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The nutritional composition and health benefits of buttercup squash

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1 Executive summary

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This report provides a summary of research and sources of information on the nutritional composition and health benefits of buttercup squash (*Cucurbita maxima*, Kabocha) that has been prepared for the New Zealand Buttercup Squash Council. Searches were conducted using the New Zealand Food Composition Database (FOODfiles) and USDA Food Composition Database, ethnobotanical databases and the scientific literature. In the United States and some other countries, pumpkins and buttercup squash types are known as 'winter squash', in contrast to the likes of zucchini, scaloppini and marrow, which are termed 'summer squash'. Buttercup squash is one of the most common varieties of winter squash. It is interesting that a number of cultures have used various parts of buttercup squash (fruit, leaves, flowers and seeds) to treat various conditions. These usages are very diverse and include burns, diabetes, heart disease, inflammation, gastrointestinal complaints, jaundice and nervous disorders. However, limited scientific evidence is available on buttercup squash, but what is available provides some support support at least some of these usages.

There are several entries in the New Zealand Food Composition Database for buttercup squash, including information for raw and steamed flesh, raw and steamed skin, plus steamed flesh and skin together (but not for raw flesh and skin together). These data do not exclusively describe New Zealand-grown squash – some data are sourced from overseas material. The dry matter of buttercup squash is primarily comprised of carbohydrate, which makes up approximately 22% of the fresh weight when cooked (steamed). Most of the carbohydrate is starch with smaller amounts of sugars present. Dietary fibre is also present at moderate levels. Fat and protein contents are relatively low.

Where buttercup squash does star is in its content of vitamins and minerals. Buttercup squash can be considered a good source (>25% RDI) of vitamin A. Although buttercup squash does not contain retinol (vitamin A) it is a good source of vitamin A because it contains high levels of provitamin A carotenoids (α- and β-carotene, as well as β-cryptoxanthin). In addition, it is a good source of folate and vitamin E and possibly potassium, although for this mineral levels between raw and cooked vary significantly and may affect the accuracy of claims. Likewise there are large differences in the vitamin C contents of raw and steamed buttercup squash that require further investigation. In addition to those vitamins and minerals that reach good source levels, buttercup squash can be considered a source of a number of others (i.e. it provides more than 10% of the RDI). These include iron, niacin, pantothenic acid, riboflavin, thiamine and vitamin B_6. The contents of niacin and riboflavin in steamed squash are much higher than in raw flesh. This may point to errors in the data or variability depending on source. The USDA data point is based on the lower values, but this needs to be checked. There are some differences in the composition of the skin and the flesh of buttercup squash. In general, the skin is significantly higher in minerals and some vitamins, and if both skin and flesh are consumed there are small increases in contribution to daily intake for some nutrients.

Apart from the core nutrients, phytochemicals are present in squash. The main class of phytochemical present is the carotenoids. These are present in high levels and include not just the provitamin A carotenoids but also a range of other related compounds that may have important health benefits. The study of other phytochemicals in *Cucurbita maxima* in general is very limited with only a handful making any mention of them. Little is known about the phenolic compounds of pumpkin and squash, let alone buttercup squash. The levels of phenolic compounds appear to be low, although this does require a little further investigation. The only other phytochemical components noted in the literature for squash were polyamines and galactolipids.

Few studies have examined the health benefits of *Cucurbita maxima*. The lack of study is not because this vegetable is nutritionally worthless, but rather for some reason research on this vegetable is not particularly popular in the USA or Europe. The core nutrients have a wide range of health benefits. The potassium in squash may help to lower blood pressure. Fibre may help to fight heart disease and colon cancer. In addition to its ability to lower high cholesterol levels, which reduces the risk of heart disease, the fibre found in winter squash can also prevent cancer-causing chemicals from attacking colon cells. This is one of the reasons why diets high in fibre-rich foods have been associated with a reduced risk of colon cancer. Folate plays an important role in preventing stroke and heart disease as well as preventing neural tube defects. In addition to the core nutrients, phytochemicals may have other benefits. There is some evidence that squash has anti-cancer properties and benefits for the prevention and treatment of diabetes. Other benefits may be due to the presence of carotenoids such as for eye health and heart disease, although buttercup squash has not been specifically studied in this regard.

The first priority for research should be the analysis of New Zealand-grown buttercup squash to provide accurate data to support possible nutrient content (and function) claims. From these data it will be possible to develop marketing claims around nutrient content and then educate consumers on the important functions of these core nutrients. Other areas for future research include the detailed composition of the carotenoids and investigation to determine how the benefits offered by squash compare to those of other dietary sources of carotenoids (e.g. enhanced bioavailability). Areas for research on the health benefits that show the most promise include diabetes/obesity, eye health and digestive health.

In conclusion, buttercup squash clearly has considerable merit in terms of its nutritional composition with a number of vitamins and minerals making a significant contribution to daily intake. Further research is required to confirm the levels of nutrients present in squash in the form in which it is frequently consumed. This will be important to reassess and possibly extend the nutrient content and function claims currently being made. If health claims are to be made, considerable investment in research will be required as there is limited information on this aspect of buttercup squash at present.

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2 Introduction

A pumpkin or a squash? Both squash and pumpkins belong to the family Cucurbitaceae, which also includes cucumber, gourd, and melons. In the United States and some other countries, pumpkins and buttercup squash types are known as `winter squash', in contrast to the likes of zucchini, scaloppini and marrow, which are termed `summer squash'. Buttercup squash is one of the most common varieties of winter squash. It has a turban-shape (a flattish top and dark green skin). The scientific name is *Cucurbita maxima*, and it is one of at least five species of cultivated squash. It is well recognised as one of the most diverse domesticated crops. This species originated in South America from the wild *C. maxima* ssp. *andreana* over 4000 years ago. Different squash types of this species were introduced into North America as early as the 16th century. By the American Revolution, the species was in cultivation by Native American tribes throughout the present-day United States. This is a vegetable that was once such an important part of the diet of the Native Americans that they buried it along with the dead to provide them with nourishment on their final journey. By the early 19th century, at least three varieties are known to have been commercially introduced in North America from seeds obtained from Native Americans. Secondary centres of diversity include India, Bangladesh, Burma, and possibly the southern Appalachians.

Squash is also well known in Japan. Kabocha (katakana: カボチャ) is a Japanese variety of winter squash. The word kabocha has come to mean a general type of winter squash to many English-speaking growers and buyers. It is generally believed that all squash originated in Mesoamerica, but may have been independently cultivated elsewhere, albeit later. The kabocha, however, was introduced to Japan by Portuguese sailors in 1541, who brought it with them from Cambodia. The Portuguese name for the pumpkin, Cambodia abóbora (カンボジャ・アボボラ), was shortened by the Japanese to kabocha. Certain regions of Japan use an alternate abbreviation, shortening the second half of the name instead to `bobora'. Another name for kabocha is 南瓜 (southern melon) or occasionally 南京瓜 (Nanking melon), which may suggest that the vegetable arrived in Japan from China.

Among cucurbitaceous vegetables, pumpkin/squash has been appreciated for high yields, long storage life and high nutritive value. The flour has been used to supplement cereal flours in bakery products, soups, instant noodles and natural colouring agent in pasta and flour mixes. Seeds, generally thrown away, are a rich source of oil and nutrients and could be consumed as food. The seed flour is used as a protein supplement in bread and cookies.

