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Nutritional attributes of herbs

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1 Executive summary

1.1 Introduction

Herbs are an ancient source of flavourings, aromatic compounds and medicines, although only those that have culinary applications will be covered in this report. The focus of this literature review will be primarily upon the compounds that give culinary herbs their health and flavouring properties, rather than on any common core nutrients they may also contain, since herbs are not consumed in sufficient quantities for these core nutrients to form a significant part of a diet.

1.2 Composition

Common culinary herbs can come from various different plant families and differ considerably in taste, aroma and chemical constituents. What they have in common is that they are all the leafy parts of the plant and have very strong flavours and aromas. Most common herbs, however, come from two main families, the Lamiaceae or mint family and the Apiaceae or carrot family. Family members often have compounds in common, and may therefore also have similar bioactivity as well as flavours and aromas.

The compounds most studied in herbs are phenolics and essential oil components. Besides their antioxidant activity, phenolic compounds have anti-inflammatory, anti-allergic, anti-microbial and anti-cancer properties. Phenolic content can vary considerably in herbs as in other plants. Although there is not complete consensus between results, it would seem that oregano/marjoram species are particularly rich in phenolic compounds, which is also reflected in their high antioxidant activity. Some of the most studied phenolics specific to herbs are the phenolic diterpenes, carnosic acid and its derivative, carnosol, and the phenolic acid, rosmarinic acid. Common flavonoids in herbs include luteolin, apigenin, hispidulin, quercetin and kaempferol.

Essential oil fractions of herbs and their chemical components have also been widely studied, stemming from early interest in their aromas and concentrated flavours. Essential oils comprise a variety of compounds, and can be loosely defined as that part of an extract collected using steam distillation. They are hydrophobic and can include terpenes, alcohols, aldehydes, ketones, acids, esters, oxides, lactones, acetals. Of these, the terpenoids have received most research attention.

1.3 Health attributes

The antioxidant activity of culinary herbs and their constituent compounds has been their most widely researched aspect, along with their antimicrobial activity. This research has been driven at least partially by industry seeking natural preservatives. Herbs and their components have high antioxidant activity, which in a food matrix can delay spoilage through retarding the development of rancidity in products such as oils, plus anti-microbial properties. In this regard, total phenolics are also often measured, as a large proportion of antioxidant activity is attributable to the presence of phenolic compounds. However, there is also relevance to human health as antioxidant activity is believed to play a part in the prevention of most major chronic diseases. There has been most research into various anti-cancer effects of herbs, through such mechanisms as increasing endogenous protective enzymes, protecting DNA from free radical-induced structural damage, encouraging the self-destruction of aberrant cells (apoptosis) and inhibiting tumour growth. Other findings include cardiovascular protective effects such as anti-thrombotic and anti-platelet aggregation activity, anti-diabetes activity, and some show possible protection against Alzheimer's disease. Some herbs and their components also possess anti-inflammatory activity, important because inflammation is thought to be a key step in the initiation of many chronic diseases and health problems associated with ageing. There have, however, been very few clinical studies in relation to the health effects of herbs or their components.

General observations from this study include:

- Most herbs show antioxidant and anti-microbial activity, though to varying degrees.
- Oregano/marjoram has been shown, by many studies and using a suite of different assays, to have the highest levels of antioxidant activity.
- Herbs from the Lamiaceae family, to which many common herbs belong (basil, lemon balm, marjoram, mint, oregano, rosemary, sage, savory and thyme), appear to be particularly rich in flavonoids, phenolic acids and terpenoids with high levels of bioactivity. This is also the family which has received most research attention.
- Herbs from the Apiaceae family (chervil, coriander, dill, fennel, lovage and parsley), the second most important herb family, have been shown to have high levels of flavonoids, but there is less information on their essential oil components.

1.4 Conclusions

Culinary herbs supply some compounds to the diet that are not provided by mainstream fruit and vegetables. Although they are concentrated sources of many phytochemicals, as well as some core nutrients, they are consumed only in small quantities, so their dietary contribution is relatively small and insufficient to show medicinal effects. However, if eaten regularly, herbs could provide useful amounts of beneficial bioactives, including both ubiquitous and less common phytochemicals. In summary, they are an important and underutilised dietary component, providing some protective/preventative health effects along with very few calories and interesting flavours.

2 Introduction

The Oxford English Dictionary defines a "herb" as any plant with leaves, seeds or flowers used for flavouring food, medicine or perfume. This report is a systematic literature review of research into the constituents and properties of culinary herbs, including notes on their composition and their purported health effects. Such herbs usually comprise the green leafy parts of the plant; other material such as roots, seeds or bark are more often classed as a spice.

Surprisingly, although herbs have been used medicinally for thousands of years, and have also played a major part in cuisine, it is only relatively recently that they have been the subject of much scientific research. Most research has focused on their antioxidant activity, though they are also known for their antimicrobial qualities. Besides being investigated for their health attributes, herbs are being increasingly researched as natural food preservatives. In this context, antioxidant activity is particularly important in delaying rancidity in oily or fatty foods, and antimicrobial properties protect the food from potential pathogens.

Because of the small quantities in which they are consumed, individual herbs do not make a significant contribution of core nutrients to the diet. For example, although parsley has high levels of vitamin C on a per-weight basis (133 mg/100 g fresh parsley, USDA 2006), the amount consumed is small. An intake of 100 g would equate to 296% of the recommended dietary intake (RDI) for a 19–51 year old woman (NHMRC 2006). For a more realistic serving size of 1 tablespoon, this is reduced to 5.1 mg (USDA 2006) or around 11% of the RDI. To put this in perspective, an average-sized kiwifruit (76 g) delivers 57 mg vitamin C and an orange (140 g) around 82.7 mg vitamin C (USDA 2006). Nonetheless, if herbs were to be a more regular part of the daily diet, as they are in Italian cuisine, for example, they would collectively be of more dietary importance. Because of their strong flavours, they can also be a means of reducing salt or sugar in the diet. They also contain some beneficial compounds at higher concentrations than found in other plants consumed as foods.

We have found that data are generally lacking on some of the less popular herbs, particularly in fresh form. Information available is also far from comprehensive. Dry herbs are commonplace in supermarkets, but drying may cause the loss of some important dietary components, such as vitamin C and carotenoids (Capecka et al. 2005). Drying also affects flavour as the more volatile components are lost. Fresh material often has a lighter, more complex taste.

Some other aspects of herb research are beyond the scope of this report, as follows.

- Some research has investigated the effects of herbs or their components incorporated into dietary supplements, although this is not covered in this report.
- As with all plant material, the chemical composition of a particular species can vary considerably depending on where and when it is grown and how it is processed. Because of the volume of material in this report,

this aspect has not been pursued, but it should be remembered that reported values are not absolute, but can vary quite considerably.

- Garlic is the most-studied herb, but will not be included here as it has already been covered in another report on the health attributes of Alliums (Hedges & Lister 2007).

3 Composition

Herbs have been used for medicinal purposes throughout history. Their health properties are linked to a number of chemical constituents, including vitamins, flavonoids, terpenoids, carotenoids, phytoestrogens and minerals (Calucci et al. 2003; Suhaj 2006). Some of these are common to a number of herbs, and some are more specific to a particular family (Table 1). For example the Alliaceae contain particular allyl sulphur compounds, the Brassicaceae contain glucosinolates, and the Lamiaceae herbs contain rosmarinic acid (Shan et al. 2005), an important bioactive with antioxidant and anti-inflammatory activities (Petersen & Simmonds 2003).

Table 1: Active phytochemicals reported in families of assorted herbs (adapted from Craig (1999), Lister (2003).

Family	Common name	Active phytochemicals
Alliaceae	Chives, garlic	Sulphur compounds, flavonoids
Asteraceae	Tarragon	Terpenoids
Apiaceae (=Umbelliferae)	Chervil, coriander,dill, fennel, lovage, parsley	Polyacetylenes, terpenoids, coumarins, phthalides
Boraginaceae	Borage	Terpenoids
Brassiciaceae (=Cruciferae)	Horseradish, wasabi	Glucosinolates/isothiocyanates, flavonoids
Lamiaceae	Basil, lemon balm, marjoram, mint, oregano, rosemary, sage, savory, thyme	Terpenoids, flavonoids, phenolic acids,
Lauraceae	Bay leaf	Terpenoids
Poaceae	Lemon grass	Terpenoids

Where available, the macronutrient and micronutrient composition of these herbs has been included in Appendix I (USDA data). Where data on fresh material are unavailable, those on dry herbs have been used. However, for reasons outlined earlier, this general area will not be discussed further.

3.1 Phenolic compounds

Phenolic compounds are particularly important antioxidant compounds. Because of their structure, they are very efficient scavengers of free radicals and they also serve as metal chelators (Shahidi & Naczk 1995). They comprise two main groups – flavonoids and phenolic acids, both of which are present in herbs. Phenolic acids have been studied largely in relation to their antioxidant activity, but flavonoids, in addition to antioxidant properties, have other potential health-promoting activities including anti-allergic, anti-inflammatory, anti-microbial and anti-cancer properties (Cody et al. 1986; Harbourne 1993). There are many ways in which flavonoids may act to prevent cancer, including inducing detoxification enzymes, inhibiting cancer cell proliferation and promoting cell differentiation (Kalt 2001). Some flavonoids are also beneficial against heart disease because they inhibit blood platelet aggregation and provide antioxidant protection for low density lipoprotein (Frankel et al. 1993). As mentioned earlier, type and amounts of compounds vary between different species and genera (see Table 2), but can also vary considerably according to a raft of factors including environmental conditions, growing practices, post-harvest treatment and processing. For example, Hinneburg et al. (2006) measured the equivalent of 13.23 mg gallic acid equivalents (GAE) in fresh basil, whereas Zheng & Wang (2001) measured 2.23 mg GAE (Table 2). A similar discrepancy was seen with fresh parsley (3.58 *vs* 1.12 mg GAE).

Table 2: Phenolic compounds in selected herbs from the Lamiaceae family (mg GAE/100 g fresh weight). From Zheng & Wang 2001.

Phenolic compound	Sage *(Salvia officinalis)*	Marjoram *(Origanum × majoricum)*	Thyme *(Thymus vulgaris)*	Rosemary *(Rosmarinus officinalis)*
Vanillic acid	2.27			1.73
Caffeic acid	7.42	10.4	11.7	2.95
Luteolin	33.4		39.5	
Rosmarinic acid	117.8	154.6	91.8	32.8
Hispidulin	16.3	48.7	20.8	19.7
Cirsimaritin	14.3			24.4
Carnosic acid				126.6
Apigenin	2.4	3.5		1.1
Naringin (naringenin-5-rhamnosidoglucoside)				53.1
Rosmanol				124.1

Because they are such powerful antioxidants, levels of phenolics generally correlate well with antioxidant activity. This is illustrated in Table 3, which shows that oregano/marjoram species contain by far the highest levels of phenolics and also have the highest antioxidant activity. Note that other studies may have found different values when measuring these, but Zheng & Wang's (2001) data provide a comprehensive range of herbs and values for both phenolic content and antioxidant activity.

Table 3: Total phenolic content and antioxidant activity (ORAC) in various herbal extracts (from Zheng & Wang 2001).

Common name	Botanical name	Total phenolic content (mg GAE/g fresh weight)	ORAC(µmol Trolox equivalents (TE)/ g fresh weight)
Chives	*Allium schoenoprasum*	1.05	9.15
Dill	*Anethum graveolens*	3.12	29.12
Fennel	*Foeniculum vulgare*	0.68	5.88
Garden sage	*Salvia officinalis*	1.34	13.28
Garden thyme	*Thymus vulgaris*	2.13	19.49
Greek mountain oregano	*Origanum vulgare* ssp. *hirtum*	11.80	64.71
Hard sweet marjoram	*Origanum × majoricum*	11.65	71.64
Lemon balm	*Melissa officinalis*	1.26	9.54
Lemon thyme	*Thymus × citriodorus*	1.78 ±	13.28
Lovage	*Levisticum officinale*	2.63	21.54
Orange mint	*Mentha aquatica*	2.26	19.80
Parsley	*Petroselinum crispum*	1.12	11.03
Pineapple sage	*Salvia elegans*	1.31	11.55
Rosemary	*Rosmarinus officinalis*	2.19	19.15
Salad burnet	*Sanguisorba minor*	0.99	8.33
Spearmint	*Mentha spicata*	0.94	8.10
Sweet basil	*Ocimum basilicum*	2.23	14.27
Sweet bay	*Laurus nobilis*	4.02	31.70
Vietnamese coriander	*Polygonum odoratum*	3.09	22.30
Winter savory	*Satureja montana*	3.16	26.34

It is interesting to compare these values with those for common fruits and vegetables (Table 4). Apart from the oreganum family, which in this study is clearly higher in phenolics than all other herbs as well as fruit and vegetables, the range of values between the herbs and fruit and vegetables is not too dissimilar.

Table 4: Total phenolic content in assorted fruit and vegetables (from Wu et al. 2004).

Food	Total phenolics (mg GAE/g fresh weight)
Fuji apple	2.11
Apricot	1.33
Blueberry, low bush	7.95
Kiwifruit	2.78
Orange, navel	3.37
Raspberry	5.04
Watermelon	1.42
Broccoli	3.37
Carrots	1.25
Lettuce, iceberg	0.5
Peppers, red	4.24
Spinach	2.17
Tomatoes	0.8

3.2 *Carotenoids*

The carotenoids are a group of yellow-orange-red pigments found in a variety of fruits and vegetables as well as in algae, fungi and bacteria. Carotenoids cannot be synthesised in the body and are present solely as a result of ingestion from other sources, either ingestion of the plant itself or a product from an animal that has consumed that plant source, e.g. egg yolks are yellow because of the carotenoids they contain. Often, the colours of the carotenoids present in plants are masked by chlorophyll, to the extent that some of the highest levels of carotenoids are found in dark green leafy vegetables such as kale and spinach.

Carotenoids are lipid-soluble and consist of a long-chain hydrocarbon molecule with a series of central, conjugated double bonds. These conjugated (alternating) double bonds not only confer colour, but also give the compounds their antioxidant properties. These compounds are especially effective in quenching singlet oxygen and peroxyl radicals. They appear to act synergistically with other carotenoids and other antioxidants. In plants, these pigments assist in the light-capturing process in photosynthesis and protect against damage from visible light. In humans one of their various benefits is believed to be protecting both the skin and the macula lutea of the eye against the same photoxidative damage (Sies & Stahl 2003).

Some carotenoids can be converted into vitamin A by the body (pro-vitamin A activity). Besides their radical scavenging activity, they have anti-cancer properties such as inhibiting tumour growth and aiding cell communication, as well as enhancing the immune system and recycling vitamin E (Lister 2003).

There is little research available on this aspect of their composition, perhaps because the small quantities consumed means that their dietary contribution is minor, or because carotenoids contribute less to antioxidant activity than do the more studied phenolics. It is nonetheless interesting to note that in comparison with many other fruit and vegetables, which are considered to be major dietary sources of the main carotenoids, they are particularly concentrated in certain herbs (Table 5).

Table 5: Carotenoid content of assorted raw herbs and yellow/orange fruit and vegetables (micrograms/100 g) from USDA National Nutrient Database for Standard Reference Release 18, 2005 and USDA National Nutrient Database for Standard Reference Release 19, 2006 (USDA 2005, 2006).

Food	β-carotene	Lutein + zeaxanthin
Basil	3142	5650
Chives	2612	323
Coriander	3930	865
Parsley	5054	5561
Thyme	2851	N/A
Apricot	1094	89
Capsicum, red, raw	1624	51
Carrot, raw	8285	256
Carrot, boiled	8332	687
Corn (sweet), raw	52	764
Persimmon	253	834
Pumpkin, raw	3100	1500
Spinach (raw)	5626	12198
Sweet potato, raw	8506	0

3.3 Chlorophyll

Chlorophyll, the pigment that gives plants their green colour and which is of major importance in photosynthesis, is also present in herbs. Two different types of chlorophyll (chlorophyll a and chlorophyll b) are found in plants, each absorbing light at slightly different wavelengths.

Relatively little is known of the health effects of chlorophyll. Some research suggests that it may be important in protecting against some forms of cancer by binding to mutant DNA to prevent it proliferating. A recent study found that chlorophyll had phase 2 enzyme-inducing potential and, although its activity was relatively weak, its high concentrations in so many edible plants might cause some of the protective effects observed in diets rich in green vegetables (Fahey et al. 2005).

3.4 Essential oils

The term "essential oil" is frequently encountered in relation to herbs. In fact, it is somewhat misleading. First, rather than being vital or indispensable, as in the sense of "essential fatty acids", the term "essential" describes how the oil represents the unique nature of the plant material – particularly its smell and taste – its essence. Second, these compounds are not food oils, which comprise a glycerol backbone and three fatty acids. Rather, they can be composed of terpenes, alcohols, aldehydes, ketones, acids, esters, oxides, lactones, acetals or phenols. Like other oils, however, they are not soluble in water and are liquid at room temperature. They are also known as volatile oils.

Essential oils are complex mixtures of a large number of components. For example, in a recent study of the composition of various essential oils, Sacchetti et al. (2005) listed over 60 individual compounds identified in thyme essential oil. Terpenoids are particularly important components, responsible for many of their biological activities, including their antioxidant activity (especially phenolic terpenoids) and their anti-microbial activity, e.g. thymol, carvacrol and eugenol (Joseph et al. 2002; Edris 2007). Table 6 lists various terpenoids and some of their sources.

Table 6: Important bioactive terpenoids found in herbs (Craig 1999; Joseph et al. 2002; Shan et al. 2005; Edris 2007).

Compound	Herb sources
Carvone	Mint, dill
Cineole	Coriander, rosemary, sage, thyme
Farnesol	Lemon grass
Geraniol	Lemon grass, coriander, lemon balm, basil, rosemary, thyme
Limonene	Mint, dill, coriander, fennel thyme
Linalool	Rosemary, lemon grass
Menthol	Peppermint
Perillyl Alcohol	Mint, sage, lemon grass
A-Pinene	Coriander, fennel, rosemary, thyme
Eugenol	Basil, bay leaf
Myristicin	Parsley, dill
Citral	Lemon grass
Thymol	Thyme
Carvacrol	Savory, basil, oregano
Carnosol, carnosic acid	Rosemary, sage
γ-Terpinine	Thyme, rosemary

Although essential oils have been mostly studied for their antioxidant and anti-microbial activity, they and their components also have various anti-cancer effects, such as preventing interactions between carcinogens and DNA, inducing endogenous protective enzymes, inhibiting cancer cell proliferation and increasing apoptosis. Potential cardiovascular-protective properties include preventing lipid peroxidation, lowering levels of plasma cholesterol and triglycerides and reducing blood pressure through vasodilatory or smooth muscle-relaxing effects. Some antidiabetic properties have also been observed. An interesting new area of research relates to the ability of some of their compounds, particularly terpenoids, to be absorbed through the skin, suggesting a possible role as vectors for transdermal drug delivery (Edris 2007).

4 Herbs and health

Perhaps the original "functional foods", herbs not only have a world-wide history as folk remedies, but continue to provide a significant contribution to medicine, with 40% of modern prescription drugs containing herbs or herb constituents (Zheng & Wang 2001). However, as dietary components, they are perhaps best viewed as having health maintenance/disease prevention roles, rather than as cures.

4.1 Antioxidant activity

Epidemiological studies have shown that large intakes of fruit and vegetables protect against a range of chronic diseases and problems associated with ageing. This is often attributed to a high intake of phytochemicals with antioxidant activity, as this is thought to be the mechanism underpinning many of these protective effects. As has already been discussed, most herbs show antioxidant activity, and some, such as oregano, at very high levels (Table 3). Many also have been shown to have a number of types of antioxidant activity, such as radical scavenging, metal reducing and lipid protective properties.

Antioxidants deactivate free radicals and other oxidants, rendering them harmless. Free radicals are highly unstable molecules, present in the body both from external sources (e.g. pollution, smoking, carcinogens in the environment) and internal sources, the result of normal physiological processes. If left uncontrolled, free radicals can damage cell components, interfering with major life processes. For example, they may damage DNA, leading to cancer, or oxidise fats in the blood, contributing to atherosclerosis and heart disease. Although the body produces its own antioxidants and has other defence mechanisms, it is thought that antioxidants from the diet also have an important role.

