-control studies respectively found no significant associations between black tea consumption and lung cancer risk.<sup>13,15</sup>

### Kidney cancer

The majority of studies show that there is no relationship between tea consumption and kidney cancer risk, although there are some inconsistent results.<sup>1,17,35</sup>

## Bladder cancer

The majority of studies show that there is no significant association between black or green tea consumption and bladder cancer.<sup>15,17</sup> Therefore, tea intake appears to have little, if any association with bladder cancer.<sup>13</sup> Interestingly, any protection conferred by tea on bladder cancer appears to be more pronounced in females than in males.<sup>18,19</sup>

A recent meta-analysis and systematic literature review was completed on tea consumption and risk of urinary tract cancer.<sup>36</sup> It found that tea consumption does not seem to be related to an increased risk of urinary tract cancer in follow-up and case-control studies (table 6). However, this review only compared 'current drinker versus non-drinker' and 'ever drinker versus non-drinker', therefore summary odd ratios cannot be quantified by amount or type of tea.

**Table 6.** Tea intake and urinary tract cancer risk.<sup>36</sup>

Tea	Urinary tract cancer					
	<i>Current versus non-drinker</i>			<i>Ever versus non-drinker</i>		
	Summary odds ratio	95% confidence interval	Number of studies	Summary odds ratio	95% confidence interval	Number of studies
Men	1.08	0.94-1.24	7	1.02	0.84-1.25	4
Women	0.99	0.81-1.20	6	1.00	0.27-3.73	3
Both	1.01	0.92-1.10	7	1.09	0.54-2.17	3

## Thyroid cancer

A meta-analysis identified and pooled nine case-control studies on tea drinking and thyroid cancer.<sup>37</sup> No association was seen for thyroid cancer risk and tea consumption (table 7).

**Table 7.** Tea intake and thyroid cancer risk.<sup>37</sup>

Tea	Thyroid cancer	
	Summary odds ratio	95% confidence interval
Case-controls	1.0	0.8-1.2
Women	0.9	0.7-1.2
Men	1.2	0.7-1.9

## Skin cancer

There is a lack of human studies examining tea and skin cancer.<sup>18</sup> A recent population based case-control study found a significant inverse relationship between tea consumption frequency and the risk of squamous cell carcinoma of the skin only after adjusting for brewing time.<sup>1,15</sup> Therefore more research is needed before a conclusion can be reached.

## Summary of epidemiology studies

Overall, it appears as though drinking tea is more likely to be beneficial than harmful in terms of cancer risk, although the risk of cancer appears to be reduced only slightly.

Green tea may *lower* the risk of colorectal cancer, although the evidence for this association is limited.

Results are *inconsistent* for tea drinking and oesophageal, stomach, colorectal<sup>#</sup>, prostate, breast, pancreatic, lung and kidney cancer. However, a slight trend towards risk reduction has been seen for green tea and cancer of the prostate, breast and stomach.

There is *no association* between tea drinking and oral, pharyngeal, nasopharyngeal, ovarian, bladder and thyroid cancer, based on limited evidence.

*No conclusion* can be reached on the association between tea drinking and total cancer risk as well as uterine, liver and skin cancer, as there are only a limited number of studies available.

## Literature on tea and cancer prevention

- Nearly all the studies on green tea were conducted in China or Japan, while some studies on black tea and cancer risk were assessed in European countries and America. Most studies showing a benefit from tea consumption come from Asia, where green tea is favoured.
- Until the mid 1990s most studies were not specifically designed to investigate the association between tea and cancer risk and therefore used a single question to assess consumption. Therefore, the level of detail available on tea (including the type of tea drunk) is often minimal in these studies. Recent trials have used more detailed assessment tools, and this may explain some of the differences in results.
- The largest consumption categories for green tea are usually much higher than that for black tea.
- Interpretation of some results is difficult because the measure of tea consumption was not quantified.
- The validity of some studies cannot be assessed because insufficient details were given on the method used, and standard epidemiological issues are present including measurement bias and differences in the intake period assessed.
- Few studies have addressed all the important confounding factors. Because some confounders have not been consistently considered, comparison across studies is difficult. For example, tea drinking is associated with healthy behaviours in most countries, but in some populations (like the UK) tea drinking seems to be associated with behaviours such as smoking. This is one factor that may have influenced the results.
- Tea consumption in countries that traditionally consume coffee may reflect non-coffee consumption and the effect attributed to tea may be due to the absence of coffee or reasons dictating that choice.
- If there is a protective effect of tea, it is difficult to determine the optimal dose, as methods of preparation differ from person-to-person and study-to-study. The differences in preparation, including brewing time, amount of tea leaves used, cup size, re-using of leaves, quality of tea, freshness of leaf and brewing temperature, may have an impact.

## Recommendations

The evidence for an inverse association between tea (both green and black) and cancer risk is largely insufficient to draw any meaningful conclusions. However, experimental studies show a protective effect of tea polyphenols against cancer and no harmful effects are apparent when tea is drunk at normal temperatures.

Cancer Council supports people drinking tea, whether it is green, black or oolong. Tea remains the second most popular beverage in the world, after water. It is relatively inexpensive, simple to use and non-toxic. Tea is a rich source of antioxidants, which are an important component of a healthy diet.

Cancer Council advises caution in the consumption of tea or other beverages at very high temperatures, due to the risk of scalding and the evidence that hot tea may increase the risk of oesophageal cancer.

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<sup>#</sup> For black tea only

As a consideration, people should be mindful of how tea drinking could contribute to sugar and fat intake, particularly in heavy tea drinkers. Cancer Council recommends that people maintain a healthy body weight by eating and drinking according to their energy needs. Drinking tea without sugar added to it, or adding smaller amounts of sugar is advised. It may be better to drink tea without milk in order to maximise its flavonoid content, but if milk is used it is recommended that people use reduced fat milk in their tea. Cancer Council reminds those who choose to drink tea without milk that it is still important to consume dairy foods as part of a healthy diet.

## Future research

More studies are needed on the association between drinking tea and cancer risk. In the future, studies need to be designed that:

- Are large and prospective i.e. randomised controlled trials and cohort studies.
- Comprehensively and accurately measure tea intake (both black and green separately) across both Asian and Western populations.
- Collect and present results for several different consumption categories.
- Ensure they address all important confounding factors.
- Identify suitable intermediate biomarkers for measuring cancer outcomes.

Additional meta-analyses are also required so that more conclusions can be reached.

## Further Information

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