A number of cultures have used various parts of *C. maxima* (fruit, leaves, flowers and seeds) to treat various conditions. Dr Duke's Phytochemical and Ethnobotanical Databases (www.ars-grin.gov/duke/) list the following usages: "Boil; Breast; Burn; Cancer; Carbuncle; Cataplasm; Chest; Diuretic; Fever; Inflammation; Nervine; Poultice; Rash; Refrigerant; Taenicide; Teething; Tonic; Tumor; Vermifuge; Wart". Various other sources list the following:

- Expels all tapeworms from the intestine and the stomach will be cleaned
- Good for leucorrhoea
- Revered as an aphrodisiac and sexual stimulant
- Contains agents that help fight jaundice when eaten raw
- Used during birth and for indigestion in cattle
- Alleviates cardiovascular diseases

- Treats constipation of stomach or intestines
- Having high K:Na ratio, it is a good diuretic
- Used to treat diabetes, rheumatism, eczema and burns, and against worms and other parasites
- Seeds are antithelmintic
- A stomachic
- Antirheumatic
- Treatment for eye problems
- Laxative
- Used in diarrhoea management
- Treatment for prostate problems
- Dermatologica
- Used for digestive problems, including ulcers
- Antidiabetic
- Antihypertensive
- Antitumour
- Immunomodulation
- Antibacterial
- Antihypercholesterolemia
- Intestinal antiparastia
- Anti-inflammatory
- Antalgic
- Unripe and ripe fruit used as a medical treatment for burns, inflammation, jaundice and nervous disorders.

In order to establish if any of these may have validity, searches of the scientific literature were conducted for information on the nutritional and phytochemical composition of squash and its health benefits. This report summarises those findings. Although the objective was to find research on buttercup squash in some areas, this scope was widened to look at *C. maxima* in general due to limited studies specifically with buttercup squash.

3 Composition

A number of factors combine to determine the levels of both core nutrients and other phytochemicals in a food. These include not only the variety/cultivar of the plant, but also relevant agronomic practices – soils, cultivation protocols (irrigation, pest control, use of fertiliser), degree of ripeness at harvest, and processing practices (harvesting, storage, method of processing). In addition, the form in which the food was analysed – raw, fresh, canned, boiled, frozen – as well as analytical techniques and variations between the laboratories doing the analysis can affect levels reported. This makes it difficult to be exact when comparing levels of these compounds from different reported sources. These various factors may cause large differences in core nutrient levels, but even greater differences may occur in terms of phytochemicals.

In order to assess the nutritional composition of buttercup squash, searches were made of the New Zealand Food Composition Database (FOODfiles) and USDA Food Composition Database (www.nal.usda.gov/fnic/foodcomp/search/). The scientific literature was also searched for phytochemical composition data.

3.1 Core nutrients

3.1.1 New Zealand data

There are several entries in the New Zealand Food Composition Database for Buttercup squash, including information for raw and steamed flesh, raw and steamed skin plus steamed flesh and skin together (but not for raw flesh and skin together). See Appendix I for detailed data from the New Zealand database FOODfiles. These data do not exclusively describe New Zealand-grown squash – some data describe material sourced from overseas.

The dry matter of buttercup squash is mostly carbohydrate, which makes up approximately 22% of the fresh weight when cooked (steamed). Most of the carbohydrate is starch with smaller amounts of sugars present. Dietary fibre is also present at moderate levels. The fibre value for steamed flesh is 2.6 g/100 g. For an adult male it is suggested to consume 30 g per day of fibre. Based on the steamed value, a serve of buttercup squash flesh (1 cup) would contribute 20% of the recommended intake of fibre. There is some variation of reported levels of fibre with one earlier value at 1.2 g/100 g; this should be investigated further to establish the correct figures. Variation may result from a variety of factors, including growing season, location and conditions and storage. In terms of other proximates, steamed buttercup squash skin is quite high in protein (7.6 g/100 g) although this does not tally with a value for raw skin of 2.4 g/100 g. Both raw and steamed flesh has a protein content of less than 2 g/100 g, so is not significant in terms of daily intake. Likewise, the fat content of buttercup squash is low at less than 1%, apart from in steamed skin which is 2% fat.

Besides the proximate, a wide range of vitamins and minerals are present. The significance of vitamin and mineral contents is best looked at in terms of the contribution supplied by the vitamins and minerals in this vegetable to recommended daily intakes (RDIs) and which are sources or good sources o the particular component. 'Source' claims can be made when at least 10% of the RDI of a vitamin/mineral is present in a food. 'Good source' claims can only be made when a food contains no less than 25% of the RDI for that vitamin/mineral. The values given in this section are RDIs for New Zealand and Australia. Each country sets its own dietary standards so adjustments may need to be made to tailor for the country in which a vegetable is being marketed.

Table 1 gives the vitamins and minerals in steamed buttercup squash flesh that reach source or good source levels based on a standard serve (1 cup diced = 225 g). Buttercup squash can be considered a good source of vitamin A. Although buttercup squash does not contain retinol (vitamin A), it is a good source of vitamin A because it contains high levels of provitamin A carotenoids (α- and β-carotene, as well as β-cryptoxanthin). In addition, it is also a good source of folate and vitamin E and possibly potassium, although for this mineral levels vary significantly between raw and cooked and may impact on claims made. On the basis of the raw data, squash is also a good source of vitamin C although the level is virtually negligible in steamed flesh. The big difference in vitamin C content between raw and cooked is unusual. Although vitamin C can be readily destroyed by cooking, it does not usually disappear almost totally with typical losses being up to 30%. For formal food composition purposes, the nutrient retention factor used for vitamin C for steaming is 0.85. Overseas data indicate that winter squash, even when cooked, does contain significant levels of vitamin C (see Section 2.1.2). This warrants further investigation to ensure correct data are available for use in possible claims.

In addition to vitamins and minerals that reach good source levels, buttercup squash can be considered a source of a number of other vitamins and minerals. These include iron, niacin, pantothenic acid, riboflavin, thiamine and vitamin B_6. Levels of niacin and riboflavin in steamed squash are much higher than in raw flesh. This may point to errors in the data or variability, depending on source. The USDA data (see below) report the lower values, but this needs to be checked.

Table 1. Key vitamin and mineral contents of steamed buttercup squash flesh[a].

Nutrient	Amount/100 g	Amount per serve (1 cup diced = 225 g)	%RDI[b] per serve
Calcium[c]	16 mg	36 mg	4%
Folate	46 µg	102 µg	26%
Iron	0.4 mg (0.7 mg)	0.9 mg (1.5 mg)	11% (19%)
Niacin	1.3 mg (0.7 mg)	2.9 mg (1.6 mg)	18% (10%)
Pantothenic acid	0.4 mg	0.9 mg	15%
Potassium	375 mg (471 mg)	844 mg (1060 mg)	22% (28%)
Riboflavin (vitamin B_2)	0.11 mg (0.01 mg)	0.24 mg (0.02 mg)	19% (2%)
Thiamin (vitamin B_1)	0.1 mg	0.23 mg	19%
Vitamin A equivalents	433 µg (531 µg)	974 µg (1195 µg)	108% (133%)
Vitamin B_6	0.06 mg (0.1 mg)	0.135 mg (0.23 mg)	10% (17%)
Vitamin C (ascorbic acid)	0.6 mg (26 mg)	1.3 mg (57.7 mg)	3% (128%)
Vitamin E (tocopherols)	1.9 mg	4.28 mg	43%

[a] Values are for steamed flesh (X225) but where there were large discrepancies (>5% RDI) between raw and cooked the raw values (X192) are also provided in brackets (see Appendix 1 for full data).
[b] RDI = Recommended dietary intake as given in Nutrient Reference Values for Australia and New Zealand Including Recommended Dietary Intakes (www.nhmrc.gov.au), where there is no RDI Adequate Intake (AI) values were used.
[c] Included for comparative purposes because skin alone reaches good source level.