4.2 Anti-inflammatory activity

Although inflammation is part of the body's defences and has a vital role in fighting infection and the repair of damaged tissue, chronic inflammation is also now believed to be implicated in the development of many major lifestyle diseases, including cancer, cardiovascular disease and Alzheimer's disease. There are anti-inflammatory compounds in herbs, including flavonoids and phenolic acids, carnosol, and thymol. Epidemiological evidence suggests that populations with diets containing high levels of phenolic compounds have lower incidences of inflammatory disease.

4.3 Cardiovascular disease

Apart from studies involving garlic, there have been few clinical trials on the effects of herb consumption on cardiovascular disease. An early study found that the consumption of lemon grass oil lowered cholesterol in a group of high-cholesterol subjects, although that study had only a small number of participants (18) and had a major flaw in that there was no control group

(Elson et al. 1989). Extracts of parsley and thyme were found to have anti-thrombotic effects in an animal study (Yamamoto et al. 2005).

4.4 Cancer

As with cardiovascular disease, it is thought that antioxidants help prevent and moderate the cascade of events that lead to cancer, and as discussed above, many herbs contain high concentrations of antioxidant compounds. There is a similar lack of clinical research on the effects of herbs on cancer in humans, though there are a number of *in vitro* and animal studies showing promising results. Because cancer is a multi-factorial disease, there are many ways in which herbs are able to exert a protective effect. Some, such as wasabi, horseradish, sage and fennel have been shown to stimulate the activity of endogenous protective enzymes, which have major antioxidant or detoxifying roles. Others, such as thyme, protect the structural integrity of DNA from free radical damage. Radical scavenging, metal chelating and protecting lipids from peroxidation can also prevent steps in the cascade of events that lead to cancer. As will be discussed more fully later, most herbs show varying degrees of antioxidant activity *in vitro*, but their precise effects *in vivo* have not been established.

4.5 Brain function

Brain function is another area in which research has identified bioactive compounds in herbs that have traditionally been used for this purpose. These include sage, thyme and salad burnet.

The events leading to neurodegenerative diseases, including Alzheimer's disease, have not been unequivocally identified, but are believed to include inflammatory processes, free radical formation after the activation of glial cells, and organelle dysfunction, leading to neuronal death (Martin et al. 2002; Staehelin 2005; Mandel et al. 2006). The fact that neurodegeneration usually occurs later in life suggests that endogenous controls diminish with age. Many researchers suggest that dietary and environmental factors much earlier in life may play an important part, both in causing and protecting against these as well as other age-related diseases. Only a relatively small number of cases are believed to be familial (Howes et al. 2003).

In order to have an effect upon brain function, potential dietary protectants need to be non-toxic, brain-permeable (or able to influence brain biochemistry in some other way such as affecting glucose supply) and have properties such as antioxidant (transition metal chelating, radical scavenging ability) and anti-inflammatory activity (Mandel et al. 2006). These characteristics have been demonstrated in a number of herbs. Besides the ethnic remedies such as gingko and St John's wort which are now being investigated scientifically in regard to their effects upon brain function, there are also some culinary herbs that have shown promise, including thyme, salad burnet and sage.

4.6 Other health problems

Herbs and herb components have shown promising properties for various other health problems, such as osteoporosis (wasabi, a powdered rosemary, sage and thyme mixture, rosemary and sage essential oils and their constituent monoterpenes) (Muhlbauer et al. 2003; Yamaguchi 2006), inhibiting HIV-1 integrase and reverse transcriptase (rosmarinic acid) (Kobayashi et al. 2000; Hooker et al. 2001) and assisting diabetes management (tarragon) (Swanston-Flatt et al. 1991). However, results are preliminary and a number of human trials would be necessary before conclusions could be drawn. It is quite possible that there could in fact be several health disorders which could benefit from herbs, but at present there is a lack of research data.

4.7 Anti-microbial activity

Although there has been much interest in and evidence for the anti-microbial properties of various herbs (Elgayyar et al. 2001; Burt 2004; Angelini et al. 2006; Rasooli et al. 2006), the relevance of this to human health has not been examined directly. Rather, research has focused on these properties in relation to food safety and extending shelf life.

5 Individual herbs

5.1 Basil

Popularised recently on account of being a major component of pesto, basil has had an interestingly chequered reputation in different parts of the globe and history. Originating in India and other parts of Asia, it features prominently both in the cuisine and ethnic remedies of those countries. It is also a component in the cuisine of many Mediterranean countries, though it has not always been well regarded in that part of the world. It was reviled in Ancient Greece, where it represented hate and misfortune (Grieve 1931), and there was an old superstition that it spawned scorpions. In some European folklore it is seen as a symbol of Satan. In India, however, Holy basil (*Ocimum sanctum*) is revered as a sacred plant, and is used for a wide variety of ailments, but particularly for treating colds and coughs (Dasgupta et al. 2004).

There does not appear to be research specifically on the effect of basil consumption upon cardiovascular disease, but a few papers relate to the anti-cancer properties of basil. A mouse study by Dasgupta et al. (2004) showed that a basil leaf extract induced phase 2 enzyme activity whilst inhibiting phase 1 enzyme activity, and increased levels of a major endogenous antioxidant enzyme. A significant reduction of lipid peroxidation and formation of lactate dehydrogenase was observed in the mouse livers. The extract inhibited the formation of carcinogen-induced tumours in both the skin and stomach, both in terms of tumour burden and the number of tumour-bearing animals. That paper also cites a number of studies showing various beneficial effects of basil including protection from radiation, chemopreventative activity, anti-inflammatory activity, a stimulatory effect upon the nervous system, bactericidal activity, modulation of glutathione and other antioxidant enzymes, anti-ulcer activity, anti-diarrhoea and blood-sugar lowering effects.

There has been a recent surge of interest from industry in using basil or basil components as natural preservatives for their antioxidant and anti-microbial activity (Dasgupta et al. 2004), aiding in food preservation by protecting food components from degradation, as opposed to preventing bacterial or fungal contamination.

The use of basil essential oil as an anti-microbial agent has been extensively reviewed by Suppakul et al. (2003). Despite many confounding variables, such as myriad basil cultivars, different growing conditions and stage of growth at harvest, different processing methods for obtaining the oil and different methods of testing, that study concluded that basil essential oil and its constituent compounds showed potential for use as a natural food preservative. Although less inhibitory than oreganum, anti-bacterial activity in basil was also observed by Elgayyar et al. (2001).

5.1.1 *Quotes and trivia*

- In France, basil is known as “herbe royale”. It is generally thought that the name basil is derived from the Greek “basileus” meaning “king”.

5.2 *Bay leaf (*Laurus nobilis*)*

Bay leaves are sometimes powdered and ingested, but are most frequently used to infuse flavour during long cooking. In the form of a tea or decoction, they have also been used as folk remedies for a variety of ailments including indigestion, rheumatism, earache, sprains, diseases of the respiratory tract, as a cough suppressant and to treat asthma and cardiac diseases (Fang et al. 2005; Dall'Acqua et al. 2006). Obviously, when bay leaves are used to infuse flavour, rather than being consumed, only those compounds that have leached out will have an effect. The extent to which this happens does not appear to have been investigated.

Bay leaves have shown high to very high antioxidant activity in a number of studies (Elmastas et al. 2006; Hinneburg et al. 2006; Pellegrini et al. 2006; Politeo et al. 2006). The compounds of interest have been identified as sesquiterpenoid lactones. Other phytochemicals include alkaloids, monoterperne and germacrane alcohols, catechin and procyanidine derivatives, glycosylated flavonoids and megastigmane glucosides. Many of these have also shown anti-microbial activity against a range of bacteria and some fungi, as well as immunological and cytotoxic properties (Dall'Acqua et al. 2006).

Sesquiterpene lactones in bay leaves have been shown to have various pharmacological attributes including anti-inflammatory activity and enhancement of the endogenous antioxidant, glutathione-S-transferase (Fang et al. 2005). Research has also shown that compounds isolated from bay leaves cause apoptosis in leukaemia cells *in vitro* (Hibisami et al. 2003, Komiya et al. 2004, cited in Dall’Acqua et al. 2006). Although they proved to be less potent than the reference drug, they were shown to have cytotoxic effects particularly against two leukaemia cell lines and also against one intestinal adenocarcinoma cell line (Dall'Acqua et al. 2006).

Two Japanese studies found interesting properties regarding bay-leaf derived compounds with respect to alcohol. Yoshikawa et al. (2000) and Matsuda et al. (1999) both found that certain compounds inhibited the absorption of alcohol in an animal study, and identified them as sesquiterpenoids. The latter study also observed a delaying of gastric emptying, which, the authors postulated was likely to be involved in exerting the observed effect.

5.2.1 *Quotes and trivia*

- Bay leaves signified victory and merit to the ancient Romans. Poets and heroes were given wreaths made of bay leaves as crowns.

5.3 *Borage (*Borago officinalis*)*

Nowadays, rather than being used as a herb, most borage is grown for seed production which is then pressed for oil. Borage oil is particularly valued on account of its high levels of the essential fatty acid, gamma linolenic acid, and it is in this area that most research has taken place. There has been comparatively little research on the leaves. However, Bandonienne & Murkovic (2002) demonstrated high levels of radical scavenging from a crude extract, with the dominant antioxidant compound identified as rosmarinic acid.

5.3.1 *Quotes and trivia*

- Mrs Grieve, in A Modern Herbal (1931), cites several references from early herbalists referring to borage’s anti-depressant or mood-improving properties e.g. “…it hath an excellent spirit to repress the fuliginous vapour of dusky melancholie” (Bacon). At that time flowers were also eaten and were purported to have the same beneficial effects: “…those of our time do use the flowers in salads to exhilarate and make the mind glad. There be also many things made of these used everywhere for the comfort of the heart, for the driving away of sorrow and increasing the joy of the mind” (Gerard).

5.4 *Chervil (*Anthriscus cerefolium*)*

Sometimes known as gourmet’s parsley (Wikipedia), chervil does in fact belong to the Apiaceae, the same family as parsley and carrots. According to Bremness (1989, cited in Fejes et al. 2000), it was used in folk medicine to treat circulatory disorders.

The chemical composition of chervil has not been comprehensively elucidated but includes the various flavonoids, such as luteolin (Fejes et al. 2000). That study observed various *in vitro* antioxidative effects of chervil extracts including radical scavenging, metal chelating and transition metal reducing activity, and the protection of membrane lipids from peroxidation. Those authors did not identify the active compounds, but thought that they were polyphenolics.

5.5 *Chives (*Allium schoenoprasum*)*

The Allium family, particularly garlic, has been well studied, with special interest in their organosulphur compounds, although these differ by species. The particular organosulphur compounds in chives appear to have been little studied. However, their antioxidant activity has been investigated, with Zheng & Weng (2001) measuring low to moderate levels of phenolics in chives and similarly low to moderate antioxidant activity compared with other herbs (Table 3). Souri et al. (2004) had similar results comparing the antioxidant activity in different Iraninan herbs. Stanjer et al. (2004) showed that all parts of the chive plant had different antioxidant activities, although the leaves contained the highest amounts of active compounds. These included flavonoids, vitamin C, carotenoids and antioxidant enzymes.

5.6 *Coriander (*Coriandrum sativum*)*

Although now a popular and fashionable herb used to flavour as well as garnish, coriander is mainly cultivated for its seeds (Wangensteen et al. 2004). It has been reported to have a number of possible health attributes, particularly relating to the gastro-intestinal tract, but also as a possible diabetic remedy (Gray & Flatt 1999; Al-Mofleh et al. 2006). However, most of these remedies and most studies utilise the seed, rather than the leaves. Powdered seed material protected the gastric mucosa from ethanol-induced damage and inhibited the formation of ulcers in a rat study (Al-Mofleh et al. 2006) and a seed decoction showed anti-hyperglycaemic action in rats (Gray & Flatt 1999). The active compounds were not identified in that study and it is not known whether they are also present in the leaves, or at what levels.

Most research relating to the leaf material relates to antioxidant activity and its constituent antioxidant components. De Almeida et al. (2005) identified the phenolic compounds in an aqueous extract of coriander leaves and stalks as catechol, salicylic acid, glycetin, pyrogallol, gentisic acid, protocatechuic aicd, quinic acid and caffeic acid. In comparison with many other herbs, coriander appeared to have relatively low levels of antioxidant activity in two studies (Dragland et al. 2003; Shan et al. 2005). For example, according to Dragland et al. (2003) using the FRAP assay, whereas oregano varieties had mean antioxidant levels of 137.5 mmol/100 g, varieties of coriander had only 3.3 mmol/100 g. Interestingly, considering the historical preference for seeds rather than leaves for medicinal purposes, Wangensteen et al. (2004) found that coriander leaf extracts had higher radical scavenging activity and lipid peroxidation inhibition than extracts from the seeds.

Essential oil from coriander showed anti-microbial activity against a range of pathogens including *Listeria monocytogenes*. *Staphylococcus aureus*, *Escherichia coli* O:157:H7, *Yersinia enterocolitica*, *Pseudomonas aeruginosa, Lactobacillus plantarum, Aspergillus niger, Geotrichum* and *Rhodotorula* (Elgayyar et al. 2001).

5.6.1 Quotes and trivia

- The leaves of fresh coriander are also known as cilantro, though the dried (and ground) seeds are referred to solely as coriander. Fresh coriander is an important ingredient in Thai and Vietnamese cuisine.

5.7 *Dill (*Anethum graveolens*)*

Like chervil and parsley, dill (often referred to as dill weed in American cookbooks), belongs to the Apiaceae family. It has high antioxidant activity according to Zheng & Wang (2001), and also contains extremely high levels of the flavonoids quercetin (48–110 mg/100 g fresh weight), kaempferol (16–24 mg/100 g fresh weight) and isorhamnetin (5–72 mg/100 g fresh weight), (Justesen & Knuthsen 2001). Extracts from dill plant material showed anti-fungal and anti-bacterial activity against three rapidly growing mycobacteria (Stavri & Gibbons 2005). The active components were identified as oxypeucedanin, oxypeucedanin hydrate and falcarindiol, with falcarindiol showing the strongest activity

5.7.1 *Quotes and trivia*

- The name dill is believed to derive from the Old Norse, dilla, to lull, alluding to its reputed stomach-soothing effects (Grieve 1931). It is an important herb in Scandinavian cuisine, often used in fish dishes.

5.8 *Fennel (*Foeniculum vulgare*)*

Unlike most other herbs in this report, all parts of the fennel plant are eaten. There is, however, little information on the feathery leaves which are considered the herb, as opposed to the bulb (a vegetable), or on the seeds, which are used particularly for the extraction of essential oils, though also for flavouring.

According to Zheng & Weng (2001) fennel extracts contained relatively low levels of phenolic compounds and showed only a low level of antioxidant activity (Table 3). Anethole, a major compound in fennel oil, has cell signalling properties that inhibit inflammation, and increase endogenous antioxidants. In addition, anethole and its derivatives appeared to suppress carcinogenesis (Chainya et al. 2000).

5.8.1 *Quotes and trivia*

- Fennel is another member of the Apiaceae family along with parsley and chervil.
- Prometheus was said to have brought the spark of fire from heaven hidden in a stalk of fennel.

5.9 *Horseradish (*Armoracia rusticana*, syn.* Cochlearia armoracia*)*

Although the leaves are edible, it is the root of the horseradish that is generally eaten, used as a condiment. Consumed largely for its pungent flavour, the compounds behind the flavour are also those of most interest in terms of health attributes. Although the whole, intact roots are not particularly aromatic, when grated, the glucosinolates in the root (mainly sinigrin and gluconasturtiin) are enzymatically hydrolysed to yield allyl isothiocyanate and 2-phenethyl isothiocyanate (PEITC), respectively, which have the characteristically pungent, mustardy aroma and taste. The volatile compounds responsible disappear with time and heat, and thus the fresher the horseradish, the sharper the taste will be.

Horseradish belongs to the Brassicaceae family, whose members, to varying degrees, share the mustardy taste and smell. Equally they contain glucosinolates, though of different kinds and in different amounts, and which are converted when cut or chewed into different secondary compounds, including isothiocyanates. There has been a considerable amount of research on the health attributes of broccoli and its related isothiocyanates, particularly sulforaphane. Most relates to anti-cancer properties, because of an ability to stimulate phase 2 enzyme activity. Anti-inflammatory activity has also been observed.

PEITC, which is also derived from watercress compounds, has been of interest in relation to preventing lung cancer. In a small human study, smokers on a watercress diet excreted higher levels of carcinogenic nitrosamines from tobacco smoke than did those on a control diet. Earlier, in an animal study, considerably fewer rats fed both a carcinogen and PEITC developed tumours than did the rats without the PEITC (Joseph et al. 2002).

5.9.1 Quotes and trivia

- "The radish is worth its weight in lead, the beet its weight in silver, the horseradish its weight in gold." Delphic oracle speaking to Apollo (www.horseradish.org/facts.html).

*5.10 Lemon balm (*Melissa officinalis*)*

A less common herb, lemon balm is used to give a citrus flavour and aroma to foods and beverages, though has also been used as a herbal medicine to treat headaches, gastrointestinal disorders, nervousness and rheumatisms (Mimica-Dukic et al. 2004). Like many herbs, the essential oil of lemon balm, which is rich in aldehydes and terpenic alcohols (Ribeiro et al. 2001), is reported to have anti-microbial properties as well as a strong protective ability against lipid peroxidation (Mimica-Dukic et al. 2004). Hydrophilic extracts have also shown strong antioxidant activity as well as very high levels of phenolics (Dragland et al. 2003; Capecka et al. 2005; Katalinic et al. 2006). However, in contrast, Zheng & Wang (2001) found relatively low levels of both antioxidant activity (ORAC) and phenolics (Table 3). The major phenolic acids with antioxidant activity in lemon balm have been identified as caffeic and rosmarinic acid by Ribiero et al (2001); Caniova & Brandsteterova (2001) also found catechuic acid.

*5.11 Lemon grass (*Cymbopogon citratus*)*

Lemongrass, a plant of West Indian origin, is one of the few herbs from the grass family. Most research relates to its essential oil, of which citral, an oxygenated terpenoid, is a major component (Paranagama et al. 2003).

In a comparison of 11 essential oils isolated from various plant sources, lemongrass oil ranked highly in terms of antioxidant activity – radical scavenging and protection of lipids from peroxidation – as well as anti-microbial activity against a range of food spoilage yeasts (Sacchetti et al. 2005). With a slightly different focus, Nakamura et al. (2003) found that citral isolated from lemongrass induced the activity of the phase 2 enzyme, glutathione-S-transferase (GST), which plays important detoxification and anti-cancer roles in the body (see Hedges & Lister 2006 for further information on phase 2 enzymes.) Using an animal skin cancer model, this study also showed that topically applied citral had an antioxidant effect in mouse skin according to biomarkers of oxidative damage. Lemongrass extract showed inhibitory effects on the early phase of induced liver cancer (Puatanachokchai et al. 2002) and on the formation of induced DNA adducts (abnormal pieces of DNA, bonded to a cancer-causing chemical) and aberrant crypt foci (precursors of colon cancer) in the rat colon (Suaeyun et al. 1997).

5.12 *Lovage (*Levisticum officinale*)*

Once a very commonly cultivated old English herb, and even consumed as a vegetable much like celery (Grieve 1931), lovage has fallen into relative obscurity.

There is little information specifically on the health benefits of lovage. Zheng and Wang (2001) found low to moderate levels of phenolics and antioxidant activity (Table 3). Justesen & Knuthsen (2001) however, found very high levels of the flavonoid quercetin (170 mg/100 g fresh weight) and some kaempferol (7 mg/100 g fresh weight).

5.13 *Mint –spearmint (*Mentha spicata*)*

Mint belongs to the Lamiaceae family and includes 25–30 species, the most popular of which is common mint or spearmint (Choudhury et al. 2006). Along with a close relative, peppermint (*Mentha piperita*), it has been used as a folk remedy particularly for complaints of the digestive tract, including nausea, indigestion, flatulence and even hiccups. In the fourteenth century it was used to whiten teeth and today is used to flavour toothpaste (Grieve 1931; Choudhury et al. 2006). Some of the health benefits attributed to mint include anti-fungal, anti-viral, anti-microbial, insecticidal, antioxidant, anti-amoebic, and anti-haemolytic activities, but is also cited as a central nervous system suppressant (sedative) and allergen (Choudhury et al. 2006). Mint has high levels of carvone, limonene and phenolics (Kumar & Chattopadhyay 2007). This is in contrast, however, to phenolics measured by Zheng and Wang (2001, Table 3), who found only average levels.

