

Chapter 9

Evaluation

Humans

The effects of cruciferous vegetables on human cancer risk have been assessed in many epidemiological studies. The conclusions that can be drawn from the current body of evidence are as follows:

There is *limited* evidence that eating cruciferous vegetables reduces the risk for cancers of the stomach and lung.

There is *inadequate* evidence that eating cruciferous vegetables reduces the risk for cancers at all other sites.

There is *inadequate* evidence to assess the independent effects on human cancer risk of isothiocyanates and indoles, as opposed to their combined effects with other compounds in cruciferous vegetables.

Experimental animals

The effects of cruciferous vegetables and of the compounds they contain on carcinogen-induced cancer have been assessed in many experimental animal models. The conclusions are difficult to generalize to all compounds in the classes of isothiocyanates and indoles, however, as differences are found by cancer site, the carcinogen used and species. The conclusions that can be drawn from the current body of evidence are as follows:

There is *sufficient* evidence that intake of cruciferous vegetables reduces the occurrence of cancer in experimental animal models. The

strongest evidence for risk reduction comes from studies in which *Brassica* species were fed in amounts equivalent to human consumption during carcinogen administration and constantly thereafter, with reductions in the occurrence of cancers of the colon, mammary gland and liver.

There is *sufficient* evidence that intake of phenethyl-, benzyl- or 3-phenylpropylisothiocyanate reduces the occurrence of cancer in experimental animal models.

There is *sufficient* evidence that intake of indole-3-carbinol or 3,3'-diindolylmethane reduces the occurrence of cancer in experimental animal models.

There is *limited* evidence that intake of glucosinolates or sulforaphane reduces the occurrence of cancer in experimental animal models.

Some of these compounds have also been shown to increase tumour growth in some experimental animal systems.

Overall evaluation

Cruciferous vegetables are an important part of the diet in many parts of the world and constitute between 5% and 25% of all vegetable intake in different countries. These vegetables are also important because they contain glucosinolates, a group of compounds not found in other vegetables. Glucosinolates degrade to isothiocyanates and indoles, two classes of compound that have been shown both *in vitro* and in experimental animals to affect cancer

risk. Although most of the effects of isothiocyanates and indoles are consistent with benefits with respect to human cancer risk, many studies showed no effect and some showed effects that could be interpreted as adverse. In epidemiological studies, cruciferous vegetables have been found to be associated with reduced risks for cancers at some sites.

In summary, the weight of the available evidence supports the following conclusions:

1. Compounds contained in cruciferous vegetables could affect cancer risk by several mechanisms: by altering the activity of various metabolizing enzymes and by affecting cellular mechanisms important in cancer development.
2. Cruciferous vegetables and compounds contained therein can have anti-cancer effects in many animal cancer models. These effects vary by compound, by experimental conditions and by species; adverse effects have been seen under some conditions.
3. Human consumption of cruciferous vegetables has been shown to be associated with modest reductions in the risks for cancers at some sites, although the reductions are no greater than those observed with total vegetable intake.

Summary of evidence for cancer preventive effects of cruciferous vegetables, isothiocyanates and indoles

	Degree of evidence for cancer preventive effect	Site and species
Humans		
<i>Cruciferous vegetables</i>	Limited	Lung, stomach
Experimental animals		
<i>Cruciferous vegetables</i>	Sufficient	Colon, mammary gland, liver (rat, mouse)
<i>Glucosinolates</i>	Limited	Colon, liver (rat)
<i>Isothiocyanates</i>		
Phenethyl-	Sufficient	Lung (rat, mouse, hamster); oesophagus (rat); liver (mouse); forestomach (mouse); pancreas (hamster)
Benzyl-	Sufficient	Oesophagus, colon, mammary gland (rat); lung, forestomach (mouse)
3-Phenylpropyl-	Sufficient	Oesophagus (rat); lung (mouse, hamster)
α -Naphthyl-	Limited	Liver (rat)
Sulforaphane	Limited	Colon, mammary gland (rat); forestomach (mouse)
<i>Indoles</i>		
Indole-3-carbinol	Sufficient	Liver (rat, trout); colon (rat); mammary gland (rat, mouse); cervix (rat); lung, skin (mouse)
3,3'-Diindolylmethane	Sufficient	Mammary gland (rat); forestomach (mouse)