There are some differences in the composition of the skin and the flesh of buttercup squash when examined on contribution to RDI, on an equal weight basis. Although this is not really a valid comparison as just skin would not be eaten, especially at such high levels, these calculations make for useful comparisons for theoretical purposes. In general, the skin is significantly higher in minerals and some vitamins (Table 2), and if both skin and flesh are consumed there are small increases in contribution to daily intake for some nutrients (Table 3). The levels of calcium, folate, iron, niacin, potassium, riboflavin and thiamin are very high in steamed skin compared to the flesh. However, there are large differences in the data for raw and steamed skin. The reasons for this are unclear. The samples were taken at a different time and from different sampling locations so it is difficult to make direct comparisons. It cannot be assumed that the differences are due to steaming (in some cases levels are higher for cooked while in others they are lower). The differences may also reflect different thickness of skin being sampled for the two samples (possibly a thinner layer taken with steamed skin). Explanations other than the effect of steaming are more likely to be valid as when differences are compared to typical nutrient retention factors in raw versus cooked samples the figures do not tally. For example, the nutrient retention factor for folate for steaming is 0.85 and so the folate content of steamed skin would be expected to be lower than in raw tissue yet in this data it is over five times higher. This is the case for other nutrients too.

The New Zealand Food Composition data show the provitamin A content of the skin and flesh to be the same. Our data from earlier work and overseas data indicate that the carotenoid content of the skin is several-fold higher than that of the flesh. It may be that the level of non-vitamin A carotenoids is higher in the skin than in the flesh while the provitamin A components remain the same, but this needs to be explored further. Overall, the high nutritional value of the skin merits it being eaten where possible.

Table 2. Key vitamin and mineral contents of buttercup squash skin (steamed)[a]. Other nutrients may be present in skin that reach source or good source levels.

Nutrient	Amount/100 g	Amount per serve (1 cup diced = 225 g)	%RDI[b] per serve
Calcium	147 mg (58 mg)	331 mg (131 mg)	33% (13%)
Folate	133 µg (21 µg)	299 µg (47 µg)	75% (12%)
Iron	3.4 mg (1.3 mg)	7.7 mg (2.9 mg)	96% (37%)
Niacin	2.6 mg (0.9 mg)	5.9 mg (2.0 mg)	37% (13%)
Pantothenic acid	0.4 mg	0.9 mg	15%
Potassium	760 mg (315 mg)	1710 mg (709 mg)	45% (19%)
Riboflavin (vitamin B_2)	0.31 mg (0.01 mg)	0.7 mg (0.02 mg)	54% (2%)
Thiamin (vitamin B_1)	0.4 mg (0.08 mg)	0.9 mg (0.18 mg)	75% (15%)
Vitamin A equivalents	433 µg (531 µg)	974 µg (1195 µg)	108% (133%)
Vitamin B_6	0.05 mg	0.11 mg	9%

Nutrient	Amount/100 g	Amount per serve (1 cup diced = 225 g)	%RDI[b] per serve
	(0.1 mg)	(0.23 mg)	(17%)
Vitamin C (ascorbic acid)	0.7 mg (26 mg)	1.7 mg (59 mg)	4% (130%)
Vitamin E (tocopherols)	1.9 mg	4.3 mg	43%

[a] Values are for steamed skin (X229) but where there were large discrepancies (>5% RDI) between raw and cooked the raw values (X178) are also provided in brackets (see Appendix 1 for full data).
[b] RDI = Recommended dietary intake as given in Nutrient Reference Values for Australia and New Zealand Including Recommended Dietary Intakes (www.nhmrc.gov.au), where there is no RDI Adequate Intake (AI) values were used.

Table 3. Key vitamin and mineral contents of steamed buttercup squash skin and flesh[a].

Nutrient	Amount/100 g	Amount per serve (1 cup diced = 225 g)	%RDI[b] per serve
Calcium	26 mg	59 mg	6%
Folate	45 µg	101 µg	25%
Iron	0.6 mg	1.4 mg	18%
Niacin	1.3 mg	3.0 mg	19%
Pantothenic acid	0.4 mg	0.9 mg	15%
Potassium	406 mg	914 mg	24%
Riboflavin (vitamin B_2)	0.12 mg	0.27 mg	21%
Thiamin (vitamin B_1)	0.11 mg	0.25 mg	21%
Vitamin A equivalents	411 µg	925 µg	103%
Vitamin B_6	0.05 mg	0.11 mg	9%
Vitamin C (ascorbic acid)	0.5 mg	1.2 mg	3%
Vitamin E (tocopherols)	1.9 mg	4.3 mg	43%

[a] Values are for steamed flesh and skin (X263) but there are no data for raw flesh and skin combined (see Appendix 1 for full data).
[b] RDI = Recommended dietary intake as given in Nutrient Reference Values for Australia and New Zealand Including Recommended Dietary Intakes (www.nhmrc.gov.au), where there is no RDI Adequate Intake (AI) values were used.

3.1.2 Overseas data

Overseas data are also available on the composition of squash, although it is often difficult to determine exactly what type of squash has been analysed. The USDA Food Composition Database does not specifically contain data on buttercup squash, but it does contain entries for winter squash (an average value of all types). Although there are some differences in composition depending on type, there are general similarities to a lot of the nutrient values reported in the New Zealand data. The detailed USDA data are given in Appendix 2.

Nutritional data on winter squash have also been compiled by The World's Healthiest Foods (www.whfoods.com/genpage.php?tname=foodspice&dbid=63). This website has a rating guide:

"In order to better help you identify foods that feature a high concentration of nutrients for the calories they contain, we created a Food Rating System. This system allows us to highlight the foods that are especially rich in particular nutrients. The following chart shows the nutrients for which this food is either an excellent, very good, or good source (below the chart you will find a table that explains these qualifications). If a nutrient is not listed in the chart, it does not necessarily mean that the food doesn't contain it. It simply means that the nutrient is not provided in a sufficient amount or concentration to meet our rating criteria. (To view this food's in-depth nutritional profile that includes values for dozens of nutrients - not just the ones rated as excellent, very good, or good - please use the link below the chart.) To read this chart accurately, you'll need to glance up in the top left corner where you will find the name of the food and the serving size we used to calculate the food's nutrient composition. This serving size will tell you how much of the food you need to eat to obtain the amount of nutrients found in the chart. Now, returning to the chart itself, you can look next to the nutrient name in order to find the nutrient amount it offers, the percent Daily Value (DV%) that this amount represents, the nutrient density that we calculated for this food and nutrient, and the rating we established in our rating system. For most of our nutrient ratings, we adopted the government standards for food labeling that are found in the U.S. Food and Drug Administration's "Reference Values for Nutrition Labeling."

Data for winter squash are provided in Figure 1 and Table 4. There are similarities between these data and New Zealand data, but there are also some differences. These differences may be due to the types of squash analysed or to factors such as growing conditions and maturity. Like the USDA data, values for the vitamin C content on this website are higher than data for New Zealand cooked samples. The thiamine and pantothenic acid values are higher than the USDA figures but are on a par with New Zealand cooked flesh. This variability confirms the potential impact of the factors discussed earlier. One component of interest in data from The World's Healthiest Foods website is omega-3 fatty acids, which are noted as contributing up to 15% of the RDI. The USDA data do not indicate that any are present and there is no specific New Zealand data for this component. This needs investigation to establish the correct figures. It may be that the figure on The World's Healthiest Foods website is based on an assessment of seeds, which do contain higher fat levels.