Kumar & Chattopadhyay (2007) also observed significant DNA protection from a mint extract *in vitro*. Similarly Yu et al. (2004) observed *in vitro* antimutagenic activity of a spearmint extract as well as a reduction in the number of aberrant crypt foci in an *in vivo* rat study. However, negative health effects were observed in rats given peppermint and spearmint tea, in place of drinking water, with dose-dependent lipid peroxidation and hepatic damage. However, it is possible that unrealistically high dosages could have been achieved (Akdogan et al. 2004). In a similar experiment using mint tea in place of drinking water, spearmint, though not peppermint, caused kidney damaging effects.

Eugenol, caffeic acid, rosmarinic acid and α-tocopherol in mint also have antioxidant properties (Arumugam et al. 2006). Justesen & Knuthsen (2001) measured moderate amounts of the flavonoids apigenin (18–99 mg/100 g fresh weight) and luteolin (11–42 mg/100 g fresh weight) in mint varieties. Zheng and Wang (2001) measured low to moderate levels of phenolics and antioxidant activity in spearmint, peppermint and orange mint (*Mentha aquatica,* Table 3).

5.13.1 *Quotes and trivia*

- The particular flavour and aroma of mint is derived largely from the terpene menthol, which is responsible for the sensation of coolness associated with mint. Besides contributing aroma and taste, menthol binds to temperature-sensing nerve cells in the mouth, which signal to the brain that they are cooler than they really are by 4–7°C. Because menthol usually degrades with heat, the taste of mint changes if cooked (McGee 2004).

5.14 *Vietnamese mint, Vietnamese coriander (*Polygonum odoratum*)*

This plant belongs to neither the mint nor coriander families, but is instead a member of the same family as buckwheat and rhubarb.

There is little information on this plant. Zheng & Wang (2001) measured its phenolic content and antioxidant activity as ranking slightly above average (Table 3). In the essential oil of Vietnamese coriander, long-chain aldehydes were found, e.g. decanal (28%), dodecanal (44%), and decanol (11%). Sesquiterpenes (α-humulene, β-caryophyllene) accounted for about 15% of the essential oil (Journal of Essential Oil Research 1997, vol., 9, p. 603, cited in Katzer 2007).

5.15 *Oregano (*Origanum vulgare*)/marjoram (*Marjorana hortensis*)/* Origanum x majoricum

Marjoram was formerly classified as coming from a sister genus of oregano, but is now officially a species of oregano itself (McGee 2004). In New Zealand the names are often used interchangeably, though marjoram (also known as sweet marjoram) differs from oregano in having a milder flavour.

Oregano is one of the most studied herbs, as it has shown consistently high levels of phenolics, antioxidant activity (Zheng & Wang 2001; Dragland et al. 2003; Capecka et al. 2005; Shan et al. 2005), and in food systems has been shown to extend shelf life particularly of oils, but also of foodstuffs containing lipids, such as meat patties (Vichi et al. 2001; Capecka et al. 2005).

According to Zheng & Wang (2001) two oregano species tested (*Origanum vulgare ssp hirtum* and *Origanum x marjoricum)* both had extremely high levels of phenolics as well as antioxidant activity (Table 3). Oregano similarly ranked very highly in a number of studies over a range of different antioxidant assays, demonstrating its various modes of antioxidant activity (Dragland et al. 2003; Capecka et al. 2005; Shan et al. 2005; Pellegrini et al. 2006).

Later studies have also found that oregano or oregano extracts exhibited antioxidant properties in processed foods by retarding lipid peroxidation in edible oils (Antoun & Tsimidou 1997; Beddows et al. 2000) and performing in this regard at least as well as, but usually better than the synthetic antioxidants BHA and BHT. Similar results were observed in relation to lard (Vichi et al. 2001), though this was not observed by Kulisic et al. (2005), who showed that various essential oils of various herbs, including oregano, performed less well than ascorbic acid and alpha-tocopherol. Dry marjoram and wild marjoram extracts effectively inhibited lipid peroxidation in chicken meat (Abd El-Alim et al. 1999) and the incorporation of oregano extract into beef patties prevented the formation of thiobarbiturate reactive substances (TBARS), markers of oxidative stress, and inhibited discolouration and extended shelf life by about 8 days (Sanchez-Escalante et al. 2003b).

A range of phenolic compounds has been identified in oregano including rosmarinic, caffeic, and p-coumaric acids and caffeoyl derivatives, the phenolic monterpenes, carvacrol and thymol, and flavonoids, luteolin, apigenin myricetin and quercetin (Shan et al. 2005; Yanishlieva et al. 2006; USDA 2007). Although most research interest has centred upon oregano as an essential oil, and its constituent compounds carvacrol and thymol, which are believed to cause its antioxidant activity, it has been shown that water extracts, which isolate a range of different compounds, are rich in phenolic acids and flavonoids also have strong antioxidant activity (Triantaphyllou et al. 2001).

The anti-microbial qualities of oregano have also been investigated. Elgayyar (2001) found that oregano essential oil showed complete inhibition of growth against a range of common pathogenic food bacteria, and Lin et al. (2005) observed a synergistic response in a cranberry/oregano/lactic acid mixture in inhibiting *Vibrio parahaemolyticus* in a laboratory medium and seafood products. Seaberg et al. (2003) observed the inhibition of *Listeria monocytogenes* in broth and meat mediums by extracts from an elite clonal oregano collection. The major components of oregano essential oil, carvacrol and thymol, both exerted a similar effect. Hew (2006), however, found that oregano extract did not destroy pathogens inoculated into chorizo sausages to a sufficient degree to ensure food safety.

Research has also investigated oregano's anti-hyperglycaemic properties, attributed to a mild inhibition of amylase by phenolic antioxidants. McCue et al. (2004) investigated the effect of oregano extracts on porcine pancreatic amylase activity *in vitro* and found that it inhibited activity by 9–57%, and that this was related to its phenolic content, individual phenolic compounds, antioxidant activity and protein content.

5.15.1 Quotes and trivia

- The name oregano is derived from Greek, meaning "joy of the mountain" (Grieve 1931).

5.16 *Par-cel (*Apium graveolens *v.* Zwolsche Krul*)*

This plant is in fact an old Dutch heritage variety of celery, bred for the leaves rather than the stalks. It has the decorative appearance of parsley, but it tastes strongly of celery and is used in salads, soups and stews (Chiltern Seeds 2007).

No Information specifically on the health benefits of this variety has been found, but for the health benefits of celery see Hedges & Lister (2005).

5.17 *Parsley (Petroselinum crispum)*

Also widely used as a garnish, parsley is one of the most popular and common of the culinary herbs. Its flavour blends well with a range of dishes, including meat and fish, vegetables, eggs and cheese. An essential ingredient in dishes such as tabouleh, it is also found in stuffings, sauces, dressings, flavoured butters and with vegetables.

An early study showed that myrisiticin, from parsley leaf oil, increased the activity of the endogenous antioxidant/detoxifying enzyme, glutathione (Zheng et al. 1992). Ahmad et al. (1997) similarly showed that myrisiticin invoked a 4–14 fold dose-dependent increase in liver glutathione-S-transferase.

Parsley contains moderate levels of phenolics and antioxidant activity according to Zheng & Wang (Table 3). Levels measured by Hinneburg et al. (2006) were slightly higher than the other herbs assayed, but still around average. By contrast, of the eight common fresh herbs investigated by Pellegrini et al. (2006), parsley ranked lowest in the three antioxidant assays used.

Phenolic compounds found in parsley include various phenolic acids, notably caffeic acid (Shan et al. 2005), minor amounts of quercetin and luteolin, and extremely high levels of apigenin (Justesen & Knuthsen 2001). Apigenin, which also occurs in onions, tea and oranges, has strong anti-inflammatory, antioxidant and anti-carcinogenic effects (Patel et al. 2007). Along with other members of the Apiaceae family, parsley also contains polyacetylenes, which are toxic to fungi, bacteria and some cancer cells, as well as having anti-inflammatory and anti-platelet aggregating activity. Recently these compounds have been investigated for their ability to reduce tumour formation in animals (Christensen & Brandt 2006). In a study of the antioxidant properties of parsley essential oil (possibly) extracted from seeds, which are likely to differ in composition from the leaves), Zhang et al. (2006) found relatively strong antioxidant activity according to the β-carotene bleaching assay, much weaker radical scavenging ability than the synthetic antioxidant BHT according to the DPPH assay, and negligible metal chelating ability according to a ferrous ion chelating assay. The major compounds identified in parsley essential oil in that study were myristicin (32.75%) and apiol (17.54%).

On the less positive side, parsley may also have neurotoxic effects and invoke allergic responses in skin (Christensen & Brandt 2006). Many of the Apiaceae contain coumarins, such as graveolone and psoralen. Psoralen and other furanocoumarins are potent photosensitising agents. Whilst this property has some medicinal applications, such as treating skin pigmentation disorders and psoriasis, they have also been shown to invoke allergic reactions. For example photodermatitis developed in parsley pickers who were exposed to both cut parsley surfaces and sunlight (Beier et al. 1994).

Many Apiaceae, including parsley, also contain compounds called phthalides. Various kinds of bioactivity have been reported in phthalides (Beck & Chou 2007), including the induction of the antioxidant enzyme gluthathione transferase (Craig 1999), though no information specifically on parsley phthalides has been located.

5.17.1 *Quotes and trivia*

- Eating fresh parsley after consuming garlic is recommended for freshening breath.
- Many ethnobotanical uses relate to parsley's use as a diuretic.

5.18 *Rosemary (*Rosmarinus officinalis*)*

"Rosemary for remembrance" is a well known epithet. Perhaps originating from its folkloric reputation for strengthening the memory and general "weaknesses of the brain", it also became associated with lovers and the concept of fidelity and thus somewhat paradoxically was used in wedding ceremonies as well as at funerals (Grieve 1931).

Studies reviewed by Yanishleva et al. (2006) identified the compounds thought to cause rosemary's antioxidant activity as carnasol, carnosic acid, rosmanol, rosmarinic acid, chlorogenic acid and several diterpenes. Of these, carnosic acid, its derivative carnasol, and rosmarinic acid appear to be the most important. Their review discusses several antioxidant studies in which rosemary compounds rank at least as well as, if not better, than synthetic antioxidants.

Carnosol and carnosic acid are phenolic diterpenes found mainly in rosemary and sage leaves and, like other phenolic compounds, show strong antioxidant activity (Wijeratne & Cuppett 2007). Besides its antioxidant properties, carnosic acid is involved in the growth and proper functioning of nerve tissues, has shown anti-proliferative activity in leukaemia cells, and has anti-inflammatory properties. In addition, it has recently been gaining interest because of its ability to limit the absorption of lipids in the digestive system, suggesting a possible role in weight management (Wijeratne & Cuppett 2007).

Rosmarinic acid (α-O-caffeoyl-3,4-dihydroxyphenyllactic acid) is a phenolic acid found mainly in the Boraginaceae and Lamiaceae families. Other herbs in which it is found include basil, borage, lemon balm, oregano and marjoram, peppermint, sage and thyme (Yanishlieva et al. 2006). It has many biological activities, including anti-tumor, anti-inflammatory and liver protective activities, and inhibits blood clots and HIV-1 integrase and reverse transcriptase (Kobayashi et al. 2000; Hooker et al. 2001). *In vitro* it shows strong free radical scavenging ability, and is able to prevent the oxidation of some transition metals. In the body it can also be used to scavenge excess free radicals and it inhibits xanthine oxidase, an enzyme involved in the generation of superoxide radicals.

Although rosemary has been one of the most extensively studied herbs as an antioxidant in various food systems, it ranks relatively lowly in comparison with other herbs according to Zheng & Wang (2001) and Katalinc et al. (2006), though not according to Pellegrini et al. (2006), who ranked it second out of eight common herbs in each of the three different antioxidant assays used. Rosemary has been considered as a potential natural preservative in a variety of foods including meat products, oils and bread (Sanchez-Escalante et al. 2003a; Martinez et al. 2006; Yanishlieva et al. 2006). Like many herbs, rosemary extracts have anti-microbial activity and this is also thought to be attributable to their carnosic and rosmarinic acid content (Moreno et al. 2006).

An early mouse study showed that a rosemary leaf extract as well as two of its constituent components, carnosol and ursolic acid, reduced numbers of induced skin tumours. It also inhibited tumour formation and tumour promotion and reduced carcinogenic enzyme activity and inflammation (Huang et al. 1994). Ground rosemary powder fed to rats prevented damage to mammary cell DNA from a known carcinogen (Amagase et al. 1996), and rosemary extract and carnosol, but not ursolic acid, similarly prevented DNA damage and consequent mammary tumours in an *in vivo* rat study (Singletary et al. 1996). Further investigation by Huang et al. (2005) demonstrated the anti-metatastic potential of carnosol using rat melanoma cells. An *in vitro* study showed carnasol to have strong antioxidant activity, to protect DNA, to suppress certain processes involved in tumorigenesis, and suggested possible mechanisms for its anti-inflammatory and chemopreventive action (Lo et al. 2002).

In an extensive study screening herbs for potential anti-thrombotic effects, Yamamoto et al. (2005) found that rosemary and common thyme showed significant anti-thrombotic activity both *in vitro* and *in vivo* using a rat model. This activity did not involve vasodilation, but rather appeared to directly inhibit platelet aggregation. The specific active components were not identified, though proved to be heat stable.

A review by Vitaglione et al. (2004) concluded that both rosemary and thyme extracts prevented acute carbon tetrachloride-induced liver damage in rats. It was thought that was achieved through maintaining the structural integrity of the hepacyte, by scavenging the free radicals induced by carbon tetrachloride. Rosemary extract also increased levels of the endogenous antioxidant glutathione-S-transferase in the liver, as well as in plasma, helped retain liver glycogen and normalised bilirubin and aminotransferase activity.

Although Ahern et al. (2007) found various protective effects of rosemary extracts (e.g. reduced H_2O_2-induced damage after pretreatment of cells), they also observed toxic effects in terms of cell membrane integrity and cell viability. Sage and oregano similarly induced cytotoxic effects, but to lesser extents. This prompted a caution from the authors against consuming high doses of these.

5.18.1 Quotes and trivia

- Rosemary is one of the ingredients used in the manufacture of the perfume, eau-de-Cologne (Grieve 1931).

- One of the properties popularly attributed to rosemary is its ability to prevent baldness by stimulating hair follicles (Grieve 1931; Duke 2003).

5.19 *Sage (*Salvia officinalis*)*

Sage is another member of the Lamiaceae or mint family and the botanical name of this genus, *Salvia*, is derived from the Latin *salvere*, to be saved, attesting to its curative powers (Grieve 1931). The modern English *salve,* meaning medicinal ointment, harks back to the esteem in which this plant was held by early herbalists.

Over 160 polyphenols have been found in *Salvia*, some of which are unique to the genus. Extensively reviewed by Lu & Yeap (2002), they include mainly phenolic acids, all caffeic acid derivatives, the flavones apigenin and luteolin and their glycosides, and the flavonols kaempferol and quercetin and their glycosides. Anthocyanins are present in the flowers. Like rosemary, sage contains carnosic acid.

According to Zheng & Wang (2001), common sage and pineapple sage ranked towards the lower end of the scale in terms of phenolic content and antioxidant activity. Incubating cells with sage extract significantly increased the content of the endogenous antioxidant, glutathione (Aherne et al. 2007), although this did not occur with rosemary or oregano. Similarly, preincubation of cells with sage extract produced a more significant reduction of peroxide-induced DNA damage than with oregano or rosemary extract, and sage was the only extract to protect against peroxide-induced cell damage.

Like many other herbs, sage can protect oils from oxidation. Bandioniene et al. (2002) showed that two different forms of sage extract stabilised rape seed oil against oxidation better than BHT.

An interesting area of research with respect to sage has been in relation to brain function, particularly Alzheimer’s disease. An animal study found that a sage leaf extract improved memory retention, possibly through an observed effect upon the cholergenic system in the brain (Eidi et al. 2006). A clinical trial in Iran, in which subjects with mild to moderate Alzheimer’s disease received 60 drops daily of a 1:1 sage:alcohol extract over 4 months, found significant improvements in cognitive functions according to the Alzheimer’s Disease Assessment Scale (Akhondzadeh et al. 2003). It has been found *in vitro*, and in an animal study, that an extract of an essential oil of Spanish sage (*Salvia lavandulaefolia*) inhibited the enzyme acetylcholinesterase, an enzyme which breaks down the important chemical acetylcholine that is involved in signal transfer in the synapses. This mechanism is the basis of many of the current anti-Alzheimer’s drugs. In addition, the extract showed anti-inflammatory, oestrogenic and sedative effects, which are also relevant to the treatment of Alzheimer’s disease (Perry et al. 2001; 2003).

5.19.1 *Quotes and trivia*

- According to old English folklore, sage, like parsley, was supposed to grow best in households where the wife was dominant (Online Etymology Dictionary 2007).

5.20 *Salad burnet (*Sanguisorba minor*)*

Salad burnet is used as a medicinal plant in parts of the Middle East, where extracts of this herb are used for their hypoglycaemic properties (Ayoub 2003). Phenolic compounds identified in an aqueous ethanol extract of salad burnet included two unique carboxylic acids, 4,8-dimethoxy-7-hydroxy-2-oxo-2H-1-benzopyran-5,6-dicarboxylic acid and 2-(4-carboxy-3-methoxystyryl)-2-methoxysuccinic acid. as well as gallic acid, ellagic acid, quercetin and quercetin-3-*O*-(6″-galloylglucose), β-glucogallin, 2,3-hexahydroxydiphenoyl-(α/β)-glucose, and 1-galloyl-2,3-hexahydroxydiphenoyl-α-glucose together with its β-isomer (Ayoub 2003). Ferreira et al. (2006) measured very good antioxidant activity in three different fractions – essential oil, ethanol and water extracts – and suggested this might be attributable to the phenolic compounds above. Like sage, salad burnet may help prevent or ameliorate Alzheimer's disease. Of the ten Portuguese medicinals tested, an ethanolic extract of salad burnet had the best inhibition of acetylcholinesterase (Ferreira et al. 2006).

5.21 *Savory (*Satureja montana *– winter savory,* Satureja hortensis *– summer savory)*

Summer savory and winter savory are two types of the same genus, with summer savory having a milder flavour (McGee 2004). The essential oil from savory species has been shown to have anti-bacterial, anti-fungal, anti-viral, antioxidant, anti-spasmodic and anti-diarrhoeal properties. The essential oil of winter savory was found to have broad spectrum antibiotic activity against a range of multidrug resistant pathogens, as well as fungicidal activity. The major component was identified as the phenolic monterpene carvacrol (45.7%) followed by the monoterpenic hydrocarbons p-cymene (12.6%), γ-terpinene (8.1%) and carvacrol methyl ether, borneol, thymol and thymol methyl ether (Skocibusic & Bezic 2004).

As with many other herbs, savory appears to protect food lips from oxidation, with Bandoniene et al. (2002) observing that acetone-extracted summer savory oleoresins and deodorised acetone extracts stabilised rape seed oil against oxidation better than the commercial antioxidant BHT. Summer savory has also shown protective antioxidative effects in sunflower oil, lard and an oil-in-water emulsion dressing. Antioxidant compounds found in summer savory include rosmarinic acid, carnosol and carnosic acid, carvacrol and thymol (Yanishlieva et al. 2006).

5.22 *Sorrel (*Rumex acetosa*)*

Also used as a vegetable, particularly in sauces and soups, sorrel is the very sour leaf of a plant belonging to the rhubarb family. It has high levels of oxalic acid, which is considered an anti-nutritional compound because it binds to important minerals like iron and calcium and prevents their absorption. It is also thought to contribute to kidney stones and gout. Large amounts of oxalic acid are also found in parsley and chives (USDA 2006), although this factor is not usually a dietary risk because of the small quantities in which herbs are eaten.

Little information has been found on sorrel. However, in a study investigating a range of herbs for possible anti-thrombotic effects, it was found that sorrel extract inhibited platelet reactivity *in vitro*, though not *in vivo* (Yamamoto et al. 2005).

5.23 *Tarragon (*Artemisia dracunculus*)*

Of the two main types of tarragon, French and Russian, the French is generally considered to have a more interesting flavour and aroma (McGee 2004). The characteristic aniseed flavour of tarragon has been generally attributed to estragole, although Kordali et al. (2005) found that its isomer, (Z)-anethole was the dominant compound in Turkish tarragon essential oils, comprising 81%.

Although the flavonoids quercetin, kaempferol, luteolin and isorhamnetin were found in tarragon by Justesen & Knuthsen (2001), they were not present in large amounts. Tarragon extract inhibited both platelet activity and coagulation *in vitro*, but showed no *in vivo* thrombolitic effect (Yamamoto et al. 2005).