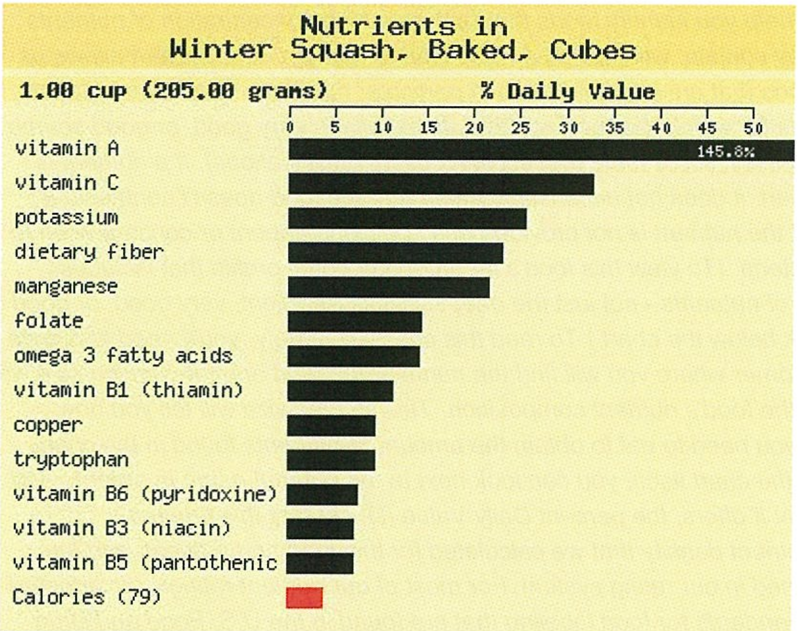

Figure 1. This chart graphically details the %DV that a serving of winter squash provides for each of the nutrients (from The World's Healthiest Foods – www.whfoods.com/genpage.php?tname=foodspice&dbid=63).

Table 4. Detailed nutritional composition of winter squash (from The World's Healthiest Foods – www.whfoods.com/genpage.php?tname=foodspice&dbid=63).

Winter squash, baked, cubes 1.00 cup 205.00 grams 79.95 calories				
Nutrient	Amount	DV (%)	Nutrient Density	World's Healthiest Foods Rating
vitamin A	7291.85 IU	145.8	32.8	excellent
vitamin C	19.68 mg	32.8	7.4	very good
potassium	895.85 mg	25.6	5.8	very good
dietary fiber	5.74 g	23.0	5.2	very good
manganese	0.43 mg	21.5	4.8	very good
folate	57.40 mcg	14.3	3.2	good
omega 3 fatty acids	0.34 g	14.2	3.2	good
vitamin B_1 (thiamin)	0.17 mg	11.3	2.6	good
copper	0.19 mg	9.5	2.1	good
tryptophan	0.03 g	9.4	2.1	good

vitamin B_6 (pyridoxine)	0.15 mg	7.5	1.7	good
vitamin B_3 (niacin)	1.44 mg	7.2	1.6	good
vitamin B_5 (pantothenic acid)	0.72 mg	7.2	1.6	good

World's Healthiest Foods Rating	Rule				
excellent	DV>=75%	OR	Density>=7.6	AND	DV>=10%
very good	DV>=50%	OR	Density>=3.4	AND	DV>=5%
good	DV>=25%	OR	Density>=1.5	AND	DV>=2.5%

3.1.3 Content claims made for core nutrients

When the nutrients present in buttercup squash are consumed in significant amounts they do have significant health benefits, both in terms of maintaining normally bodily functioning as well as preventing disease (Table 5). The most common `claims' with regards to nutritional composition of squash are its vitamin A equivalents. There is little doubt about these because the carotenoid (provitamin A) content is so high. Other claims have also been made. Both the New Zealand Buttercup Squash Council and LeaderBrand make claims on their websites.

New Zealand Buttercup Squash Council website (www.nzbsc.com/nutrition.php) makes the following claims:

- New Zealand Buttercup Squash is rich in beta carotene, with iron, vitamin C, potassium, and smaller traces of calcium, folic acid, and minute amounts of B vitamins.

Energy: Buttercup squash is packed with good energy: over 85% complex carbohydrates, 12% protein. It is an excellent choice for weight watchers.

Vitamin A & C: Just 200 g of Buttercup squash provides a whole day's vitamin C and vitamin A requirements.

Calcium: Buttercup squash skin packs 22% more calcium than the same weight of milk. It is ideal for helping prevent osteoporosis.

Iron: The skin also compares with the best source of iron – lean red meat.

Dietary fibre: Buttercup squash has more dietary fibre than potatoes, carrots or even kiwifruit.

Beta-carotene: Buttercup squash is one of the best sources of beta-carotene, comparable to carrots.

LeaderBrand makes the following claims for Buttercup squash on its website (www.leaderbrand.co.nz/Buttercup_Squash_47.aspx):

- Iron: The iron content of the LeaderBrand kabocha is comparable to red meat, the best source of iron!
- Calcium: LeaderBrand kabocha packs 22% more calcium than the same weight of milk. Calcium is an essential mineral, especially for woman.
- Vitamin A: 1 cup of mashed kabocha contains over 90% of the recommended daily intake.
- Energy: Over 85% of its energy is from carbohydrate and 12% from protein. With only 2.5% fat, kabocha is an excellent choice for weight watchers.
- Dietary Fibre: LeaderBrand kabocha has more dietary fibre than traditional “high fibre” vegetables like potatoes, carrots and kiwifruit.
- Beta-Carotene: LeaderBrand kabocha is an excellent source of beta-carotene, comparable to carrots.
- Magnesium: Just 1 cup of kabocha provides your daily magnesium needs. Magnesium is a major mineral involved in activating enzymes and muscle and nerve function.
- Other minerals contained in the flesh and skin include: zinc, copper, manganese and thiamine.

It appears that these data come from a report conducted by Barbara Burlingame for the Buttercup Squash Council in 1993. The two websites make similar claims although on the LeaderBrand site the fact that some values relate to content in the skin is not stated. The comments about energy on both sites are correct. Likewise, information on the vitamin A content is correct, although technically it is vitamin A equivalents or provitamin A – retinol itself (vitamin A) is not present in vegetables. However, there are discrepancies in the other data and these need to be adapted to ensure they are presented in the context of a healthy diet as generally consumed by New Zealanders The iron content of buttercup squash (steamed skin and flesh) is 0.6 mg/100 g whereas that of beef steak is around 3.6 mg/100 g. Buttercup squash can be considered a good source of iron as 1 cup (a serving) contains 18% of the RDI. While the iron content of the skin appears to be high (3.4 mg/100 g when steamed, although only 1.3 mg/100 g in raw skin), it is unlikely that anyone would eat the skin alone and in significant quantities for it to contribute as much to the diet as eating a serving of red meat. Likewise the calcium level of buttercup squash (steamed skin and flesh) is only 26 mg/100 g while milk contains 100–200 mg/100 ml. The calcium content of the skin is higher at 147 mg/100 g for steamed skin (although only 58 mg/100 g for raw skin) and would be regarded as a good source of calcium if a serving of skin was consumed, but again this is unlikely.

A few of the other statements may need some rewording:

- With regards to fibre, buttercup squash has a fibre content of 2.5 g/100 g when flesh is steamed (although one set of data gives a lower figure), potatoes around 2 g/100 g (depending on how prepared), carrots 3.2 g/100 g and kiwifruit 1.6 g/100 g. So squash is no higher in fibre than carrots.