Tarragon has also been investigated in terms of diabetes. In an animal model tarragon reduced the symptoms of weight loss, excessive thirst and excessive appetite, but did not lower glucose concentrations (Swanston-Flatt et al. 1991).

In comparison with the commercial antioxidant BHT, tarragon essential oil showed only weak radical scavenging activity. However, it had fungicidal activity against 34 fungal agricultural pathogenic species, although this was weaker than that of two related species (Kordali et al. 2005): the authors hypothesised that this was due to the absence of oxygenated monoterpenes in tarragon.

5.24 *Thyme (*Thymus vulgaris*)*

Besides valuing it for its antiseptic qualities, to the ancient Greeks thyme symbolised courage. Later, Roman soldiers bathed in water infused with thyme to gain courage and strength, and in the Middle Ages, ladies embroidered a sprig of thyme on the scarves of knights for bravery (Grieve 1931; McCormick 2006).

Zheng & Wang (2001) found moderate levels of phenolics and antioxidant activity in thyme in comparison with other herbs (Table 3). They also found a variation according to species, with common garden thyme ranking more highly in both respects than creeping or lemon thyme. According to Pellegrini et al. (2006), thyme ranked around the middle of eight herbs tested for various aspects of antioxidant activity. Shan et al. (2005) showed New Zealand-grown thyme to have levels of antioxidant activity and phenolic compounds roughly similar to that of New Zealand-grown mint, rosemary and bay leaf, although much lower than those of oregano.

The major flavonoid in thyme measured by Justesen & Knuthsen (2001) was luteolin, which was present at the high level of 51 mg/100 g fresh weight), followed by a small amount of apigenin (5 mg/100 g fresh weight). Shan et al.

(2005) identified the major phenolic compounds as gallic aicd, caffeic acid, rosmarinic acid, thymol, phenolic diterpenes and (unspecified) flavonoids.

There have been a few trials involving human cells. In two laboratory studies Braga et al. (2006a; 2006b) investigated the effects of thymol on human neutrophils in relation to inflammation. It was shown that thymol was able to interfere with the production of reactive oxygen species released by neutrophils, as well as inhibiting the release of elastase, which degrades tissue and is a marker of inflammatory diseases. A further non-cell-based assay showed thymol to have significant scavenging activity, which the authors attributed to its phenolic structure. Thymol also showed significant anti-thrombotic activity *in vitro* and *in vivo* in mice (Yamamoto et al. 2005). Youdim & Deans (2000) demonstrated a beneficial effect of supplementation with thyme essential oil or thymol on antioxidant status and fatty acid composition in the brains of ageing rats, both of which are believed to be important in maintaining brain function. In an animal study investigating its use as a burn treatment, a traditional herbal remedy of thyme oil served as a tissue-protective agent by decreasing the amount of nitrous oxide produced after the burn injury. It was also observed that more new tissue formed on the wounds of rats receiving the treatment than on the control animals.

Aydin et al. (2005) observed lower levels of induced DNA damage with treatment of thymol, carvacrol and gamma terpinine at low concentrations, but increased DNA damage to human lymphocyte cells at higher concentrations. However, it is unlikely that the concentrations used in the trial, which proved to be toxic, would be achieved by consuming thyme in the normal way.

There is also information attesting to the antioxidant behaviour of thyme or thyme components in food matrices (Murkovic et al. 1998; Abd El-Alim et al. 1999; Abdalla & Roozen 1999; Burt 2004). Equally there is much research relating to their anti-microbial activity (Burt 2004; Sacchetti et al. 2005; Angelini et al. 2006; Bozin et al. 2006; Rasooli et al. 2006; Viuda-Martos et al. 2007)

5.25 *Wasabi (*Wasabia japonica*)*

Also known as Japanese horseradish, wasabi shares both the pungent, peppery taste and some constituent compounds with traditional horseradish. It is technically a rhizome, which when used fresh is grated, like horseradish, though is more commonly available as a powder. Like horseradish, mustard and broccoli, its pungency derives from glucosinolate breakdown products. The wasabi compound which has been of most research is 6-(methylsulfinyl)hexyl isothiocyanate (6-MITC).

An *in vitro* study of roots and leaves of wasabi samples showed antioxidant, radical scavenging, anti-mutagenic and peroxidise activity (Kinae et al. 2000). Subsequent study has related primarily to anti-cancer properties, although new areas of research have evolved as more about its constituent compounds are known.

Substantial research has shown that sulforaphane, a structurally similar compound to 6-MITC, is a major inducer of phase 2 detoxification enzymes.

Morimitsu et al. (2002) similarly showed that 6-MITC was a potent activator of the important phase 2 detoxification enzyme, glutathione-S-transferase.

6-MITC isolated from wasabi inhibited the development of chemically induced lung tumours in mice, by suppression of the initiation stage (Yano et al. 2000). Wasabi powder administered in drinking water was also shown to suppress induced glandular stomach carcinogenesis in rats (Tanida et al. 1991) and compounds purified from a wasabi rhizome extract showed inhibitory activities in colon, lung and stomach cancer cells as well as towards COX-1 enzymes. The active compounds in this study were identified as linolenoyloleoyl-3-beta-galactosylglycerol, and 1,2-dipalmitoyl-3-beta-galactosylglycerol (Weil et al. 2005). However, in contrast, a previous study by the same authors had shown that desulfosinigrin, isolated from a commercial wasabi powder and fresh wasabi roots, promoted the growth of human colon and lung cancer cells at certain concentrations (Weil et al. 2004).

6-MITC isolated from wasabi powder had a beneficial effect upon markers of type 2 diabetes-related kidney disorders, although this was not observed with the wasabi powder itself (Fukuchi et al. 2004).

Wasabi leafstalk extract had an anabolic effect upon bone components in an animal study and *in vitro* was shown to stimulate bone calcification, though the active component(s) were not identified (Yamaguchi 2006).

6 Conclusions

Herbs contain high concentrations of both ubiquitous and less common compounds. Their importance as ethnic remedies, together with the fact that herbs still are the basis for a significant proportion of prescription drugs, is testament to their potential health attributes. Herbs, herb extracts and pure compounds isolated from herbs have been shown scientifically to have a range of beneficial properties, with those most studied to date being their *in vitro* antioxidant and anti-microbial activities. However, there are increasing numbers of studies relating particularly to anti-cancer properties. Newer areas of research, often stemming from traditional remedies, include their effect upon blood clotting, brain function and diabetes.

It is also important to remember that the perceived health benefits of a particular herb will depend partly on the level of research to which it has been subjected, as well as the levels of bioactive components that it contains. Thus, it is possible that some lesser known herbs may not stand out at present, but in future could be found to have important health attributes.

Although when used as ethnic remedies and drug constituents, the bioactive chemicals in herbs will be more concentrated than if consumed in the plant form as cuisine flavourings, it can be appreciated that regular consumption of even small quantities can provide a boost in dietary phytochemicals, including those with antioxidant activity. The concept of “a little and often” is well suited to deriving maximum benefits from herbs, in this way aiming to protect against health problems rather than treating them.

7 References

Abd El-Alim SSL, Lugasi A, Hovari J, Dworschak E 1999. Culinary herbs inhibit lipid oxidation in raw and cooked minced meat patties during storage. Journal of the Science of Food and Agriculture 79(2): 277–285.

Abdalla AE, Roozen JP 1999. Effect of plant extracts on the oxidative stability of sunflower oil and emulsion. Food Chemistry, 64(3): 323–329.

Aherne SA, Kerry JP, O'Brien NM 2007. Effects of plant extracts on antioxidant status and oxidant-induced stress in Caco-2 cells. British Journal of Nutrition, 97(2): 321–328.

Ahmad H, Tijerina MT, Tobola AS 1997. Preferential overexpression of a class MU glutathione S-transferase subunit in mouse liver by myristicin. Biochemical and Biophysical Research Communications, 236(3): 825–828.

Akdogan M, Ozguner M, Aydin G, Gokalp O 2004. Investigation of biochemical and histopathological effects of *Mentha piperita* Labiatae and *Mentha spicata* Labiatae on liver tissue in rats. Human & Experimental Toxicology, 23(1): 21–28.

Akhondzadeh S, Noroozian M, Mohammadi M, Ohadinia S, Jamshidi AH, Khani M 2003. *Salvia officinalis* extract in the treatment of patients with mild to moderate Alzheimer's disease: a double blind, randomized and placebo-controlled trial. Journal of Clinical Pharmacy and Therapeutics, 28(1): 53–59.

Al-Mofleh IA, Alhaider AA, Mossa JS, Al-Sohaibani MO, Rafatullah S, Qureshi S 2006. Protection of gastric mucosal damage by *Coriandrum sativum* L. pretreatment in Wistar albino rats. Environmental Toxicology and Pharmacology, 22(1): 64–69.

Amagase H, Sakamoto K, Segal ER, Milner JA 1996. Dietary rosemary suppresses 7,12-dimethylbenz(a)anthracene binding to rat mammary cell DNA. Journal of Nutrition, 126(5): 1475–1480.

Angelini P, Pagiotti R, Menghini A, Vianello B 2006. Anti-microbial activities of various essential oils against foodborne pathogenic or spoilage moulds. Annals of Microbiology, 56(1): 65–69.

Antoun N, Tsimidou M 1997. Gourmet olive oils: stability and consumer acceptability studies. Food Research International, 30(2): 131–136.

Arumugam P, Ramamurthy P, Santhiya ST, Ramesh A 2006. Antioxidant activity measured in different solvent fractions obtained from *Mentha spicata* Linn.: An analysis by ABTS(.+) decolorization assay. Asia Pacific Journal of Clinical Nutrition, 15(1): 119–124.

Aydin S, Basaran AA, Basaran N 2005. Modulating effects of thyme and its major ingredients on oxidative DNA damage in human lymphocytes. Journal of Agricultural and Food Chemistry, 53(4): 1299–1305.

Ayoub NA 2003. Unique phenolic carboxylic acids from *Sanguisorba minor.* Phytochemistry, 63(4): 433–436.

Bandoniene D, Venskutonis P, Gruzdiene D, Murkovic M 2002. Antioxidative activity of sage *Salvia officinalis* L.), savory (*Satureja hortensis* L.) and borage (*Borago officinalis* L.) extracts in rapeseed oil. European Journal of Lipid Science and Technology, 104(5): 286–292.

Beck JJ, Chou SC 2007. The Structural Diversity of Phthalides from the Apiaceae. Journal of Natural Products 70(5): 891–900.

Beier RC, Ivie GW, Oertli EH 1994. Linear furanocoumarins and graveolone from the common herb parsley. Phytochemistry 36(4): 869–872.

Beddows CG, Jagait C, Kelly MJ 2000. Preservation of alpha-tocopherol in sunflower oil by herbs and spices. International Journal of Food Sciences and Nutrition 51(5): 327–339.

Bozin B, Mimica-Dukic N, Simin N, Anackov G 2006. Characterization of the volatile composition of essential oils of some lamiaceae spices and the anti-microbial and antioxidant activities of the entire oils. Journal of Agricultural and Food Chemistry 54(5): 1822–1828.

Braga PC, Dal Sasso M, Culici M, Bianchi T, Bordoni L, Marabini L 2006a. Anti-inflammatory activity of thymol: Inhibitory effect on the release of human neutrophil elastase. Pharmacology 77(3): 130–136.

Braga PC, Dal Sasso M, Culici M, Galastri L, Marceca MT, Guffanti EE 2006b. Antioxidant potential of thymol determined by chemiluminescence inhibition in human neutrophils and cell-free systems. Pharmacology 76(2): 61–68.

Burt S 2004. Essential oils: their antibacterial properties and potential applications in foods – a review. International Journal of Food Microbiology 94(3): 223–253.

Calucci L, Pinzino C, Zandomeneghi M, Capocchi A, Ghiringhelli S, Saviozzi F, Tozzi S, Galleschi L 2003. Effects of Irradiation on the Free Radical and Antioxidant Contents in Nine Aromatic Herbs and Spices. Journal of Agricultural and Food Chemistry 51(4): 927–934.

Caniova A, Brandsteterova E 2001. HPLC analysis of phenolic acids in *Melissa officinalis.* Journal of Liquid Chromatography & Related Technologies 24(17): 2647–2659.

Capecka E, Mareczek A, Leja M 2005. Antioxidant activity of fresh and dry herbs of some Lamiaceae species. Food Chemistry 93(2): 223–226.

Chainya GB, Mannaa SK, Chaturvedi MM, Aggarwal BB 2000. Anethole blocks both early and late cellular responses transduced by tumor necrosis factor: effect on NF-B, AP-1, JNK, MAPKK and apoptosis. Oncogene 19(25): 2943–2950.

Chiltern Seeds 2007. Chiltern Seeds Online Catalogue www.edirectory.co.uk/chilternseeds/pages/moreinfor.asp?pe=DBFAAAAAQ_+celery+parsley+zwolsche+krul&cid=211 .

Choudhury RP, Kumar A, Garg AN 2006. Analysis of Indian mint (Mentha spicata) for essential, trace and toxic elements and its antioxidant behaviour. Journal of Pharmaceutical and Biomedical Analysis 41(3): 825–832.

Christensen LP, Brandt K 2006. Bioactive polyacetylenes in food plants of the Apiaceae family: Occurrence, bioactivity and analysis. Journal of Pharmaceutical and Biomedical Analysis 41(3): 683–693.

Craig WJ 1999. Health-promoting properties of common herbs. American Journal of Clinical Nutrition 70(3): 491S–499.

Dall'Acqua S, Giampietro V, Giorgetti M, C. LM, Innocenti G 2006. Two New Sesquiterpene Lactones from the Leaves of *Laurus nobilis*. Chemcical and Pharmaceutical Bulletin 54: 1187–1189.

Dasgupta T, Rao AR, Yadava PK 2004. Chemomodulatory efficacy of Basil leaf (Ocimum basilicum) on drug metabolizing and antioxidant enzymes, and on carcinogen-induced skin and forestomach papillomagenesis. Phytomedicine 11(2-3): 139–151.

de Almeida Melo E, Mancini Filho J, Barbosa Guerra N 2005. Characterization of antioxidant compounds in aqueous coriander extract (*Coriandrum sativum* L.). Lebensmittel-Wissenschaft und-Technologie 38(1): 15–19.

Dragland S, Senoo H, Wake K, Holte K, Blomhoff R 2003. Several Culinary and Medicinal Herbs Are Important Sources of Dietary Antioxidants. Journal of Nutrition 133(5): 1286–1290.

Duke J 2003. Dr Duke's Phytochemical and Ethnobotanicial Databases. www.ars-grin.gov/duk/index.html [accessed 21/05/2003 2001].

Edris AE 2007. Pharmaceutical and therapeutic Potentials of essential oils and their individual volatile constituents: a review. Phytotherapy Research 21(4): 308–323.

Eidi M, Eidi A, Bahar M 2006. Effects of *Salvia officinalis* L. (sage) leaves on memory retention and its interaction with the cholinergic system in rats. Nutrition 22(3): 321–326.

Elgayyar M, Draughon FA, Golden DA, Mount JR 2001. Anti-microbial activity of essential oils from plants against selected pathogenic and saprophytic microorganisms. Journal of Food Protection 64(7): 1019–1024.

Elmastas M, Gulcin I, Isildak O, Kufrevioglu OI, Ibaoglu K, Aboul-Enein HY 2006. Radical scavenging activity and antioxidant capacity of bay leaf extracts. Journal of the Iranian Chemical Society 3(3): 258–266.

Elson CE, Underbakke GL, Hanson P, Shrago E, Wainberg RH, Qureshi AA 1989. Impact of lemongrass oil, an essential oil, on serum-cholesterol. Lipids, 24(8): 677–679.

Fahey JW, Stephenson KK, Dinkova-Kostova AT, Egner PA, Kensler TW, Talalay P 2005. chlorophyll, chlorophyllin and related tetrapyrroles are significant inducers of mammalian phase 2 cytoprotective genes. Carcinogenesis 26(7): 1247–1255.

Fang F, Sang S, Chen KY, Gosslau A, Ho C-T, Rosen RT 2005. Isolation and identification of cytotoxic compounds from Bay leaf (*Laurus nobilis*). Food Chemistry 93(3): 497–501.

Fejes S, Blazovics A, Lugasi A, Lemberkovics E, Petri G, Kery A 2000. In vitro antioxidant activity of *Anthriscus cerefolium* L. (Hoffm.) extracts. Journal of Ethnopharmacology 69(3): 259–265.

Ferreira A, Proenca C, Serralheiro MLM, Araujo MEM 2006. The in vitro screening for acetylcholinesterase inhibition and antioxidant activity of medicinal plants from Portugal. Journal of Ethnopharmacology 108(1): 31–37.

Fukuchi Y, Kato Y, Okunishi I, Matsutani Y, Osawa T, Naito M 2004. 6-methylsulfinylhexyl isothiocyanate, an antioxidant derived from Wasabia japonica MATUM, ameliorates diabetic nephropathy in type-2 diabetic mice. Food Science and Technology Research 10(3): 290–295.

Gray AM, Flatt PR 1999. Insulin-releasing and insulin-like activity of the traditional anti-diabetic plant *Coriandrum sativum* (coriander). British Journal of Nutrition 81(3): 203–209.

Grieve M 1931. A Modern Herbal. Harmondsworth, Penguin. 912 p.

Hedges LJ, Lister CE 2005. The nutritional attributes of salad vegetables. Crop & Food Research Confidential report no. 1473. Christchurch, New Zealand Institute for Crop & Food Research Ltd. 29 p.

Hedges LJ, Lister CE 2006. Nutritional attributes of *Brassica* vegetables. Crop & Food Research Confidential report no. 1618. Christchurch, New Zealand Institute for Crop & Food Research Ltd. 46 p.

Hedges LJ, Lister CE 2007. Nutritional attributes of allium species. Crop & Food Research Confidential report no. 1814. Christchurch, New Zealand Institute for Crop & Food Research Ltd. 44 p.

Hew CM, Hajmeer MN, Farver TB, Riemann HP, Glover JM, Cliver DO 2006. Pathogen survival in chorizos: Ecological factors. Journal of Food Protection 69(5): 1087–1095.

Hinneburg I, Damien Dorman HJ, Hiltunen R 2006. Antioxidant activities of extracts from selected culinary herbs and spices. Food Chemistry 97(1): 122–129.

Hooker CW, Lott WB, Harrich D 2001. Inhibitors of Human Immunodeficiency Virus Type 1 Reverse Transcriptase Target Distinct Phases of Early Reverse Transcription. Journal of Virology 75(7): 3095–3104.

Howes MJR, Perry NSL, Houghton PJ 2003. Plants with traditional uses and activities, relevant to the management of Alzheimer's disease and other cognitive disorders. Phytotherapy Research 17(1): 1–18.

Huang MT, Ho CT, Wang ZY, Ferraro T, Lou YR, Stauber K, Ma W, Georgiadis C, Laskin JD, Conney AH 1994. Inhibition of skin tumorigenesis by rosemary and its constituents carnosol and ursolic acid. Cancer Research 54(3): 701–708.

Huang SC, Ho CT, Lin-Shiau SY, Lin JK 2005. Carnosol inhibits the invasion of B16/F10 mouse melanoma cells by suppressing metalloproteinase-9 through down-regulating nuclear factor-kappaB and c-Jun. Biochemical Pharmacology 69(2): 221–232.

Joseph JA, Nadeau DA, Underwood A 2002. The Color Code: A Revolutionary Eating Plan for Optimum Health. New York, Hypericon. 308 p.

Justesen U, Knuthsen P 2001. Composition of flavonoids in fresh herbs and calculation of flavonoid intake by use of herbs in traditional Danish dishes. Food Chemistry 73(2): 245–250.

Katalinic V, Milos M, Kulisic T, Jukic M 2006. Screening of 70 medicinal plant extracts for antioxidant capacity and total phenols. Food Chemistry 94(4): 550–557.

Kinae N, Masuda H, Shin IS, Furugori M, Shimoi K 2000. Functional properties of wasabi and horseradish. Biofactors 13(1-4): 265–269.

Kordali S, Kotan R, Mavi A, Cakir A, Ala A, Yildirim A 2005. Determination of the Chemical Composition and Antioxidant Activity of the Essential Oil of Artemisia dracunculus and of the Antifungal and Antibacterial Activities of Turkish Artemisia, absinthium, *A. dracunculus, Artemisia santonicum*, and *Artemisia spicigera* Essential Oils. Journal of Agricultural and Food Chemistry 53(24): 9452–9458.

Kobayashi Y, Watanabe M, Ogihara J, Kato J, Oishi K 2000. Inhibition of HIV-1 reverse transcriptase by methanol extracts of commercial herbs and spices. Journal of the Japanese Society for Food Science and Technology-Nippon Shokuhin Kagaku Kogaku Kaishi 47(8): 642–645.

Kulisic T, Radonic A, Milos M 2005. Inhibition of lard oxidation by fractions of different essential oils. Grasas Y Aceites 56(4): 284–291.

Kumar A, Chattopadhyay S 2007. DNA damage protecting activity and antioxidant potential of pudina extract. Food Chemistry 100(4): 1377–1384.

Lin YT, Kwon YI, Labbe RG, Shetty K 2005. Inhibition of Helicobacter pylori and Associated Urease by Oregano and Cranberry Phytochemical Synergies. Applied Environmental Microbiology 71(12): 8558–8564.

Lister CE 2003. Antioxidants: a health revolution. 1st ed. Christchurch, New Zealand Institute for Crop and Food Research. 96 p.

Lo AH, Liang YC, Lin-Shiau SY, Ho CT, Lin JK 2002. Carnosol, an antioxidant in rosemary, suppresses inducible nitric oxide synthase through down-regulating nuclear factor-kappa B in mouse macrophages. Carcinogenesis 23(6): 983–991.

Lu Y, Yeap FL 2002. Polyphenolics of Salvia – a review. Phytochemistry, 59(2): 117–140.

Mandel S, Amit T, Reznichenko L, Weinreb O, Youdim MBH 2006. Green tea catechins as brain-permeable, natural iron chelators-antioxidants for the treatment of neurodegenerative disorders. Molecular Nutrition & Food Research 50(2): 229–234.

Martin A, Youdim K, Szprengiel A, Shukitt-Hale B, Joseph J 2002. Roles of vitamins E and C on neurodegenerative diseases and cognitive performance. Nutrition Reviews 60(10): 308–326.

Martinez L, Cilla I, Beltran JA, Roncales P 2006. Antioxidant effect of rosemary, borage, green tea, pu-erh tea and ascorbic acid on fresh pork sausages packaged in a modified atmosphere: Influence of the presence of sodium chloride. Journal of the Science of Food and Agriculture 86(9): 1298–1307.

Matsuda H, Shimoda H, Uemura T, Yoshikawa M 1999. Preventive effect of sesquiterpenes from bay leaf on blood ethanol elevation in ethanol-loaded rat: Structure requirement and suppression of gastric emptying. Bioorganic & Medicinal Chemistry Letters 9(18): 2647–2652.

McCormick 2006. McCormick - Spice Encyclopedia - thyme. http://www.mccormick.com/content.cfm?id=8209 [accessed 29/5/2007 2007].

McCue P, Vattem D, Shetty K 2004. Inhibitory effect of clonal oregano extracts against porcine pancreatic amylase in vitro. Asia Pacific Journal of Clinical Nutrition 13(4): 401–408.

McGee H 2004. On food and cooking. Revised ed. New York, Scribner. 884 p.

Mimica-Dukic N, Bozin B, Sokovic M, Simin N 2004. Anti-microbial and antioxidant activities of *Melissa officinalis* L. (Lamiaceae) essential oil. Journal of Agricultural and Food Chemistry 52(9): 2485–2489.

Moreno S, Scheyer T, Romano CS, Vojnov AA 2006. Antioxidant and antimicrobial activities of rosemary extracts linked to their polyphenol composition. Free Radical Research 40(2): 223–231.

Morimitsu Y, Nakagawa Y, Hayashi K, Fujii H, Kumagai T, Nakamura Y, Osawa T, Horio F, Itoh K, Iida K, Yamamoto M, Uchida K 2002. A sulforaphane analogue that potently activates the Nrf2-dependent detoxification pathway. Journal of Biological Chemistry 277(5): 3456–3463.

Muhlbauer RC, Lozano A, Palacio S, Reinli A, Felix R 2003. Common herbs, essential oils, and monoterpenes potently modulate bone metabolism. Bone 32(4): 372–380.

Murkovic M, Steinberger D, Pfannhauser W 1998. Antioxidant spices reduce the formation of heterocyclic amines in fried meat. Zeitschrift Fur Lebensmittel-Untersuchung Und-Forschung a-Food Research and Technology 207(6): 477–480.

Nakamura Y, Miyamoto M, Murakami A, Ohigashi H, Osawa T, Uchida K 2003. A phase II detoxification enzyme inducer from lemongrass: identification of citral and involvement of electrophilic reaction in the enzyme induction. Biochemical and Biophysical Research Communications 302(3): 593–600.

NHMRC 2006. Nutrient Reference Values for Australia and New Zealand. www.nhmrc.gov.au/publications/_files/n35.pdf [accessed 6/10/2006 2006].

Online Encyclopedia Britannica 2007. Essential oils.

Paranagama PA, Abeysekera KHT, Abeywickrama K, Nugaliyadde L 2003. Fungicidal and anti-aflatoxigenic effects of the essential oil of *Cymbopogon citratus* (DC.) Stapf. (lemongrass) against *Aspergillus flavus* Link. isolated from stored rice. Letters in Applied Microbiology 37(1): 86–90.

Patel D, Shukla S, Gupta S 2007. Apigenin and cancer chemoprevention: Progress, potential and promise (Review). International Journal of Oncology 30(1): 233–245.

Pellegrini N, Serafini M, Salvatore S, Del Rio D, Bianchi M, Brighenti F 2006. Total antioxidant capacity of spices, dried fruits, nuts, pulses, cereals and sweets consumed in Italy assessed by three different in vitro assays. Molecular Nutrition & Food Research 50(11): 1030–1038.

Perry NSL, Bollen C, Perry EK, Ballard C 2003. Salvia for dementia therapy: review of pharmacological activity and pilot tolerability clinical trial. Pharmacology Biochemistry and Behavior 75(3): 651–659.

Perry NSL, Houghton PJ, Sampson J, Theobald AE, Hart S, Lis-Balchin M, Hoult JRS, Evans P, Jenner P, Milligan S, Perry EK 2001. In-vitro activity of S-lavandulaefolia (Spanish sage) relevant to treatment of Alzheimer's disease. Journal of Pharmacy and Pharmacology 53(10): 1347–1356.

Petersen M, Simmonds MSJ 2003. Rosmarinic acid. Phytochemistry 62(2): 121–125.

Politeo O, Jukic M, Milos M 2006. Chemical composition and antioxidant activity of essential oils of twelve spice plants. Croatica Chemica Acta 79(4): 545–552.

Puatanachokchai R, Kishida H, Denda A, Murata N, Konishi Y, Vinitketkumnuen U, Nakae D 2002. Inhibitory effects of lemon grass (*Cymbopogon citratus*, Stapf) extract on the early phase of hepatocarcinogenesis after initiation with diethylnitrosamine in male Fischer 344 rats. Cancer Letters 183(1): 9–15.

Rasooli I, Rezaei MB, Allameh A 2006. Ultrastructural studies on antimicrobial efficacy of thyme essential oils on Listeria monocytogenes. International Journal of Infectious Diseases 10(3): 236–241.

Ribeiro MA, Bernardo-Gil MG, Esquivel MM 2001. *Melissa officinalis*, L.: study of antioxidant activity in supercritical residues. Journal of Supercritical Fluids 21(1): 51–60.

Sacchetti G, Maietti S, Muzzoli M, Scaglianti M, Manfredini S, Radice M, Bruni R 2005. Comparative evaluation of 11 essential oils of different origin as functional antioxidants, antiradicals and antimicrobials in foods. Food Chemistry 91(4): 621–632.

Sanchez-Escalante A, Djenane D, Torrescano G, Beltran JA, Roncales P 2003a. Antioxidant action of borage, rosemary, oregano, and ascorbic acid in beef patties packaged in modified atmosphere. Journal of Food Science 68(1): 339–344.

Sanchez-Escalante A, Torrescano G, Djenane D, Beltran JA, Roncales P 2003b. Combined effect of modified atmosphere packaging and addition of lycopene rich tomato pulp, oregano and ascorbic acid and their mixtures on the stability of beef patties. Food Science and Technology International, 9(2): 77–84.

Seaberg AC, Labbe RG, Shetty K 2003. Inhibition of Listeria monocytogenes by elite clonal extracts of oregano (*Origanum vulgare*). Food Biotechnology 17(2): 129–149.

Shan B, Cai YZ, Sun M, Corke H 2005. Antioxidant Capacity of 26 Spice Extracts and Characterization of Their Phenolic Constituents. Journal of Agricultural and Food Chemistry 53(20): 7749–7759.

Sies H, Stahl W 2003. Non-nutritive bioactive constituents of plants: lycopene, lutein and zeaxanthin. International Journal of Nutrition Research, 73(2): 95–100.

Singletary K, MacDonald C, Wallig M 1996. Inhibition by rosemary and carnosol of 7,12 dimethylbenz[alpha]anthracene (DMBA)-induced rat mammary tumorigenesis and in vivo DMBA-DNA adduct formation. Cancer Letters 104(1): 43–48.

Skocibusic M, Bezic N 2004. Phytochemical analysis and in vitro antimicrobial activity of two Satureja species essential oils. Phytotherapy Research 18(12): 967–970.

Souri E, Amin G, Farsam H, Andaji S 2004. The antioxidant activity of some commonly used vegetables in Iranian diet. Fitoterapia 75(6): 585–588.

Staehelin HB 2005. Micronutrients and Alzheimer's disease. Proceedings of the Nutrition Society 64(4): 565–570.

Stajner D, Canadanovic-Brunet J, Pavlovic A 2004. *Allium schoenoprasum* (L.), as a natural antioxidant. Phytotherapy Research 18(7): 522–524.

Stavri M, Gibbons S 2005. The antimycobacterial constituents of dill (*Anethum graveolens*). Phytotherapy Research 19(11): 938–941.

Suaeyun R, Kinouchi T, Arimochi H, Vinitketkumnuen U, Ohnishi Y 1997. Inhibitory effects of lemon grass (*Cymbopogon citratus* Stapf) on formation of azoxymethane-induced DNA adducts and aberrant crypt foci in the rat colon. Carcinogenesis 18(5): 949–955.

Suhaj M 2006. Spice antioxidants isolation and their antiradical activity: a review. Journal of Food Composition and Analysis 19(6-7): 531–537.

Suppakul P, Miltz J, Sonneveld K, Bigger SW 2003. Antimicrobial Properties of Basil and Its Possible Application in Food Packaging. Journal of Agricultural and Food Chemistry 51(11): 3197–3207.

Swanston-Flatt SK, Flatt PR, Day C, Bailey CJ 1991. Traditional dietary adjuncts for the treatment of diabetes mellitus. Proceedings of the Nutrition Society 50: 641–651.

Tanida N, Kawaura A, Takahashi A, Sawada K, Shimoyama T 1991. Suppressive Effect Of Wasabi (Pungent Japanese Spice) On Gastric Carcinogenesis Induced By Mnng In Rats. Nutrition and Cancer-an International Journal 16(1): 53–58.

Triantaphyllou K, Blekas G, Boskou D 2001. Antioxidative properties of water extracts obtained from herbs of the species Lamiaceae. International Journal of Food Sciences and Nutrition 52(4): 313–317.

USDA 2005. National Nutrient Database for Standard Reference Release 18. In, Agricultural Research Service.

USDA 2006. National Nutrient Database for Standard Reference Release 19. In, Agricultural Research Service.

USDA 2007. USDA Database for the Flavonoid Content of Selected Foods. Release 2.1. In, Agricultural Research Service.

Vichi S, Zitterl-Eglseer K, M. J, Franz C 2001. Determination of the presence of antioxidants deriving from sage and oregano extracts added to animal fat by means of assessment of the radical scavenging capacity by photochemiluminescence analysis. Nahrung/Food, 45(2): 101–104.

Vitaglione P, Morisco F, Caporaso N, Fogliano V 2004. Dietary antioxidant compounds and liver health. Critical Reviews in Food Science and Nutrition 44(7-8): 575–586.

Viuda-Martos M, Ruiz-Navajas Y, Fernandez-Lopez J, Perez-Alvarez JA 2007. Antifungal activities of thyme, clove and oregano essential oils. Journal of Food Safety 27(1): 91–101.

Wangensteen H, Samuelsen AB, Malterud KE 2004. Antioxidant activity in extracts from coriander. Food Chemistry 88(2): 293–297.

Weil MJ, Zhang Y, Nair MG 2005. Tumor Cell Proliferation and Cyclooxygenase Inhibitory Constituents in Horseradish (*Armoracia rusticana*) and Wasabi (*Wasabia japonica*). Journal of Agricultural and Food Chemistry 53(5): 1440–1444.

Weil MJ, Zhang YJ, Nair MG 2004. Colon cancer proliferating desulfosinigrin in wasabi (*Wasabia japonica*). Nutrition and Cancer-an International Journal 48(2): 207–213.

Wijeratne SSK, Cuppett SL 2007. Potential of Rosemary (*Rosemarinus officinalis* L.) Diterpenes in Preventing Lipid Hydroperoxide-Mediated Oxidative Stress in Caco-2 Cells. Journal of Agricultural and Food Chemistry 55(4): 1193–1199.

Wu X, Beecher GR, Holden JM, Haytowitz DB, Gebhardt SE, Prior RL 2004. Lipophilic and hydrophilic antioxidant capacities of common foods in the United States. Journal of Agricultural and Food Chemistry 52(12): 4026–4037.

Yamaguchi M 2006. Regulatory mechanism of food factors in bone metabolism and prevention of osteoporosis. Yakugaku Zasshi-Journal of the Pharmaceutical Society of Japan 126(11): 1117–1137.

Yamamoto J, Yamada K, Naemura A, Yamashita T, Arai R 2005. Testing various herbs for antithrombotic effect. Nutrition 21(5): 580–587.

Yanishlieva NV, Marinova E, Pokorný J 2006. Natural antioxidants from herbs and spices. European Journal of Lipid Science and Technology 108(9): 776–793.

Yano T, Yajima S, Virgona N, Yano Y, Otani S, Kumagai H, Sakurai H, Kishimoto M, Ichikawa T 2000. The effect of 6-methylthiohexyl isothiocyanate isolated from *Wasabia japonica* (wasabi) on 4-(methylnitrosamino)-1-(3-pyridyl)-1-buatnone-induced lung tumorigenesis in mice. Cancer Letters 155(2): 115–120.

Yoshikawa M, Shimoda H, Uemura T, Morikawa T, Kawahara Y, Matsuda H 2000. Alcohol absorption inhibitors from bay leaf (*Laurus nobilis*): Structure-requirements of sesquiterpenes for the activity. Bioorganic & Medicinal Chemistry 8(8): 2071–2077.

Youdim KA, Deans SG 2000. Effect of thyme oil and thymol dietary supplementation on the antioxidant status and fatty acid composition of the ageing rat brain. British Journal of Nutrition 83(1): 87–93.

Yu TW, Xu MR, Dashwood RH 2004. Antimutagenic activity of spearmint. Environmental and Molecular Mutagenesis 44(5): 387–393.

Zhang H, Chen F, Wang X, Yao H-Y 2006. Evaluation of antioxidant activity of parsley (*Petroselinum crispum*) essential oil and identification of its antioxidant constituents. Food Research International 39(8): 833–839.

Zheng GQ, Kenney PM, Lam LKT 1992. Myristicin - a potential cancer chemopreventive agent from parsley leaf oil. Journal of Agricultural and Food Chemistry 40(1): 107–110.

Zheng W, Wang SY 2001. Antioxidant Activity and Phenolic Compounds in Selected Herbs. Journal of Agricultural and Food Chemistry 49(11): 5165–5170.

Appendix

Appendix I USDA Nutrient information

(http://www.ars.usda.gov/main/site_main.htm)

Basil, fresh

Refuse: 36% (Tough stems, flower heads and trimmings)
Scientific Name: *Ocimum basilicum*
NDB No: 02044 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 2 tbsp ------- 5.3g	1.00 X 5 leaves ------- 2.5g
Proximates						
Water	g	90.96	2		4.82	2.27
Energy	kcal	27	0		1	1
Energy	kj	113	0		6	3
Protein	g	2.54	2		0.13	0.06
Total lipid (fat)	g	0.61	2		0.03	0.02
Ash	g	1.55	2		0.08	0.04
Carbohydrate, by difference	g	4.34	0		0.23	0.11
Fiber, total dietary	g	3.9	0		0.2	0.1
Sugars, total	g	0.30	1		0.02	0.01
Minerals						
Calcium, Ca	mg	154	2		8	4
Iron, Fe	mg	3.17	0		0.17	0.08
Magnesium, Mg	mg	81	2		4	2
Phosphorus, P	mg	69	2		4	2
Potassium, K	mg	462	2		24	12
Sodium, Na	mg	4	2		0	0
Zinc, Zn	mg	0.85	2		0.05	0.02

Copper, Cu	mg	0.290	2		0.015	0.007
Manganese, Mn	mg	1.446	2		0.077	0.036
Selenium, Se	mcg	0.3	0		0.0	0.0
Vitamins						
Vitamin C, total ascorbic acid	mg	18.0	0		1.0	0.5
Thiamin	mg	0.026	2		0.001	0.001
Riboflavin	mg	0.073	2		0.004	0.002
Niacin	mg	0.925	2		0.049	0.023
Pantothenic acid	mg	0.238	2		0.013	0.006
Vitamin B-6	mg	0.129	2		0.007	0.003
Folate, total	mcg	64	2		3	2
Folic acid	mcg	0	0		0	0
Folate, food	mcg	64	2		3	2
Folate, DFE	mcg_DFE	64	0		3	2
Vitamin B-12	mcg	0.00	0		0.00	0.00
Vitamin A, IU	IU	5275	0		280	132
Vitamin A, RAE	mcg_RAE	264	0		14	7
Retinol	mcg	0	0		0	0
Vitamin K (phylloquinone)	mcg	414.8	1		22.0	10.4
Lipids						
Fatty acids, total saturated	g	0.041	0		0.002	0.001
4:0	g	0.000	0		0.000	0.000
6:0	g	0.000	0		0.000	0.000
8:0	g	0.000	0		0.000	0.000
10:0	g	0.000	0		0.000	0.000
12:0	g	0.000	0		0.000	0.000
14:0	g	0.000	0		0.000	0.000
16:0	g	0.036	1		0.002	0.001
18:0	g	0.005	1		0.000	0.000
Fatty acids, total monounsaturated	g	0.088	0		0.005	0.002
16:1 undifferentiated	g	0.000	0		0.000	0.000
18:1	g	0.088	1		0.005	0.002

undifferentiated						
20:1	g	0.000	0		0.000	0.000
22:1 undifferentiated	g	0.000	0		0.000	0.000
Fatty acids, total polyunsaturated	g	0.389	0		0.021	0.010
18:2 undifferentiated	g	0.073	1		0.004	0.002
18:3 undifferentiated	g	0.316	1		0.017	0.008
18:4	g	0.000	0		0.000	0.000
20:4 undifferentiated	g	0.000	0		0.000	0.000
20:5 n-3	g	0.000	0		0.000	0.000
22:5 n-3	g	0.000	0		0.000	0.000
22:6 n-3	g	0.000	0		0.000	0.000
Cholesterol	mg	0	0		0	0
Amino acids						
Tryptophan	g	0.039	0		0.002	0.001
Threonine	g	0.104	0		0.006	0.003
Isoleucine	g	0.104	0		0.006	0.003
Leucine	g	0.191	0		0.010	0.005
Lysine	g	0.110	0		0.006	0.003
Methionine	g	0.036	0		0.002	0.001
Cystine	g	0.028	0		0.001	0.001
Phenylalanine	g	0.130	0		0.007	0.003
Tyrosine	g	0.077	0		0.004	0.002
Valine	g	0.127	0		0.007	0.003
Arginine	g	0.117	0		0.006	0.003
Histidine	g	0.051	0		0.003	0.001
Alanine	g	0.132	0		0.007	0.003
Aspartic acid	g	0.301	0		0.016	0.008
Glutamic acid	g	0.277	0		0.015	0.007
Glycine	g	0.122	0		0.006	0.003
Proline	g	0.104	0		0.006	0.003
Serine	g	0.099	0		0.005	0.002
Other						

Alcohol, ethyl	g	0.0	0		0.0	0.0
Carotene, beta	mcg	3142	10	1361.178	167	79
Carotene, alpha	mcg	0	6	0	0	0
Cryptoxanthin, beta	mcg	46	7	43.25	2	1
Lycopene	mcg	0	6	0	0	0
Lutein + zeaxanthin	mcg	5650	7	1400	299	141