- The β-carotene content of buttercup squash is high at 3180 µg/100 g, but carrots are even higher at 8900 µg/100 g. Squash might be higher in other carotenoids with specific health benefits, and this needs further examination.

- There are questions around the vitamin C content as the data differ significantly for raw and cooked in the New Zealand Food Composition Database. Taking the raw value, it is a good source of vitamin C but when steamed the content is minimal.

Table 5. Benefits of the key vitamin and minerals of buttercup squash.

Nutrient	RDI[a]	Health benefits[b]
Calcium	1000 mg	Essential for formation and maintenance of bones and teeth Plays a role in mediating the constriction and relaxation of blood vessels (vasoconstriction and vasodilation), nerve impulse transmission, muscle contraction, and the secretion of hormones like insulin Calcium is necessary to stabilise a number of proteins and enzymes, optimising their activities, and is especially important for blood clotting
Folate	400 µg	Coenzyme in DNA synthesis and amino acid synthesis. Important for preventing neural tube defects Key role in preventing stroke and heart disease, including reducing blood homocysteine levels with vitamin B_{12} May protect against colonic and rectal cancer Involved in the formation of blood cells May have benefits for bone health, cognitive function and diabetes
Iron	8 mg	Component of haemoglobin and myoglobin in blood, needed for oxygen transport Role in cellular function and respiration
Niacin	16 mg	Coenzyme or cosubstrate in many biological reduction and oxidation reactions required for energy metabolism and fat synthesis and breakdown Reduces LDL cholesterol and increases HDL cholesterol
Pantothenic acid	6.0 mg	Coenzyme in fatty acid metabolism and synthesis of some hormones Maintenance and repair of cell tissues
Potassium	3800 mg	Major ion of intracellular fluid Maintains water, electrolyte and pH balances Important in preventing high blood pressure Role in cell membrane transfer and nerve impulse transmission
Riboflavin (vitamin B_2)	1.3 mg	Important for skin and eye health Coenzyme in numerous cellular redox reactions

Nutrient	RDI[a]	Health benefits[b]
		involved in energy metabolism, especially from fat and protein
Thiamin (vitamin B_1)	1.2 mg	Coenzyme in the metabolism of carbohydrates and branched-chain amino acids Needed for nerve transmission Involved in formation of blood cells
Vitamin A equivalents	900 µg	Important for normal vision and eye health Involved in gene expression, embryonic development and growth and health of new cells Aids immune function and resistance to infection May protect against epithelial cancers and atherosclerosis Carotenoids have antioxidant activity
Vitamin B_6	1.3 mg	Coenzyme in nucleic acid metabolism, neurotransmitter synthesis, haemoglobin synthesis. Involved in neuronal excitation Reduces blood homocysteine levels Prevents megaloblastic anemia
Vitamin C (ascorbic acid)	45 mg	Necessary for healthy connective tissues – tendons, ligaments, cartilage, wound healing and healthy teeth Assists in iron absorption A protective antioxidant – may protect against certain cancers Involved in hormone and neurotransmitter synthesis May lower the risk of stroke
Vitamin E (tocopherols)	10 mg	Provides dietary support for heart, lungs, prostate, and digestive tract Reduces peroxidation of fatty acids Non-specific chain-breaking antioxidant May protect against atherosclerosis and some cancers

[a] RDI= Recommended dietary intake as given in Nutrient Reference Values for Australia and New Zealand Including Recommended Dietary Intakes (www.nhmrc.gov.au), where there is no RDI Adequate Intake (AI) values were used.
[b] Note these are not claims that could be made

3.2 Phytochemicals

Apart from the core nutrients there are phytochemicals present in squash. A phytochemical is *"a plant-derived chemical that is not considered an essential nutrient in the human diet but is believed to have beneficial health effects"* (see The Free Dictionary at www.thefreedictionary.com). Searches were conducted in the scientific literature to determine the extent of investigation into the phytochemical composition of squash. Information is summarised below and further details are also provided in Appendix 3.

3.2.1 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 human body and are present solely as a result of ingestion from other sources, either the plant source itself or a product from an animal that has consumed that plant source. 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 lipids 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 are also responsible for the compounds' antioxidant properties. These compounds have been found to be 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).

There are two general classes of carotenoids – the carotenes, and their oxygenated derivatives, the xanthophylls. The two groups are almost structurally identical, except that the xanthophylls have a terminal hydroxyl group. Their structure determines their properties and thus also their activities and physiological roles. The body can convert α-carotene, β-carotene and β-cryptoxanthin into retinol, or vitamin A. They are non-polar and hence tend to be located on the periphery of cell membranes. Lycopene and the xanthophylls lutein and zeaxanthin have no vitamin A capacity. The latter, being more polar, are believed to span cell membranes, with their hydrophobic hydrocarbon chain inside the lipid bilayer and their hydrophilic hydroxyl groups emerging on the other side (Gruszecki & Sielewiesiuk 1990). Because of their similarity, the two compounds are often reported as a combined total.

Carotenoids are fat-soluble compounds and thus are best absorbed in the body if accompanied by some form of oil or fat in the meal. It has also been shown that chopping and cooking helps to release carotenoids from the food matrix, which also increases their bioavailability.

The carotenoid content of some common yellow/orange fruits and vegetables is shown in Table 6. The carotenoid content of winter squash is not as high as of carrots or sweet potato, but it is still significant.

Table 6. The carotenoid content of assorted yellow/orange fruits and vegetables (μg/100 g) from USDA National Nutrient Database for Standard reference, Release 22 (2009).

Food	β-carotene	α-carotene	β-cryptoxanthin	Lycopene	Lutein + zeaxanthin
Apricot	1094	19	104	0	89
Capsicum, red, raw	1624	20	490	308	51
Capsicum, yellow, raw	120	na	na	Na	Na
Carrot, raw	8285	3477	125	1	256
Carrot, boiled	8332	3776	202	0	687
Corn, raw	52	18	127	0	764
Corn, boiled	66	23	161	0	967
Melon	2020	16	1	0	26
Orange	87	7	116	0	129
Peach	162	0	67	0	91
Persimmon	253	0	1447	159	834
Pumpkin, raw	3100	515	2145	0	1500

Pumpkin, boiled	2096	348	1450	0	1014
Squash, winter, raw	820	0	0	0	38
Squash, winter, baked	2793	682	0	0	1415
Sweet potato, raw	8506	7	0	0	0
Sweet potato, boiled	9444	0	0	0	0

A search of the literature found many references examining the colour and carotenoid composition of squash with some papers specifically referring to at buttercup squash. As noted above squash contain high levels of both α- and β-carotene (considered core nutrients in some respects because they have provitamin A activity). Other carotenoids are also present, including lutein, zeaxanthin, violaxanthin, antheraxanthin, cucurbitaxanthin, zeaxanthin, β-cryptoxanthin, lycopene, neoxanthin and zeta-carotene.

The exact composition of carotenoids does vary between studies and often relates to the particular type of squash analysed. In some studies β-carotene is the predominant carotenoid while in others lutein is predominant. This is probably due to the particular type of squash analysed. The carotenoids of fully ripe Japanese squash were analysed at maturity (Kon & Schimba 1988). The total carotenoid content was 6200 µg/100 g fresh weight. The carotenoids were lutein (63.9%), α-carotene (10.9 %), β-carotene (7.8%), antheraxanthin (6.0%), vioalaxanthin (4.3%), α-cryptoxanthin (2.6%) and minor other components

One study examining the lutein content in several selected crops grown in southern Ontario, Canada found free lutein to be the predominant form in three squash cultivars (Tsao & Yang 2006). It was mostly found in the skin rather than the more commonly consumed flesh. `Sweet Mamma', `Buttercup' and `Pepper' squash cultivars contained 25.4, 18.4 and 30.1 mg/100 g fresh weigh (FW) of lutein in the skin, respectively. These concentrations were significantly higher than those in spinach and kale (3.7 and 12.3 mg/100 g FW). Most of the β-carotene was found in the skin of `Sweet Mamma' squash – 13.6 mg/100 g FW – whereas it was below 2 mg/100 g FW in samples of the skin of other cultivars or in the flesh. Cooking increased extractable free lutein by 22–65% in squash skins.