USDA National Nutrient Database for Standard Reference, Release 19 (2006)

Bay leaf

Refuse: 0%
Scientific Name: *Laurus nobilis*
NDB No: 02004 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 tbsp, crumbled ------- 1.8g	1.00 X 1 tsp, crumbled ------- 0.6g
Proximates						
Water	g	5.44	23	0.254	0.10	0.03
Energy	kcal	313	0		6	2
Energy	kj	1312	0		24	8
Protein	g	7.61	6	0.426	0.14	0.05
Total lipid (fat)	g	8.36	6	0.262	0.15	0.05
Ash	g	3.62	24	0.089	0.07	0.02
Carbohydrate, by difference	g	74.97	0		1.35	0.45
Fiber, total dietary	g	26.3	0		0.5	0.2
Minerals						
Calcium, Ca	mg	834	4	168.952	15	5
Iron, Fe	mg	43.00	4	17.353	0.77	0.26
Magnesium, Mg	mg	120	3	20.817	2	1
Phosphorus, P	mg	113	3	8.819	2	1

Potassium, K	mg	529	5	60.093	10	3
Sodium, Na	mg	23	4	1.548	0	0
Zinc, Zn	mg	3.70	3	0.625	0.07	0.02
Copper, Cu	mg	0.416	0		0.007	0.002
Manganese, Mn	mg	8.167	0		0.147	0.049
Selenium, Se	mcg	2.8	0		0.1	0.0
Vitamins						
Vitamin C, total ascorbic acid	mg	46.5	1		0.8	0.3
Thiamin	mg	0.009	1		0.000	0.000
Riboflavin	mg	0.421	1		0.008	0.003
Niacin	mg	2.005	1		0.036	0.012
Vitamin B-6	mg	1.740	2		0.031	0.010
Folate, total	mcg	180	0		3	1
Folic acid	mcg	0	0		0	0
Folate, food	mcg	180	0		3	1
Folate, DFE	mcg_DFE	180	0		3	1
Vitamin B-12	mcg	0.00	0		0.00	0.00
Vitamin A, IU	IU	6185	1		111	37
Vitamin A, RAE	mcg_RAE	309	1		6	2
Retinol	mcg	0	0		0	0
Lipids						
Fatty acids, total saturated	g	2.280	0		0.041	0.014
4:0	g	0.000	0		0.000	0.000
6:0	g	0.000	0		0.000	0.000
8:0	g	0.010	1		0.000	0.000
10:0	g	0.010	1		0.000	0.000
12:0	g	0.530	1		0.010	0.003
14:0	g	0.210	1		0.004	0.001
16:0	g	1.270	1		0.023	0.008
18:0	g	0.160	0		0.003	0.001
Fatty acids, total monounsaturated	g	1.640	0		0.030	0.010
16:1 undifferentiated	g	0.140	1		0.003	0.001
18:1	g	1.500	1		0.027	0.009

undifferentiated						
20:1	g	0.000	0		0.000	0.000
22:1 undifferentiated	g	0.000	0		0.000	0.000
Fatty acids, total polyunsaturated	g	2.290	0		0.041	0.014
18:2 undifferentiated	g	1.240	1		0.022	0.007
18:3 undifferentiated	g	1.050	1		0.019	0.006
18:4	g	0.000	0		0.000	0.000
20:4 undifferentiated	g	0.000	0		0.000	0.000
20:5 n-3	g	0.000	0		0.000	0.000
22:5 n-3	g	0.000	0		0.000	0.000
22:6 n-3	g	0.000	0		0.000	0.000
Cholesterol	mg	0	0		0	0
Other						
Alcohol, ethyl	g	0.0	0		0.0	0.0

USDA National Nutrient Database for Standard Reference, Release 19 (2006)

Borage, raw

Refuse: 20% (Tough leaves and stems)
Scientific Name: *Borago officinalis*
NDB No: 11613 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 cup (1" pieces) ------- 89g
Proximates					
Water	g	93.00	1		82.77
Energy	kcal	21	0		19
Energy	kj	88	0		78
Protein	g	1.80	1		1.60
Total lipid (fat)	g	0.70	1		0.62

Ash	g	1.44	0		1.28
Carbohydrate, by difference	g	3.06	0		2.72
Minerals					
Calcium, Ca	mg	93	1		83
Iron, Fe	mg	3.30	1		2.94
Magnesium, Mg	mg	52	1		46
Phosphorus, P	mg	53	1		47
Potassium, K	mg	470	1		418
Sodium, Na	mg	80	1		71
Zinc, Zn	mg	0.20	0		0.18
Copper, Cu	mg	0.130	0		0.116
Manganese, Mn	mg	0.349	0		0.311
Selenium, Se	mcg	0.9	0		0.8
Vitamins					
Vitamin C, total ascorbic acid	mg	35.0	1		31.1
Thiamin	mg	0.060	1		0.053
Riboflavin	mg	0.150	1		0.134
Niacin	mg	0.900	1		0.801
Pantothenic acid	mg	0.041	0		0.036
Vitamin B-6	mg	0.084	0		0.075
Folate, total	mcg	13	0		12
Folic acid	mcg	0	0		0
Folate, food	mcg	13	0		12
Folate, DFE	mcg_DFE	13	0		12
Vitamin B-12	mcg	0.00	0		0.00
Vitamin A, IU	IU	4200	1		3738
Vitamin A, RAE	mcg_RAE	210	1		187
Retinol	mcg	0	0		0
Lipids					
Fatty acids, total saturated	g	0.170	0		0.151
16:0	g	0.060	0		0.053
18:0	g	0.021	0		0.019
Fatty acids, total monounsaturated	g	0.211	0		0.188

16:1 undifferentiated	g	0.191	0		0.170
22:1 undifferentiated	g	0.020	0		0.018
Fatty acids, total polyunsaturated	g	0.109	0		0.097
18:2 undifferentiated	g	0.109	0		0.097
Cholesterol	mg	0	0		0

USDA National Nutrient Database for Standard Reference, Release 19 (2006)

Chervil, dried

Refuse: 0%
Scientific Name: *Anthriscus cerefolium*
NDB No: 02008 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 tbsp ------- 1.9g	1.00 X 1 tsp ------- 0.6g
Proximates						
Water	g	7.20	1		0.14	0.04
Energy	kcal	237	0		5	1
Energy	kj	990	0		19	6
Protein	g	23.20	1		0.44	0.14
Total lipid (fat)	g	3.90	1		0.07	0.02
Ash	g	16.60	2		0.32	0.10
Carbohydrate, by difference	g	49.10	0		0.93	0.29
Fiber, total dietary	g	11.3	0		0.2	0.1
Minerals						
Calcium, Ca	mg	1346	2		26	8
Iron, Fe	mg	31.95	2		0.61	0.19
Magnesium, Mg	mg	130	1		2	1

Phosphorus, P	mg	450	1		9	3
Potassium, K	mg	4740	2		90	28
Sodium, Na	mg	83	2		2	0
Zinc, Zn	mg	8.80	1		0.17	0.05
Copper, Cu	mg	0.440	0		0.008	0.003
Manganese, Mn	mg	2.100	0		0.040	0.013
Selenium, Se	mcg	29.3	0		0.6	0.2
Vitamins						
Vitamin C, total ascorbic acid	mg	50.0	0		0.9	0.3
Thiamin	mg	0.380	0		0.007	0.002
Riboflavin	mg	0.680	0		0.013	0.004
Niacin	mg	5.400	0		0.103	0.032
Vitamin B-6	mg	0.930	2		0.018	0.006
Folate, total	mcg	274	0		5	2
Folic acid	mcg	0	0		0	0
Folate, food	mcg	274	0		5	2
Folate, DFE	mcg_DFE	274	0		5	2
Vitamin B-12	mcg	0.00	0		0.00	0.00
Vitamin A, IU	IU	5850	0		111	35
Vitamin A, RAE	mcg_RAE	293	0		6	2
Retinol	mcg	0	0		0	0
Lipids						
Fatty acids, total saturated	g	0.169	0		0.003	0.001
4:0	g	0.000	0		0.000	0.000
6:0	g	0.000	0		0.000	0.000
8:0	g	0.000	0		0.000	0.000
10:0	g	0.000	0		0.000	0.000
12:0	g	0.000	0		0.000	0.000
14:0	g	0.000	0		0.000	0.000
16:0	g	0.169	0		0.003	0.001
18:0	g	0.000	0		0.000	0.000
Fatty acids, total monounsaturated	g	1.399	0		0.027	0.008
16:1 undifferentiated	g	0.000	0		0.000	0.000

18:1 undifferentiated	g	1.399	0		0.027	0.008
20:1	g	0.000	0		0.000	0.000
22:1 undifferentiated	g	0.000	0		0.000	0.000
Fatty acids, total polyunsaturated	g	1.800	0		0.034	0.011
18:2 undifferentiated	g	1.800	0		0.034	0.011
18:3 undifferentiated	g	0.000	0		0.000	0.000
18:4	g	0.000	0		0.000	0.000
20:4 undifferentiated	g	0.000	0		0.000	0.000
20:5 n-3	g	0.000	0		0.000	0.000
22:5 n-3	g	0.000	0		0.000	0.000
22:6 n-3	g	0.000	0		0.000	0.000
Cholesterol	mg	0	0		0	0
Other						
Alcohol, ethyl	g	0.0	0		0.0	0.0
Caffeine	mg	0	0		0	0
Theobromine	mg	0	0		0	0

USDA National Nutrient Database for Standard Reference, Release 19 (2006)

Chives, raw

Refuse: 0%
Scientific Name: *Allium schoenoprasum*
NDB No: 11156 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 tbsp chopped ------- 3g	1.00 X 1 tsp chopped ------- 1g
Proximates						
Water	g	90.65	3	1.042	2.72	0.91
Energy	kcal	30	0		1	0
Energy	kj	124	0		4	1
Protein	g	3.27	3	0.488	0.10	0.03
Total lipid (fat)	g	0.73	3	0.107	0.02	0.01
Ash	g	1.00	2		0.03	0.01
Carbohydrate, by difference	g	4.35	0		0.13	0.04
Fiber, total dietary	g	2.5	0		0.1	0.0
Sugars, total	g	1.85	0		0.06	0.02
Minerals						
Calcium, Ca	mg	92	3	22.146	3	1
Iron, Fe	mg	1.60	1		0.05	0.02
Magnesium, Mg	mg	42	3	6.592	1	0
Phosphorus, P	mg	58	3	4.359	2	1
Potassium, K	mg	296	3	32.682	9	3
Sodium, Na	mg	3	3	1.453	0	0
Zinc, Zn	mg	0.56	2		0.02	0.01
Copper, Cu	mg	0.157	2		0.005	0.002
Manganese, Mn	mg	0.373	2		0.011	0.004
Selenium, Se	mcg	0.9	0		0.0	0.0
Vitamins						
Vitamin C, total	mg	58.1	3	14.155	1.7	0.6

ascorbic acid						
Thiamin	mg	0.078	3	0.029	0.002	0.001
Riboflavin	mg	0.115	3	0.033	0.003	0.001
Niacin	mg	0.647	3	0.091	0.019	0.006
Pantothenic acid	mg	0.324	2		0.010	0.003
Vitamin B-6	mg	0.138	2		0.004	0.001
Folate, total	mcg	105	2		3	1
Folic acid	mcg	0	0		0	0
Folate, food	mcg	105	2		3	1
Folate, DFE	mcg_DFE	105	0		3	1
Vitamin B-12	mcg	0.00	0		0.00	0.00
Vitamin B-12, added	mcg	0.00	0		0.00	0.00
Vitamin A, IU	IU	4353	0		131	44
Vitamin A, RAE	mcg_RAE	218	0		7	2
Retinol	mcg	0	0		0	0
Vitamin E (alpha-tocopherol)	mg	0.21	0		0.01	0.00
Vitamin E, added	mg	0.00	0		0.00	0.00
Vitamin K (phylloquinone)	mcg	212.7	0		6.4	2.1
Lipids						
Fatty acids, total saturated	g	0.146	0		0.004	0.001
4:0	g	0.000	0		0.000	0.000
6:0	g	0.000	0		0.000	0.000
8:0	g	0.000	0		0.000	0.000
10:0	g	0.000	0		0.000	0.000
12:0	g	0.000	0		0.000	0.000
14:0	g	0.034	1		0.001	0.000
16:0	g	0.103	1		0.003	0.001
18:0	g	0.009	1		0.000	0.000
Fatty acids, total monounsaturated	g	0.095	0		0.003	0.001
16:1 undifferentiated	g	0.000	0		0.000	0.000

18:1 undifferentiated	g	0.095	1		0.003	0.001
20:1	g	0.000	0		0.000	0.000
22:1 undifferentiated	g	0.000	0		0.000	0.000
Fatty acids, total polyunsaturated	g	0.267	0		0.008	0.003
18:2 undifferentiated	g	0.252	1		0.008	0.003
18:3 undifferentiated	g	0.015	1		0.000	0.000
18:4	g	0.000	0		0.000	0.000
20:4 undifferentiated	g	0.000	0		0.000	0.000
20:5 n-3	g	0.000	0		0.000	0.000
22:5 n-3	g	0.000	0		0.000	0.000
22:6 n-3	g	0.000	0		0.000	0.000
Cholesterol	mg	0	0		0	0
Phytosterols	mg	9	1		0	0
Amino acids						
Tryptophan	g	0.037	0		0.001	0.000
Threonine	g	0.128	0		0.004	0.001
Isoleucine	g	0.139	0		0.004	0.001
Leucine	g	0.195	0		0.006	0.002
Lysine	g	0.163	0		0.005	0.002
Methionine	g	0.036	0		0.001	0.000
Phenylalanine	g	0.105	0		0.003	0.001
Tyrosine	g	0.095	0		0.003	0.001
Valine	g	0.145	0		0.004	0.001
Arginine	g	0.237	0		0.007	0.002
Histidine	g	0.057	0		0.002	0.001
Alanine	g	0.148	0		0.004	0.001
Aspartic acid	g	0.303	0		0.009	0.003
Glutamic acid	g	0.677	0		0.020	0.007
Glycine	g	0.162	0		0.005	0.002
Proline	g	0.216	0		0.006	0.002
Serine	g	0.148	0		0.004	0.001

Other						
Alcohol, ethyl	g	0.0	0		0.0	0.0
Caffeine	mg	0	0		0	0
Theobromine	mg	0	0		0	0
Carotene, beta	mcg	2612	0		78	26
Carotene, alpha	mcg	0	0		0	0
Cryptoxanthin, beta	mcg	0	0		0	0
Lycopene	mcg	0	0		0	0
Lutein + zeaxanthin	mcg	323	0		10	3

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Coriander (cilantro) leaves, raw

Refuse: 15% (Roots, old and bruised leaves)
Scientific Name: *Coriandrum sativum*
NDB No: 11165 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 0.25 cup ------- 4g	1.00 X 9 sprigs ------- 20g
Proximates						
Water	g	92.21	7	0.27	3.69	18.44
Energy	kcal	23	0		1	5
Energy	kj	95	0		4	19
Protein	g	2.13	3	0.224	0.09	0.43
Total lipid (fat)	g	0.52	3	0.047	0.02	0.10
Ash	g	1.47	3	0.186	0.06	0.29
Carbohydrate, by difference	g	3.67	0		0.15	0.73
Fiber, total	g	2.8	2		0.1	0.6

dietary						
Sugars, total	g	0.87	0		0.03	0.17
Minerals						
Calcium, Ca	mg	67	2		3	13
Iron, Fe	mg	1.77	3	0.641	0.07	0.35
Magnesium, Mg	mg	26	3	4.735	1	5
Phosphorus, P	mg	48	3	7.143	2	10
Potassium, K	mg	521	3	43.979	21	104
Sodium, Na	mg	46	3	10.403	2	9
Zinc, Zn	mg	0.50	2		0.02	0.10
Copper, Cu	mg	0.225	2		0.009	0.045
Manganese, Mn	mg	0.426	2		0.017	0.085
Selenium, Se	mcg	0.9	0		0.0	0.2
Vitamins						
Vitamin C, total ascorbic acid	mg	27.0	3	12.941	1.1	5.4
Thiamin	mg	0.067	3	0.023	0.003	0.013
Riboflavin	mg	0.162	3	0.033	0.006	0.032
Niacin	mg	1.114	3	0.195	0.045	0.223
Pantothenic acid	mg	0.570	2		0.023	0.114
Vitamin B-6	mg	0.149	3	0.019	0.006	0.030
Folate, total	mcg	62	2		2	12
Folic acid	mcg	0	0		0	0
Folate, food	mcg	62	2		2	12
Folate, DFE	mcg_DFE	62	0		2	12
Vitamin B-12	mcg	0.00	0		0.00	0.00
Vitamin B-12, added	mcg	0.00	0		0.00	0.00
Vitamin A, IU	IU	6748	0		270	1350
Vitamin A, RAE	mcg_RAE	337	0		13	67
Retinol	mcg	0	0		0	0
Vitamin E (alpha-tocopherol)	mg	2.50	0		0.10	0.50
Vitamin E, added	mg	0.00	0		0.00	0.00
Vitamin K	mcg	310.0	0		12.4	62.0

(phylloquinone)						
Lipids						
Fatty acids, total saturated	g	0.014	0		0.001	0.003
4:0	g	0.000	0		0.000	0.000
6:0	g	0.000	0		0.000	0.000
8:0	g	0.000	0		0.000	0.000
10:0	g	0.000	0		0.000	0.000
12:0	g	0.000	0		0.000	0.000
14:0	g	0.000	0		0.000	0.000
16:0	g	0.012	0		0.000	0.002
18:0	g	0.001	0		0.000	0.000
Fatty acids, total monounsaturated	g	0.275	0		0.011	0.055
16:1 undifferentiated	g	0.002	0		0.000	0.000
18:1 undifferentiated	g	0.273	0		0.011	0.055
20:1	g	0.000	0		0.000	0.000
22:1 undifferentiated	g	0.000	0		0.000	0.000
Fatty acids, total polyunsaturated	g	0.040	0		0.002	0.008
18:2 undifferentiated	g	0.040	0		0.002	0.008
18:3 undifferentiated	g	0.000	0		0.000	0.000
18:4	g	0.000	0		0.000	0.000
20:4 undifferentiated	g	0.000	0		0.000	0.000
20:5 n-3	g	0.000	0		0.000	0.000
22:5 n-3	g	0.000	0		0.000	0.000
22:6 n-3	g	0.000	0		0.000	0.000
Cholesterol	mg	0	0		0	0
Phytosterols	mg	5	1		0	1
Stigmasterol	mg	3	1		0	1
Campesterol	mg	0	1		0	0
Beta-sitosterol	mg	2	1		0	0

Other						
Alcohol, ethyl	g	0.0	0		0.0	0.0
Caffeine	mg	0	0		0	0
Theobromine	mg	0	0		0	0
Carotene, beta	mcg	3930	15	365.713	157	786
Carotene, alpha	mcg	36	3	27.27	1	7
Cryptoxanthin, beta	mcg	202	3	44.373	8	40
Lycopene	mcg	0	1		0	0
Lutein + zeaxanthin	mcg	865	6		35	173

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Dill weed, fresh

Refuse: 41% (Tough stems and trimmings)
Scientific Name: *Anethum graveolens*
NDB No: 02045 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 cup sprigs ------- 8.9g	1.00 X 5 sprigs ------- 1g
Proximates						
Water	g	85.95	2		7.65	0.86
Energy	kcal	43	0		4	0
Energy	kj	180	0		16	2
Protein	g	3.46	2		0.31	0.03
Total lipid (fat)	g	1.12	2		0.10	0.01
Ash	g	2.45	2		0.22	0.02
Carbohydrate, by difference	g	7.02	0		0.62	0.07
Fiber, total dietary	g	2.1	0		0.2	0.0