As noted earlier, the carotenoid composition of squash has been determined and reported in the literature and databases, but data are highly variable, both qualitatively and quantitatively. One of the reasons may be variability in the type of pumpkin/squash analysed (these are not always well defined in papers and sometimes the assignments are wrong). The carotenoid composition of squashes and pumpkins currently marketed in Brazil was determined by HPLC-DAD, complemented by HPLC-MS for identification (Azevedo-Meleiro & Rodriguez-Amaya 2007). *Cucurbita moschata* 'Menina Brasileira' and *C. moschata* 'Goianinha' had similar profiles, with β-carotene and α-carotene as the major carotenoids. The hybrid 'Tetsukabuto' resembled the *Cucurbita pepo* 'Mogango', lutein and β-carotene being the principal carotenoids. *Cucurbita maxima* 'Exposicao' had a different profile, with the predominance of violaxanthin, followed by β-carotene and lutein. Combining data from the current study with those in the literature, profiles for the Cucurbita species could be observed. The principal carotenoids in *C. moschata* were β-carotene and α-carotene whereas lutein and β-carotene dominate in *C. maxima* and *C. pepo*.

Further study is suggested to confirm the exact composition of New Zealand-grown buttercup squash and distribution in skin and flesh.

Other phytochemicals

The study of other phytochemicals in *C. maxima* in general is very limited with only a handful of researchers mentioning them. One of the main phytochemical groups in fruit and vegetables is the phenolics. Phenolic compounds are a large group of secondary plant products that differ in chemical structure and reactivity. They are present in most, if not all, plants. The chemical structures range from quite simple compounds, like caffeic acid, to highly polymerised substances, like tannins. Their contribution to the pigmentation of plants is well recognised, although not all phenolics are coloured. There are numerous different groups of phenolics, but the most common phenolics found in foods generally belong to phenolic acids, flavonoids, lignans, stilbenes, coumarins and tannins. They are of interest primarily because of their radical scavenging and antioxidant activities, which are determined by their structure, particularly the number and configuration of H-donating hydroxyl groups (Soobrattee et al. 2005).

Little is known about the phenolic compounds of pumpkin and squash, let alone buttercup squash. Small amounts of vanillic acid, p-coumaric acid, and sinapic acid were found in pumpkin skin (Schmidtlein 1975). The flavone luteolin was found in pumpkin puree at the concentration of 16.3 mg/kg (Lugasi 2002). A more recent study found the major phenolic compounds in squash (*C. maxima* cv. `Turkinja') to be chlorogenic and syringic acids with smaller amounts of caffeic (Dragovic-Uzelac 2005). The levels of these phenolic acids were very low though at less than 5 mg/100 g FW. The total phenolic content of squash is around 35 mg/100 g. This is low compared to berryfruit, which can have phenolic contents in excess of 1000 mg/100 g. A recent report examining the antioxidant activityof the pericarp of *C. maxima* Duch. ex Lam found total polyphenolic, flavonoid and flavonol contents of methanol extracts to be 1200 mg/100 g (gallic acid equivalent), 380 mg/100 g and 80 mg/100 g (rutin equivalent) respectively (Attarde 2010). However, the full paper was not available to establish the validity of these data and if the results were expressed on a fresh weight basis.

The only other phytochemical components noted in the literature were polyamines and galactolipids. Foods found to be rich in polyamines include Japanese pumpkin (Nishimura 2006). It is unclear if this is buttercup squash and further details were unavailable. Polyamines may be important in the diet especially as we age. Galactolipids are a class of compounds widely found in the plant kingdom, including edible plants, and are an important part of the cell membranes. Galactolipids in plants consist mainly of monogalactosyldiacylglycerols and digalactosyldiacylglycerols,which contain one or two saturated and/or unsaturated fatty acids linked to the glycerol moiety. Several galactolipids have been shown to possess *in vitro* and/or *in vivo* anti-tumour promoting activity and anti-inflammatory activity. Recently, it has been demonstrated that the galactolipid, 1,2-di-O-alpha-linolenoyl-3-O-beta-D-galactopyranosyl-sn-glycerol (1), may be important for the anti-inflammatory activity of dog rose (*Rosa canina*), a medicinal plant with documented effect on anti-inflammatory diseases such as arthritis. This galactolipid also occurs in relative high concentrations in certain legumes (e.g. common bean, pea), leaf vegetables (e.g. kale, leek, parsley, perilla and spinach), stem vegetables (e.g. asparagus, broccoli, Brussels sprouts), and fruit vegetables (e.g. chilli, bell pepper, pumpkin). No further details could be found.

3.2.2 Bioavailability and significance of intake

In addition to the actual content of phytochemicals, it is important to consider their bioavailability because for many compounds this is a limiting factor. The area of bioavailability broadly addresses the issue of how well a compound is absorbed so that it can be utilised by the body. It involves the degree and rate at which a substance is absorbed into a living system or is made available at the site of physiological activity. Absorption may be determined by a range of variables, such as the chemical structure and nature of the compound, the amount consumed, the food matrix in which it is contained, the presence of other compounds within the meal and the nutrient status of the subject.

Carotenoids have been widely investigated in terms of bioavailability. The large difference between the number of carotenoids ingested as plant material and those absorbed into human plasma indicates selective uptake. Carotenoids occur in plants in three forms:

- As part of the photosynthetic apparatus, where they are complexed to proteins in chromoplasts and trapped within the cell structures, and are thus protected from absorption (green, leafy vegetables)

- Dissolved in oil droplets in chromoplasts, which are readily extracted during digestion (mango, papaya, pumpkin and sweetpotato)

- As semi-crystalline membrane-bound solids (carrot, tomato), which, though soluble in the intestinal tract, probably pass through too quickly to allow much solubilisation.

These differences in location and form strongly affect absorption and explain differences in bioavailability in different food matrices (Borel 2003). Particle size and cooking, which breaks down the cell matrix of the food, also influence uptake, presumably by making the carotenoid more available for absorption in the lumen.

It should be noted that hydrocarbon carotenoids (e.g. β-carotene, lycopene) are absorbed differently from xanthophylls (e.g. lutein, zeaxanthin). Within the intestinal lumen, the non-polar carotenes are thought to be located in the hydrophobic core of lipid emulsions and bile salt micelles, whereas the more polar xanthophylls are thought to be located at the surface (Borel et al. 1996).

The presence of fat or oil, either as part of the meal (e.g. in whole milk, cheese or a dressing) or used in cooking, also increases absorption. Because carotenoids are fat-soluble compounds, they are absorbed in parallel with fat metabolism, and it has been estimated that a fat intake of at least 5 g of fat per day is necessary for an adequate uptake of dietary carotenoids (West & Castenmiller 1998). Polyunsaturated fatty acid rich dietary fat increases serum response to β-carotene more than does mono-unsaturated fatty acid-rich dietary fat. The solubility of β-carotene and zeaxanthin decreases with increased chain length in triglyceride fatty acids.

Protein present in the small intestine also assists absorption through the stabilisation of fat emulsions and enhanced micelle formation with associated carotenoid uptake (West & Castenmiller 1998). Lecithin may also promote the absorption of fat-soluble vitamins and carotenoids as well as triglycerides by facilitating micelle formation. Similarly, long-chain fatty acids that increase cholesterol absorption may also increase the absorption of solubilised lipophilic phytochemicals (West & Castenmiller 1998).

Dietary fibre has a negative effect on β-carotene bioavailability. It is thought that fibre may entrap carotenoids and, through its interaction with bile acids, increase the excretion of bile acids. This, in turn, may reduce the absorption of fats and fat-soluble substances, including carotenoids (Yeum & Russell 2002). The presence of soluble fibre, in the form of citrus pectin, has been shown to reduce the increase in β-carotene absorption following ingestion of a β-carotene capsule (Rock & Swendseid 1992, cited in West & Castenmiller, 1998). Similarly, Hoffmann et al. (1999) showed that dietary fibre, pectin, guar and cellulose supplementation decreased antioxidant activity of a carotenoid and α-tocopherol mixture (Yeum & Russell 2002).

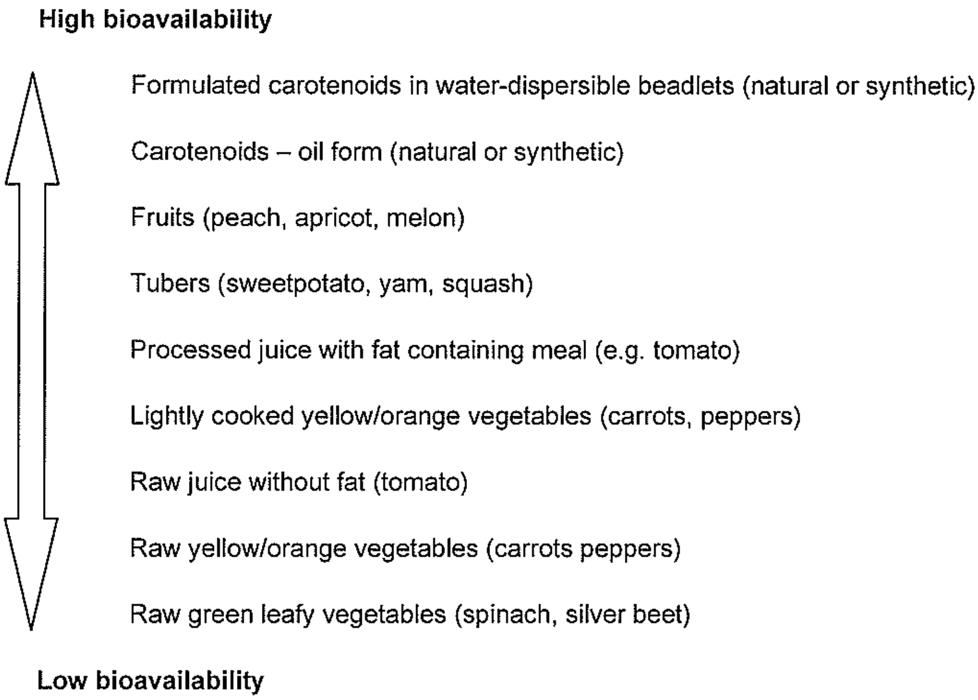

Figure 2. Relative bioavailability of carotenoids according to food matrix (adapted from Boileau et al. 1998; Lister 2003).

This relatively high bioavailability means that carotenoids in buttercup squash may have advantages over other common dietary sources of carotenoids (e.g. carrots, tomatoes). Relative bioavailability of β-carotene from pumpkin was found to be 1.8 times greater than that from spinach, based on data from faeces compared with 1.7 times based on data from serum (van Lieshout 2003). Another bioavailability study showed that the contribution to the recommended daily allowance is greater when pumpkins are prepared as a curry with coconut milk. The percentage contribution to recommended daily allowance from pumpkin cooked with coconut milk was 21.8% (Priyadarshani 2007).

4 Health benefits

Few studies have examined the health benefits of *Cucurbita maxima* and what there is is summarised in Appendix 4. The lack of study is not because these vegetables are nutritionally worthless, but rather reflects the fact that for some reason squash is not particularly popular in the USA or Europe.

As noted in Table 5, the core nutrients have a wide range of health benefits. The potassium in squash may help to lower blood pressure, and the vitamin C present may help reduce the severity of conditions like asthma, osteoarthritis, and rheumatoid arthritis and also to prevent the progression of conditions like atherosclerosis and diabetic heart disease. Fibre may help to fight heart disease and colon cancer. In addition to its ability to lower high cholesterol levels, which reduces the risk of heart disease, the fibre found in winter squash can also prevent cancer-causing chemicals from attacking colon cells. This is one of the reasons why diets high in fibre-rich foods have been associated with a reduced risk of colon cancer.

In addition to the core nutrients, the phytochemicals may carry other benefits.

4.1 Anti-cancer

Although not as potent as root vegetables like burdock, garlic or onion, winter squash has been found to have anti-cancer type effects. Phytonutrient research on squash is still limited, but some lab studies have shown vegetable juices obtained from squash to be equal to juices made from leeks, pumpkin, and radish in their ability to prevent cell mutations (cancer-like changes). The prostate cancer risk declined with increasing consumption of lycopene, α-carotene, β-carotene, β-cryptoxanthin, lutein and zeaxanthin. Intake of tomatoes, pumpkin, spinach, watermelon and citrus fruits was also inversely associated with rates of prostate cancer.

Phenolic acids such as those found in buttercup squash skin, have been found to have some antioxidant/radical quenching activity (Attarde 2010). In particular, some phenolic acids are believed to help combat the effects of carcinogenic nitrosamines, such as those in some processed meats and cigarette smoke (Joseph et al. 2002). Carotenoids have also been shown to have anti-cancer benefits (see below).

4.2 Diabetes

Over the centuries, Chinese herbal drugs have served as a major source of medicines for the prevention and treatment of diseases, including diabetes mellitus (known as 'Xiao-ke'). It is estimated that more than 200 species of plants exhibit hypoglycaemic properties, including many common plants, such as pumpkin, wheat, celery, wax guard, lotus root and bitter melon (Jia 2003). Other cultures have also used *Cucurbita* spp. for the treatment/prevention of diabetes. There has been some report in the scientific literature to substantiate these benefits (Kwon et al. 2007; Quanhong et al. 2005; Suzuki et al. 2002). The benefits may be wider than just blood glucose control; phenolics also reduce hyperglycemia-induced pathogenesis and associated complications linked to cellular oxidation stress and hypertension (Kwon et al. 2007). Antidiabetic effects have been attributed to the phenolics but also protein-bound polysaccharide fractions from the fruits (Quanhong et al. 2005). Another study showed trigonelline and nicotinic acid from the flesh of pumpkins suppressed both triglycerides and the accumulation and the progression of diabetes (Yoshinari 2009).

4.3 Other health benefits of related species

Because of the lack of information for buttercup squash and even *C. maxima* in general searches were conducted to see what health benefits have been reported for other cucurbits. There may be similarities in the benefits because of similarities in phytochemical composition. The following reports were found:

- In research studies, extracts from *Cucurbita pepo* have also been found to help reduce symptoms of a condition occurring in men called benign prostatic hypertrophy, or BPH (Wilt 2000). In this condition, the prostate gland becomes problematically enlarged, which can cause difficulty with urinary and sexual function. Particularly in combination with other phytonutrient-containing foods, squash may be helpful in reducing BPH symptoms.