Minerals						
Calcium, Ca	mg	208	2		19	2
Iron, Fe	mg	6.59	0		0.59	0.07
Magnesium, Mg	mg	55	2		5	1
Phosphorus, P	mg	66	2		6	1
Potassium, K	mg	738	2		66	7
Sodium, Na	mg	61	2		5	1
Zinc, Zn	mg	0.91	2		0.08	0.01
Copper, Cu	mg	0.146	2		0.013	0.001
Manganese, Mn	mg	1.264	2		0.112	0.013
Vitamins						
Vitamin C, total ascorbic acid	mg	85.0	0		7.6	0.8
Thiamin	mg	0.058	2		0.005	0.001
Riboflavin	mg	0.296	2		0.026	0.003
Niacin	mg	1.570	2		0.140	0.016
Pantothenic acid	mg	0.397	2		0.035	0.004
Vitamin B-6	mg	0.185	2		0.016	0.002
Folate, total	mcg	150	2		13	2
Folic acid	mcg	0	0		0	0
Folate, food	mcg	150	2		13	2
Folate, DFE	mcg_DFE	150	0		13	2
Vitamin B-12	mcg	0.00	0		0.00	0.00
Vitamin A, IU	IU	7718	0		687	77
Vitamin A, RAE	mcg_RAE	386	0		34	4
Retinol	mcg	0	0		0	0
Lipids						
Fatty acids, total saturated	g	0.060	0		0.005	0.001
12:0	g	0.001	1		0.000	0.000
14:0	g	0.001	1		0.000	0.000
16:0	g	0.049	1		0.004	0.000
18:0	g	0.009	1		0.001	0.000
Fatty acids, total monounsaturated	g	0.802	0		0.071	0.008
16:1 undifferentiated	g	0.004	1		0.000	0.000

18:1 undifferentiated	g	0.798	1		0.071	0.008
Fatty acids, total polyunsaturated	g	0.095	0		0.008	0.001
18:2 undifferentiated	g	0.082	1		0.007	0.001
18:3 undifferentiated	g	0.013	1		0.001	0.000
Cholesterol	mg	0	0		0	0
Amino acids						
Tryptophan	g	0.014	0		0.001	0.000
Threonine	g	0.068	0		0.006	0.001
Isoleucine	g	0.195	0		0.017	0.002
Leucine	g	0.159	0		0.014	0.002
Lysine	g	0.246	0		0.022	0.002
Methionine	g	0.011	0		0.001	0.000
Cystine	g	0.017	0		0.002	0.000
Phenylalanine	g	0.065	0		0.006	0.001
Tyrosine	g	0.096	0		0.009	0.001
Valine	g	0.154	0		0.014	0.002
Arginine	g	0.142	0		0.013	0.001
Histidine	g	0.071	0		0.006	0.001
Alanine	g	0.227	0		0.020	0.002
Aspartic acid	g	0.343	0		0.031	0.003
Glutamic acid	g	0.290	0		0.026	0.003
Glycine	g	0.169	0		0.015	0.002
Proline	g	0.248	0		0.022	0.002
Serine	g	0.158	0		0.014	0.002

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Marjoram, dried

Refuse: 0%
Scientific Name: *Origanum majorana*
NDB No: 02023 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 tbsp ------- 1.7g	1.00 X 1 tsp ------- 0.6g
Proximates						
Water	g	7.64	28	0.148	0.13	0.05
Energy	kcal	271	0		5	2
Energy	kj	1136	0		19	7
Protein	g	12.66	5	0.515	0.22	0.08
Total lipid (fat)	g	7.04	5	0.176	0.12	0.04
Ash	g	12.10	203	0.229	0.21	0.07
Carbohydrate, by difference	g	60.56	0		1.03	0.36
Fiber, total dietary	g	40.3	0		0.7	0.2
Sugars, total	g	4.09	0		0.07	0.02
Minerals						
Calcium, Ca	mg	1990	10	197.69	34	12
Iron, Fe	mg	82.71	8	7.638	1.41	0.50
Magnesium, Mg	mg	346	8	15.717	6	2
Phosphorus, P	mg	306	7	39.093	5	2
Potassium, K	mg	1522	12	72.982	26	9
Sodium, Na	mg	77	15	9.4	1	0
Zinc, Zn	mg	3.60	5	0.378	0.06	0.02
Copper, Cu	mg	1.133	0		0.019	0.007
Manganese, Mn	mg	5.433	0		0.092	0.033
Selenium, Se	mcg	4.5	0		0.1	0.0
Vitamins						
Vitamin C, total ascorbic acid	mg	51.4	1		0.9	0.3
Thiamin	mg	0.289	1		0.005	0.002
Riboflavin	mg	0.316	1		0.005	0.002

Niacin	mg	4.120	1		0.070	0.025
Vitamin B-6	mg	1.190	2		0.020	0.007
Folate, total	mcg	274	0		5	2
Folic acid	mcg	0	0		0	0
Folate, food	mcg	274	0		5	2
Folate, DFE	mcg_DFE	274	0		5	2
Vitamin B-12	mcg	0.00	0		0.00	0.00
Vitamin B-12, added	mcg	0.00	0		0.00	0.00
Vitamin A, IU	IU	8068	1		137	48
Vitamin A, RAE	mcg_RAE	403	1		7	2
Retinol	mcg	0	0		0	0
Vitamin E (alpha-tocopherol)	mg	1.69	0		0.03	0.01
Vitamin E, added	mg	0.00	0		0.00	0.00
Vitamin K (phylloquinone)	mcg	621.7	0		10.6	3.7
Lipids						
Fatty acids, total saturated	g	0.529	0		0.009	0.003
4:0	g	0.000	0		0.000	0.000
6:0	g	0.000	0		0.000	0.000
8:0	g	0.000	0		0.000	0.000
10:0	g	0.000	0		0.000	0.000
12:0	g	0.000	0		0.000	0.000
14:0	g	0.000	0		0.000	0.000
16:0	g	0.294	0		0.005	0.002
18:0	g	0.235	0		0.004	0.001
Fatty acids, total monounsaturated	g	0.940	0		0.016	0.006
16:1 undifferentiated	g	0.000	0		0.000	0.000
18:1 undifferentiated	g	0.940	0		0.016	0.006
20:1	g	0.000	0		0.000	0.000
22:1	g	0.000	0		0.000	0.000

undifferentiated						
Fatty acids, total polyunsaturated	g	4.405	0		0.075	0.026
18:2 undifferentiated	g	1.175	0		0.020	0.007
18:3 undifferentiated	g	3.230	0		0.055	0.019
18:4	g	0.000	0		0.000	0.000
20:4 undifferentiated	g	0.000	0		0.000	0.000
20:5 n-3	g	0.000	0		0.000	0.000
22:5 n-3	g	0.000	0		0.000	0.000
22:6 n-3	g	0.000	0		0.000	0.000
Cholesterol	mg	0	0		0	0
Phytosterols	mg	60	0		1	0
Other						
Alcohol, ethyl	g	0.0	0		0.0	0.0
Caffeine	mg	0	0		0	0
Theobromine	mg	0	0		0	0
Carotene, beta	mcg	4806	0		82	29
Carotene, alpha	mcg	0	0		0	0
Cryptoxanthin, beta	mcg	70	0		1	0
Lycopene	mcg	0	0		0	0
Lutein + zeaxanthin	mcg	862	0		15	5

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Oregano, dried

Refuse: 0%
Scientific Name: *Origanum vulgare*
NDB No: 02027 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 tsp, leaves ------- 1g	1.00 X 1 tsp, ground ------- 1.8g
Proximates						
Water	g	7.16	22	0.322	0.07	0.13
Energy	kcal	306	0		3	6
Energy	kj	1280	0		13	23
Protein	g	11.00	3	1.313	0.11	0.20
Total lipid (fat)	g	10.25	6	1.356	0.10	0.18
Ash	g	7.15	20	0.252	0.07	0.13
Carbohydrate, by difference	g	64.43	0		0.64	1.16
Fiber, total dietary	g	42.8	0		0.4	0.8
Sugars, total	g	4.09	1		0.04	0.07
Sucrose	g	0.91	1		0.01	0.02
Glucose (dextrose)	g	1.90	1		0.02	0.03
Fructose	g	1.13	1		0.01	0.02
Lactose	g	0.00	1		0.00	0.00
Maltose	g	0.00	1		0.00	0.00
Galactose	g	0.15	1		0.00	0.00
Minerals						
Calcium, Ca	mg	1576	4	169.009	16	28
Iron, Fe	mg	44.00	3	11.533	0.44	0.79
Magnesium, Mg	mg	270	3	10	3	5
Phosphorus, P	mg	200	3	23.094	2	4
Potassium, K	mg	1669	4	62.397	17	30
Sodium, Na	mg	15	6	4.142	0	0
Zinc, Zn	mg	4.43	3	0.498	0.04	0.08

Copper, Cu	mg	0.943	0		0.009	0.017
Manganese, Mn	mg	4.667	0		0.047	0.084
Selenium, Se	mcg	5.9	2		0.1	0.1
Vitamins						
Vitamin C, total ascorbic acid	mg	50.0	0		0.5	0.9
Thiamin	mg	0.341	1		0.003	0.006
Riboflavin	mg	0.320	0		0.003	0.006
Niacin	mg	6.220	1		0.062	0.112
Vitamin B-6	mg	1.210	0		0.012	0.022
Folate, total	mcg	274	0		3	5
Folic acid	mcg	0	0		0	0
Folate, food	mcg	274	0		3	5
Folate, DFE	mcg_DFE	274	0		3	5
Choline, total	mg	32.3	0		0.3	0.6
Betaine	mg	9.8	1		0.1	0.2
Vitamin B-12	mcg	0.00	0		0.00	0.00
Vitamin B-12, added	mcg	0.00	0		0.00	0.00
Vitamin A, IU	IU	6903	1		69	124
Vitamin A, RAE	mcg_RAE	345	0		3	6
Retinol	mcg	0	0		0	0
Vitamin E (alpha-tocopherol)	mg	18.86	1		0.19	0.34
Vitamin E, added	mg	0.00	0		0.00	0.00
Tocopherol, beta	mg	10.88	1		0.11	0.20
Tocopherol, gamma	mg	19.84	1		0.20	0.36
Tocopherol, delta	mg	4.03	1		0.04	0.07
Vitamin K (phylloquinone)	mcg	621.7	1		6.2	11.2
Lipids						
Fatty acids, total saturated	g	2.660	0		0.027	0.048
4:0	g	0.000	0		0.000	0.000

6:0	g	0.000	0		0.000	0.000
8:0	g	0.000	0		0.000	0.000
10:0	g	0.040	1		0.000	0.001
12:0	g	0.020	1		0.000	0.000
14:0	g	0.170	1		0.002	0.003
16:0	g	1.700	1		0.017	0.031
18:0	g	0.580	1		0.006	0.010
Fatty acids, total monounsaturated	g	0.670	0		0.007	0.012
16:1 undifferentiated	g	0.160	1		0.002	0.003
18:1 undifferentiated	g	0.510	1		0.005	0.009
20:1	g	0.000	0		0.000	0.000
22:1 undifferentiated	g	0.000	0		0.000	0.000
Fatty acids, total polyunsaturated	g	5.230	0		0.052	0.094
18:2 undifferentiated	g	1.050	1		0.011	0.019
18:3 undifferentiated	g	4.180	1		0.042	0.075
18:4	g	0.000	0		0.000	0.000
20:4 undifferentiated	g	0.000	0		0.000	0.000
20:5 n-3	g	0.000	0		0.000	0.000
22:5 n-3	g	0.000	0		0.000	0.000
22:6 n-3	g	0.000	0		0.000	0.000
Cholesterol	mg	0	0		0	0
Phytosterols	mg	203	0		2	4
Other						
Alcohol, ethyl	g	0.0	0		0.0	0.0
Caffeine	mg	0	0		0	0
Theobromine	mg	0	0		0	0
Carotene, beta	mcg	4112	0		41	74
Carotene, alpha	mcg	0	0		0	0
Cryptoxanthin, beta	mcg	60	0		1	1

Lycopene	mcg	0	1		0	0
Lutein + zeaxanthin	mcg	862	1		9	16

USDA National Nutrient Database for Standard Reference, Release 19 (2006)

Parsley, raw

Scientific Name: *Petroselinum crispum*
NDB No: 11297 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 cup ------- 60g	1.00 X 1 tbsp ------- 3.8g	1.00 X 10 sprigs ------- 10g
Proximates							
Water	g	87.71	11	0.668	52.63	3.33	8.77
Energy	kcal	36	0		22	1	4
Energy	kj	153	0		92	6	15
Protein	g	2.97	3	0.426	1.78	0.11	0.30
Total lipid (fat)	g	0.79	3	0.267	0.47	0.03	0.08
Ash	g	2.20	2		1.32	0.08	0.22
Carbohydrate, by difference	g	6.33	0		3.80	0.24	0.63
Fiber, total dietary	g	3.3	0		2.0	0.1	0.3
Sugars, total	g	0.85	0		0.51	0.03	0.09
Minerals							
Calcium, Ca	mg	138	4	6.838	83	5	14
Iron, Fe	mg	6.20	1		3.72	0.24	0.62
Magnesium, Mg	mg	50	4	10.578	30	2	5
Phosphorus, P	mg	58	4	8.035	35	2	6
Potassium, K	mg	554	7	77.704	332	21	55
Sodium, Na	mg	56	7	19.862	34	2	6
Zinc, Zn	mg	1.07	3	0.391	0.64	0.04	0.11

Copper, Cu	mg	0.149	3	0.013	0.089	0.006	0.015
Manganese, Mn	mg	0.160	1		0.096	0.006	0.016
Selenium, Se	mcg	0.1	0		0.1	0.0	0.0
Vitamins							
Vitamin C, total ascorbic acid	mg	133.0	3	30.935	79.8	5.1	13.3
Thiamin	mg	0.086	3	0.015	0.052	0.003	0.009
Riboflavin	mg	0.098	3	0.007	0.059	0.004	0.010
Niacin	mg	1.313	3	0.334	0.788	0.050	0.131
Pantothenic acid	mg	0.400	2		0.240	0.015	0.040
Vitamin B-6	mg	0.090	2		0.054	0.003	0.009
Folate, total	mcg	152	5	21.74	91	6	15
Folic acid	mcg	0	0		0	0	0
Folate, food	mcg	152	5	21.74	91	6	15
Folate, DFE	mcg_DFE	152	0		91	6	15
Vitamin B-12	mcg	0.00	0		0.00	0.00	0.00
Vitamin B-12, added	mcg	0.00	0		0.00	0.00	0.00
Vitamin A, IU	IU	8424	0		5054	320	842
Vitamin A, RAE	mcg_RAE	421	0		253	16	42
Retinol	mcg	0	0		0	0	0
Vitamin E (alpha-tocopherol)	mg	0.75	1		0.45	0.03	0.07
Vitamin E, added	mg	0.00	0		0.00	0.00	0.00
Tocopherol, beta	mg	0.00	1		0.00	0.00	0.00
Tocopherol, gamma	mg	0.53	1		0.32	0.02	0.05
Tocopherol, delta	mg	0.00	1		0.00	0.00	0.00
Vitamin K (phylloquinone)	mcg	1640.0	4	0	984.0	62.3	164.0
Lipids							
Fatty acids, total saturated	g	0.132	0		0.079	0.005	0.013
4:0	g	0.000	0		0.000	0.000	0.000
6:0	g	0.000	0		0.000	0.000	0.000

8:0	g	0.000	0		0.000	0.000	0.000
10:0	g	0.000	0		0.000	0.000	0.000
12:0	g	0.000	0		0.000	0.000	0.000
14:0	g	0.008	1		0.005	0.000	0.001
16:0	g	0.084	1		0.050	0.003	0.008
18:0	g	0.039	1		0.023	0.001	0.004
Fatty acids, total monounsaturated	g	0.295	0		0.177	0.011	0.029
16:1 undifferentiated	g	0.008	1		0.005	0.000	0.001
18:1 undifferentiated	g	0.287	1		0.172	0.011	0.029
20:1	g	0.000	0		0.000	0.000	0.000
22:1 undifferentiated	g	0.000	0		0.000	0.000	0.000
Fatty acids, total polyunsaturated	g	0.124	0		0.074	0.005	0.012
18:2 undifferentiated	g	0.115	1		0.069	0.004	0.012
18:3 undifferentiated	g	0.008	1		0.005	0.000	0.001
18:4	g	0.000	0		0.000	0.000	0.000
20:4 undifferentiated	g	0.000	0		0.000	0.000	0.000
20:5 n-3	g	0.000	0		0.000	0.000	0.000
22:5 n-3	g	0.000	0		0.000	0.000	0.000
22:6 n-3	g	0.000	0		0.000	0.000	0.000
Cholesterol	mg	0	0		0	0	0
Phytosterols	mg	5	1		3	0	0
Amino acids							
Tryptophan	g	0.045	0		0.027	0.002	0.004
Threonine	g	0.122	0		0.073	0.005	0.012
Isoleucine	g	0.118	0		0.071	0.004	0.012
Leucine	g	0.204	0		0.122	0.008	0.020
Lysine	g	0.181	0		0.109	0.007	0.018
Methionine	g	0.042	0		0.025	0.002	0.004
Cystine	g	0.014	0		0.008	0.001	0.001
Phenylalanine	g	0.145	0		0.087	0.006	0.014

Tyrosine	g	0.082	0		0.049	0.003	0.008
Valine	g	0.172	0		0.103	0.007	0.017
Arginine	g	0.122	0		0.073	0.005	0.012
Histidine	g	0.061	0		0.037	0.002	0.006
Alanine	g	0.195	0		0.117	0.007	0.020
Aspartic acid	g	0.294	0		0.176	0.011	0.029
Glutamic acid	g	0.249	0		0.149	0.009	0.025
Glycine	g	0.145	0		0.087	0.006	0.014
Proline	g	0.213	0		0.128	0.008	0.021
Serine	g	0.136	0		0.082	0.005	0.014
Other							
Alcohol, ethyl	g	0.0	0		0.0	0.0	0.0
Caffeine	mg	0	0		0	0	0
Theobromine	mg	0	0		0	0	0
Carotene, beta	mcg	5054	7	310.986	3032	192	505
Carotene, alpha	mcg	0	1		0	0	0
Cryptoxanthin, beta	mcg	0	1		0	0	0
Lycopene	mcg	0	1		0	0	0
Lutein + zeaxanthin	mcg	5561	7	2753.943	3337	211	556

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Rosemary, fresh (1)

Refuse: 35% (Stems)
Scientific Name: *Rosmarinus officinalis*
NDB No: 02063 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 tbsp ------- 1.7g	1.00 X 1 tsp ------- 0.7g
Proximates						
Water	g	67.77	2		1.15	0.47
Energy	kcal	131	0		2	1
Energy	kj	548	0		9	4
Protein	g	3.31	2		0.06	0.02
Total lipid (fat)	g	5.86	2		0.10	0.04
Ash	g	2.35	2		0.04	0.02
Carbohydrate, by difference	g	20.70	0		0.35	0.14
Fiber, total dietary	g	14.1	2		0.2	0.1
Minerals						
Calcium, Ca	mg	317	2		5	2
Iron, Fe	mg	6.65	2		0.11	0.05
Magnesium, Mg	mg	91	2		2	1
Phosphorus, P	mg	66	2		1	0
Potassium, K	mg	668	2		11	5
Sodium, Na	mg	26	2		0	0
Zinc, Zn	mg	0.93	2		0.02	0.01
Copper, Cu	mg	0.301	2		0.005	0.002
Manganese, Mn	mg	0.960	2		0.016	0.007
Vitamins						
Vitamin C, total ascorbic acid	mg	21.8	0		0.4	0.2
Thiamin	mg	0.036	2		0.001	0.000
Riboflavin	mg	0.152	2		0.003	0.001
Niacin	mg	0.912	2		0.016	0.006

Pantothenic acid	mg	0.804	2		0.014	0.006
Vitamin B-6	mg	0.336	2		0.006	0.002
Folate, total	mcg	109	2		2	1
Folic acid	mcg	0	0		0	0
Folate, food	mcg	109	2		2	1
Folate, DFE	mcg_DFE	109	0		2	1
Vitamin B-12	mcg	0.00	0		0.00	0.00
Vitamin A, IU	IU	2924	1		50	20
Vitamin A, RAE	mcg_RAE	146	1		2	1
Retinol	mcg	0	0		0	0
Lipids						
Fatty acids, total saturated	g	2.838	0		0.048	0.020
10:0	g	0.019	0		0.000	0.000
12:0	g	0.014	0		0.000	0.000
14:0	g	0.121	0		0.002	0.001
16:0	g	1.921	0		0.033	0.013
18:0	g	0.231	0		0.004	0.002
Fatty acids, total monounsaturated	g	1.160	0		0.020	0.008
16:1 undifferentiated	g	0.066	0		0.001	0.000
18:1 undifferentiated	g	1.024	0		0.017	0.007
20:1	g	0.048	0		0.001	0.000
Fatty acids, total polyunsaturated	g	0.901	0		0.015	0.006
18:2 undifferentiated	g	0.447	0		0.008	0.003
18:3 undifferentiated	g	0.414	0		0.007	0.003
Cholesterol	mg	0	0		0	0
Phytosterols	mg	44	0		1	0
Amino acids						
Tryptophan	g	0.051	0		0.001	0.000
Threonine	g	0.136	0		0.002	0.001
Isoleucine	g	0.136	0		0.002	0.001
Leucine	g	0.249	0		0.004	0.002

Lysine	g	0.143	0		0.002	0.001
Methionine	g	0.047	0		0.001	0.000
Cystine	g	0.037	0		0.001	0.000
Phenylalanine	g	0.169	0		0.003	0.001
Tyrosine	g	0.100	0		0.002	0.001
Valine	g	0.165	0		0.003	0.001
Arginine	g	0.153	0		0.003	0.001
Histidine	g	0.066	0		0.001	0.000
Alanine	g	0.172	0		0.003	0.001
Aspartic acid	g	0.391	0		0.007	0.003
Glutamic acid	g	0.361	0		0.006	0.003
Glycine	g	0.159	0		0.003	0.001
Proline	g	0.136	0		0.002	0.001
Serine	g	0.129	0		0.002	0.001

Footnotes:
1 Leaf

USDA National Nutrient Database for Standard Reference, Release 19 (2006)

Sage, ground

Refuse: 0%
Scientific Name: *Salvia officinalis*
NDB No: 02038 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 tbsp ------- 2g	1.00 X 1 tsp ------- 0.7g
Proximates						
Water	g	7.96	14	0.367	0.16	0.06
Energy	kcal	315	0		6	2
Energy	kj	1317	0		26	9
Protein	g	10.63	4	0.307	0.21	0.07
Total lipid (fat)	g	12.75	24	0.292	0.26	0.09

Ash	g	7.95	45	0.284	0.16	0.06
Carbohydrate, by difference	g	60.73	0		1.21	0.43
Fiber, total dietary	g	40.3	0		0.8	0.3
Sugars, total	g	1.71	0		0.03	0.01
Minerals						
Calcium, Ca	mg	1652	6	107.505	33	12
Iron, Fe	mg	28.12	6	3.969	0.56	0.20
Magnesium, Mg	mg	428	5	19.079	9	3
Phosphorus, P	mg	91	4	7.181	2	1
Potassium, K	mg	1070	7	100.712	21	7
Sodium, Na	mg	11	4	3.342	0	0
Zinc, Zn	mg	4.70	5	0.622	0.09	0.03
Copper, Cu	mg	0.757	0		0.015	0.005
Manganese, Mn	mg	3.133	0		0.063	0.022
Selenium, Se	mcg	3.7	1		0.1	0.0
Vitamins						
Vitamin C, total ascorbic acid	mg	32.4	2		0.6	0.2
Thiamin	mg	0.754	1		0.015	0.005
Riboflavin	mg	0.336	1		0.007	0.002
Niacin	mg	5.720	1		0.114	0.040
Vitamin B-6	mg	2.690	2		0.054	0.019
Folate, total	mcg	274	0		5	2
Folic acid	mcg	0	0		0	0
Folate, food	mcg	274	0		5	2
Folate, DFE	mcg_DFE	274	0		5	2
Vitamin B-12	mcg	0.00	0		0.00	0.00
Vitamin B-12, added	mcg	0.00	0		0.00	0.00
Vitamin A, IU	IU	5900	1		118	41
Vitamin A, RAE	mcg_RAE	295	1		6	2
Retinol	mcg	0	0		0	0
Vitamin E (alpha-tocopherol)	mg	7.48	0		0.15	0.05

Vitamin E, added	mg	0.00	0		0.00	0.00
Vitamin K (phylloquinone)	mcg	1714.5	0		34.3	12.0
Lipids						
Fatty acids, total saturated	g	7.030	0		0.141	0.049
4:0	g	0.000	0		0.000	0.000
6:0	g	0.000	0		0.000	0.000
8:0	g	0.710	1		0.014	0.005
10:0	g	0.760	1		0.015	0.005
12:0	g	0.300	1		0.006	0.002
14:0	g	0.720	1		0.014	0.005
16:0	g	3.150	1		0.063	0.022
18:0	g	1.250	1		0.025	0.009
Fatty acids, total monounsaturated	g	1.870	0		0.037	0.013
16:1 undifferentiated	g	0.120	1		0.002	0.001
18:1 undifferentiated	g	1.750	1		0.035	0.012
20:1	g	0.000	0		0.000	0.000
22:1 undifferentiated	g	0.000	0		0.000	0.000
Fatty acids, total polyunsaturated	g	1.760	0		0.035	0.012
18:2 undifferentiated	g	0.530	1		0.011	0.004
18:3 undifferentiated	g	1.230	1		0.025	0.009
18:4	g	0.000	0		0.000	0.000
20:4 undifferentiated	g	0.000	0		0.000	0.000
20:5 n-3	g	0.000	0		0.000	0.000
22:5 n-3	g	0.000	0		0.000	0.000
22:6 n-3	g	0.000	0		0.000	0.000
Cholesterol	mg	0	0		0	0
Phytosterols	mg	244	0		5	2
Other						

Alcohol, ethyl	g	0.0	0		0.0	0.0
Caffeine	mg	0	0		0	0
Theobromine	mg	0	0		0	0
Carotene, beta	mcg	3485	0		70	24
Carotene, alpha	mcg	0	0		0	0
Cryptoxanthin, beta	mcg	109	0		2	1
Lycopene	mcg	0	0		0	0
Lutein + zeaxanthin	mcg	862	0		17	6

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Spearmint, fresh (1)

Refuse: 59% (Stems)
Scientific Name: *Mentha spicata*
NDB No: 02065 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 2 tbsp ------- 11.4g
Proximates					
Water	g	85.55	2		9.75
Energy	kcal	44	0		5
Energy	kj	184	0		21
Protein	g	3.29	2		0.38
Total lipid (fat)	g	0.73	2		0.08
Ash	g	2.03	2		0.23
Carbohydrate, by difference	g	8.41	0		0.96
Fiber, total dietary	g	6.8	2		0.8
Minerals					
Calcium, Ca	mg	199	2		23
Iron, Fe	mg	11.87	2		1.35
Magnesium, Mg	mg	63	2		7

Phosphorus, P	mg	60	2		7
Potassium, K	mg	458	2		52
Sodium, Na	mg	30	2		3
Zinc, Zn	mg	1.09	2		0.12
Copper, Cu	mg	0.240	2		0.027
Manganese, Mn	mg	1.118	2		0.127
Vitamins					
Vitamin C, total ascorbic acid	mg	13.3	2		1.5
Thiamin	mg	0.078	2		0.009
Riboflavin	mg	0.175	2		0.020
Niacin	mg	0.948	2		0.108
Pantothenic acid	mg	0.250	2		0.029
Vitamin B-6	mg	0.158	2		0.018
Folate, total	mcg	105	2		12
Folic acid	mcg	0	0		0
Folate, food	mcg	105	2		12
Folate, DFE	mcg_DFE	105	0		12
Vitamin B-12	mcg	0.00	0		0.00
Vitamin A, IU	IU	4054	2		462
Vitamin A, RAE	mcg_RAE	203	2		23
Retinol	mcg	0	0		0
Lipids					
Fatty acids, total saturated	g	0.191	0		0.022
14:0	g	0.004	0		0.000
16:0	g	0.137	0		0.016
18:0	g	0.020	0		0.002
Fatty acids, total monounsaturated	g	0.025	0		0.003
16:1 undifferentiated	g	0.002	0		0.000
18:1 undifferentiated	g	0.022	0		0.003
Fatty acids, total polyunsaturated	g	0.394	0		0.045
18:2 undifferentiated	g	0.054	0		0.006

18:3 undifferentiated	g	0.338	0		0.039
Cholesterol	mg	0	0		0
Phytosterols	mg	10	0		1
Amino acids					
Tryptophan	g	0.050	0		0.006
Threonine	g	0.135	0		0.015
Isoleucine	g	0.135	0		0.015
Leucine	g	0.247	0		0.028
Lysine	g	0.141	0		0.016
Methionine	g	0.046	0		0.005
Cystine	g	0.036	0		0.004
Phenylalanine	g	0.168	0		0.019
Tyrosine	g	0.099	0		0.011
Valine	g	0.164	0		0.019
Arginine	g	0.151	0		0.017
Histidine	g	0.066	0		0.008
Alanine	g	0.171	0		0.019
Aspartic acid	g	0.388	0		0.044
Glutamic acid	g	0.358	0		0.041
Glycine	g	0.158	0		0.018
Proline	g	0.135	0		0.015
Serine	g	0.128	0		0.015

Footnotes:
1 Leaf

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Spices, tarragon, dried

Refuse: 0%
Scientific Name: *Artemisia dracunculus*
NDB No: 02041 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 tsp, leaves ------- 0.6g	1.00 X 1 tbsp, leaves ------- 1.8g	1.00 X 1 tsp, ground ------- 1.6g
Proximates							
Water	g	7.74	7	1.181	0.05	0.14	0.12
Energy	kcal	295	0		2	5	5
Energy	kj	1236	0		7	22	20
Protein	g	22.77	4	1.475	0.14	0.41	0.36
Total lipid (fat)	g	7.24	4	0.411	0.04	0.13	0.12
Ash	g	12.03	5	0.834	0.07	0.22	0.19
Carbohydrate, by difference	g	50.22	0		0.30	0.90	0.80
Fiber, total dietary	g	7.4	0		0.0	0.1	0.1
Minerals							
Calcium, Ca	mg	1139	4	180.298	7	21	18
Iron, Fe	mg	32.30	4	5.952	0.19	0.58	0.52
Magnesium, Mg	mg	347	3	64.377	2	6	6
Phosphorus, P	mg	313	3	12.019	2	6	5
Potassium, K	mg	3020	6	356.46	18	54	48
Sodium, Na	mg	62	4	25.44	0	1	1
Zinc, Zn	mg	3.90	3	1.562	0.02	0.07	0.06
Copper, Cu	mg	0.677	0		0.004	0.012	0.011
Manganese, Mn	mg	7.967	0		0.048	0.143	0.127
Selenium, Se	mcg	4.4	1		0.0	0.1	0.1
Vitamins							
Vitamin C, total ascorbic acid	mg	50.0	0		0.3	0.9	0.8
Thiamin	mg	0.251	1		0.002	0.005	0.004
Riboflavin	mg	1.339	1		0.008	0.024	0.021

Niacin	mg	8.950	1		0.054	0.161	0.143
Vitamin B-6	mg	2.410	2		0.014	0.043	0.039
Folate, total	mcg	274	0		2	5	4
Folic acid	mcg	0	0		0	0	0
Folate, food	mcg	274	0		2	5	4
Folate, DFE	mcg_DFE	274	0		2	5	4
Vitamin B-12	mcg	0.00	0		0.00	0.00	0.00
Vitamin A, IU	IU	4200	1		25	76	67
Vitamin A, RAE	mcg_RAE	210	1		1	4	3
Retinol	mcg	0	0		0	0	0
Lipids							
Fatty acids, total saturated	g	1.881	0		0.011	0.034	0.030
4:0	g	0.000	0		0.000	0.000	0.000
6:0	g	0.000	0		0.000	0.000	0.000
8:0	g	0.000	0		0.000	0.000	0.000
10:0	g	0.028	0		0.000	0.001	0.000
12:0	g	0.014	0		0.000	0.000	0.000
14:0	g	0.120	0		0.001	0.002	0.002
16:0	g	1.202	0		0.007	0.022	0.019
18:0	g	0.410	0		0.002	0.007	0.007
Fatty acids, total monounsaturated	g	0.474	0		0.003	0.009	0.008
16:1 undifferentiated	g	0.113	0		0.001	0.002	0.002
18:1 undifferentiated	g	0.361	0		0.002	0.006	0.006
20:1	g	0.000	0		0.000	0.000	0.000
22:1 undifferentiated	g	0.000	0		0.000	0.000	0.000
Fatty acids, total polyunsaturated	g	3.698	0		0.022	0.067	0.059
18:2 undifferentiated	g	0.742	0		0.004	0.013	0.012
18:3 undifferentiated	g	2.955	0		0.018	0.053	0.047
18:4	g	0.000	0		0.000	0.000	0.000
20:4	g	0.000	0		0.000	0.000	0.000

undifferentiated							
20:5 n-3	g	0.000	0		0.000	0.000	0.000
22:5 n-3	g	0.000	0		0.000	0.000	0.000
22:6 n-3	g	0.000	0		0.000	0.000	0.000
Cholesterol	mg	0	0		0	0	0
Phytosterols	mg	81	0		0	1	1
Other							
Alcohol, ethyl	g	0.0	0		0.0	0.0	0.0
Caffeine	mg	0	0		0	0	0
Theobromine	mg	0	0		0	0	0

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Thyme, fresh

Scientific Name: *Thymus vulgaris*
NDB No: 02049 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 tsp ------- 0.8g	1.00 X 0.5 tsp ------- 0.4g
Proximates						
Water	g	65.11	2		0.52	0.26
Energy	kcal	101	0		1	0
Energy	kj	423	0		3	2
Protein	g	5.56	2		0.04	0.02
Total lipid (fat)	g	1.68	2		0.01	0.01
Ash	g	3.20	2		0.03	0.01
Carbohydrate, by difference	g	24.45	0		0.20	0.10
Fiber, total dietary	g	14.0	2		0.1	0.1
Minerals						
Calcium, Ca	mg	405	2		3	2
Iron, Fe	mg	17.45	2		0.14	0.07
Magnesium, Mg	mg	160	2		1	1

Phosphorus, P	mg	106	2		1	0
Potassium, K	mg	609	2		5	2
Sodium, Na	mg	9	2		0	0
Zinc, Zn	mg	1.81	2		0.01	0.01
Copper, Cu	mg	0.555	2		0.004	0.002
Manganese, Mn	mg	1.719	2		0.014	0.007
Vitamins						
Vitamin C, total ascorbic acid	mg	160.1	2		1.3	0.6
Thiamin	mg	0.048	2		0.000	0.000
Riboflavin	mg	0.471	2		0.004	0.002
Niacin	mg	1.824	2		0.015	0.007
Pantothenic acid	mg	0.409	2		0.003	0.002
Vitamin B-6	mg	0.348	2		0.003	0.001
Folate, total	mcg	45	2		0	0
Folic acid	mcg	0	0		0	0
Folate, food	mcg	45	2		0	0
Folate, DFE	mcg_DFE	45	0		0	0
Vitamin B-12	mcg	0.00	0		0.00	0.00
Vitamin A, IU	IU	4751	2		38	19
Vitamin A, RAE	mcg_RAE	238	2		2	1
Retinol	mcg	0	0		0	0
Lipids						
Fatty acids, total saturated	g	0.467	0		0.004	0.002
8:0	g	0.041	2		0.000	0.000
10:0	g	0.021	2		0.000	0.000
12:0	g	0.039	2		0.000	0.000
14:0	g	0.026	2		0.000	0.000
16:0	g	0.293	2		0.002	0.001
18:0	g	0.047	2		0.000	0.000
Fatty acids, total monounsaturated	g	0.081	0		0.001	0.000
18:1 undifferentiated	g	0.081	2		0.001	0.000
Fatty acids, total polyunsaturated	g	0.532	0		0.004	0.002

18:2 undifferentiated	g	0.085	2		0.001	0.000
18:3 undifferentiated	g	0.447	2		0.004	0.002
Cholesterol	mg	0	0		0	0
Amino acids						
Tryptophan	g	0.114	0		0.001	0.000
Threonine	g	0.154	0		0.001	0.001
Isoleucine	g	0.285	0		0.002	0.001
Leucine	g	0.262	0		0.002	0.001
Lysine	g	0.126	0		0.001	0.001
Valine	g	0.307	0		0.002	0.001
Other						
Carotene, beta	mcg	2851	2		23	11

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Wasabi, root, raw

Refuse: 23% (Peel)
Scientific Name: *Wasabia japonica*
NDB No: 11990 (Nutrient values and weights are for edible portion)

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 cup, sliced ------- 130g	1.00 X 1 root ------- 169g
Proximates						
Water	g	69.11	2		89.84	116.80
Energy	kcal	109	0		142	184
Energy	kj	456	0		593	771
Protein	g	4.80	2		6.24	8.11
Total lipid (fat)	g	0.63	2		0.82	1.06
Ash	g	1.92	2		2.50	3.24
Carbohydrate, by difference	g	23.54	0		30.60	39.78

Fiber, total dietary	g	7.8	2		10.1	13.2
Minerals						
Calcium, Ca	mg	128	2		166	216
Iron, Fe	mg	1.03	2		1.34	1.74
Magnesium, Mg	mg	69	2		90	117
Phosphorus, P	mg	80	2		104	135
Potassium, K	mg	568	2		738	960
Sodium, Na	mg	17	2		22	29
Zinc, Zn	mg	1.62	2		2.11	2.74
Copper, Cu	mg	0.155	2		0.201	0.262
Manganese, Mn	mg	0.391	2		0.508	0.661
Vitamins						
Vitamin C, total ascorbic acid	mg	41.9	2		54.5	70.8
Thiamin	mg	0.131	2		0.170	0.221
Riboflavin	mg	0.114	2		0.148	0.193
Niacin	mg	0.743	2		0.966	1.256
Pantothenic acid	mg	0.203	2		0.264	0.343
Vitamin B-6	mg	0.274	2		0.356	0.463
Folate, total	mcg	18	2		23	30
Folic acid	mcg	0	0		0	0
Folate, food	mcg	18	2		23	30
Folate, DFE	mcg_DFE	18	0		23	30
Vitamin B-12	mcg	0.00	0		0.00	0.00
Vitamin A, IU	IU	35	0		46	59
Vitamin A, RAE	mcg_RAE	2	0		3	3
Retinol	mcg	0	0		0	0
Lipids						
Cholesterol	mg	0	0		0	0
Other						
Carotene, beta	mcg	21	3		27	35
Carotene,	mcg	0	2		0	0

alpha							
Cryptoxanthin, beta	mcg	0	2		0	0	

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Appendix II

Table 7: Summary of health attributes of assorted herbs or their major constituents reported in literature.

Herb	Health effect
Basil	Antioxidant activity, induced phase 2 enzymes, decreased lipid peroxidation, inhibited tumour growth, provided protection from radiation, anti-inflammatory, stimulated nervous system, antimicrobial, anti-ulcer, anti-diarrhoea, blood sugar lowering, modulated antioxidant enzymes
Bay leaf	Antioxidant activity, cytotoxic to leukaemia cells, inhibited alcohol absorption, delayed gastric emptying
Borage	Radical scavenging activity, iron chelating, prevented lipid peroxidation
Chervil	Radical scavenging activity, metal chelating, transition metal reducing, protected membrane lipids from oxidative damage
Chives	Antioxidant activity
Coriander	Radical scavenging, protected lipids from peroxidation
Dill	Antioxidant activity
Fennel	Anti-inflammatory, stimulated endogenous antioxidants
Horseradish	Induced phase 2 enzymes, antimicrobial
Lemon balm	Antioxidant activity, antimicrobial, protected against lipid peroxidation
Lemon grass	Antioxidant activity – radical scavenging, protected against lipid peroxidation, induced phase 2 enzymes
Lovage	Antioxidant activity
Marjoram/oregano	Antioxidant activity, prevented lipid peroxidation, antimicrobial, antihyperglycaemic
Mint	Antioxidant activity, antimicrobial, antiviral

Herb	Health effect
Vietnamese mint	Antioxidant activity
Parsley	Antioxidant activity, anti-inflammatory, anti-platelet aggregation, anti C
Rosemary	Antioxidant activity, antimicrobial, antithrombotic, reduced tumour formation, increased antioxidant enzymes, inhibited blood clots, protected liver, anti-hepatitis, inhibited HIV, anti-inflammatory, some cytotoxic effects
Sage	Antioxidant activity, anti-Alzheimer's disease, increased endogenous antioxidants, protected DNA
Salad burnet	Antioxidant activity, anti-Alzheimer's disease
Savory	Antioxidant activity, antimicrobial, antiviral, antispasmodic, anti-diarrhoeal, protected lipids from peroxidation
Sorrel	High in oxalic acid (negative health effects – kidney stones, gout)
Tarragon	Antioxidant activity, fungicidal, reduced some symptoms of diabetes
Thyme	Antioxidant activity, anti-inflammatory, anti-thrombotic, anti-Alzheimer's disease, DNA protective, used as burn treatment
Wasabi	Antioxidant activity, antimutagenic, increased phase 2 enzymes, assisted apoptosis.