- A significant decrease in alkaline phosphatase (AP) activity and mucosal thickness and increase in ulcer index (UI) was observed in aspirin treated stomach and duodenum of albino rats. However, pretreatment with *C. pepo* fruit pulp extract for 14 consecutive days showed increase in AP activity and mucosal thickness along with decrease in UI, suggesting gastroduodenal protective and anti-ulcerogenic properties of *C. pepo* (Sarkar 2008).

- During the screening of a variety of plant sources for their anti-obesity activity, it was found that a water-soluble extract, named PG105, prepared from stem parts of *Cucurbita moschata*, contains potent anti-obesity activities in a high fat diet-induced obesity mouse model (Choi 2007).

- In the present study, the antihyperglycemic effects of *Cucurbita ficifolia* fruit extract were investigated on streptozotocin-induced experimental diabetes in rats. Oral administration of the extract (300 and 600 mg/kg body weight, day) for 30 days significantly reduced blood glucose, glycosylated haemoglobin, and an increase in plasma insulin and total haemoglobin. The effect was compared with 150 mg/kg bw tolbutamide.(Xia 2006).

- Bioassay-guided purification of an extract of *Cucurbita andreana* fruits yielded cucurbitacins B (1), D (2), E (3), and I (4). These cucurbitacins had inhibitory effects on the growth of human colon (HCT-116), breast (MCF-7), lung (NCI-H460), and central nervous system (CNS) (SF-268) cancer cell lines, and cyclooxygenase-2 (COX-2) enzymes and on lipid peroxidation (Jayaprakasam 2003).

These studies back up some of the traditional usages of pumpkins/squash.

4.4 Health benefits of carotenoids in general

α- and β-carotene differ only very slightly in structure. They are very commonly occurring carotenoids and are antioxidants, as well as having other potential health benefits. As mentioned earlier, both can be converted into vitamin A by the body, though β-carotene has about twice the provitamin A activity of α-carotene. Sometimes carotenoid content is measured as retinol (pre-formed vitamin A) equivalents; β-carotene has 1/6 the vitamin A activity of retinol while α-carotene and β-cryptoxanthin each have about 1/12. **Note:** Although there is some controversy internationally regarding the carotenoid/retinol conversion rate, the rates above are used in New Zealand and Australia in accordance with the FAO/WHO decision (Health 2004).

4.4.1 β-carotene

Of the carotenoids, β-carotene has probably been the focus of most research. Epidemiological studies have demonstrated that high intakes of fruit and vegetables protect against a range of chronic diseases and problems associated with ageing. Carotenoid-rich foods have also been associated with health benefits for some time and this has been attributed largely to the β-carotene they contain. It was hypothesised that β-carotene might help prevent the formation of lesions that led to cancer, and in vitro cell experiments have indicated that carotenoids also possess properties consistent with anti-cancer activity, e.g. they may play an important role in the cell communication that leads to the removal of pre-cancerous cells. However, results have been somewhat inconsistent. For example, although a review of case control studies looking at diet and breast cancer found a significant inverse association between β-carotene intake and breast cancer in 4 studies, 5 studies found no association and 7 studies found only a loose association, which was not statistically significant (Cooper et al. 1999). Similarly, although early studies observed a protective effect of β-carotene on lung cancer, more recent studies have found no significant association between dietary β-carotene intake and lung cancer risk. A study evaluating the effect of β-carotene supplements on lung cancer risk in smokers and other at-risk groups found that the risk of developing lung cancer actually increased in those taking supplements. However, no such effect has been found in studies where the β-carotene was consumed as part of a food as opposed to a supplement form, where the compound has been isolated and concentrated. Mixed results have also been reported from studies relating to prostate and colorectal cancer.

Similarly, there have been mixed results regarding the effect of dietary β-carotene on cardiovascular disease. It has been established that the development of cardiovascular disease involves the oxidation of low-density lipoprotein (LDL) and its subsequent uptake by foam cells in the vascular endothelium, where it can lead to the development of atherosclerotic lesions. It was hypothesised that β-carotene, which itself is carried in LDL, might help prevent this oxidation, as a number of in vitro studies had shown it to be capable of scavenging potentially damaging radicals. However, whilst some research has shown higher plasma levels of carotenoids to be associated with better vascular health and lower cardiovascular disease risk, other studies have shown no effect (Higdon 2005; Cooper et al. 1999). Further, some recent studies have produced contradictory results regarding the ability of β-carotene to stabilise LDL against oxidation (Cooper et al. 1999).

β-carotene may also protect against diabetic heart disease and may be useful for preventing other complications caused by free radicals often seen in long-term diabetes. Additionally, intake of foods such as winter squash that are rich in carotenoids may be beneficial to blood sugar regulation. Research has suggested that physiological levels, as well as dietary intake, of carotenoids may be inversely associated with insulin resistance and high blood sugar levels.

β-carotene has also been demonstrated to improve iron absorption in vitro and in human absorption studies by a mechanism that is yet to be elucidated but could be associated with its provitamin-A activity. Carotenoid without provitamin A activity (lycopene, lutein, and zeaxanthin) have also been shown to significantly increase iron absorption in human beings from corn and wheat meals. A range of carotenoids tested (lycopene, lutein, or zeaxanthin) were capable of overcoming coffee-mediated inhibition of iron absorption (Garcia-Casal 2006).

Finally, β-carotene's anti-inflammatory effects may help to reduce the severity of conditions like asthma, osteoarthritis, and rheumatoid arthritis, which all involve inflammation.

4.4.2 α-carotene

α-carotene is less well-known and studied than β-carotene, but it has shown some promising results. Some studies have shown α-carotene to be even more effective than β-carotene at inhibiting cancer cells.

4.4.3 β-cryptoxanthin

This carotenoid is orange-yellow in colour and is found in various fruits and vegetables, including pumpkins. There are indications that it may play an important role in cardiac health. It may also significantly lower the risk of developing lung cancer. A study published in Cancer Epidemiology, Biomarkers and Prevention reviewed dietary and lifestyle data collected from over 60,000 adults in China and found that those eating the most crytpoxanthin-rich foods showed a 27% reduction in lung cancer risk. When current smokers were evaluated, those who were also in the group consuming the most cryptoxanthin-rich foods were found to have a 37% lower risk of lung cancer than smokers who ate the least of these health-protective foods.

4.4.4 Lutein and zeaxanthin

These two carotenoids are often grouped together as they have very similar structure and functions and it is only relatively recently, with technology such as high performance liquid chromatography (HPLC), that it has been possible to differentiate between the two individual compounds. Lutein and zeaxanthin are essential for maintaining proper vision and may help to prevent macular degeneration and cataracts. They may also help to reduce the risk of certain types of cancer.

4.5 The health benefits of other plant parts

In addition to the fruits, other plant parts have been shown to have health benefits:

- Pumpkin/squash leaves are eaten in some cultures. The leaves of *C. maxima* are rich in lutein and have strong provitamin A activity. The lutein is quite bioavailable (Chandrika et al. 2010; Priyadarshani et al. 2007).

- Pumpkin seed oil has been used in the treatment of dietary-induced high cholesterol (Al Zuhair et al. 1997), treatment of arthritis (Fahim et al. 1995) and testosterone-induced hyperplasia of the prostate (Gossell-Williams et al. 2006).

- Effects of pumpkin (*C. maxima*) seed flours on glucose and lipid metabolism were studied in recently weaned male Wistar rats (Machado de Cerqueira et al. 2008). Results indicated that pumpkin seed flours are good sources of protein, lipids and dietary fibre. The animals showed similar growth and food intake. Glucose and triglycerides were significantly decreased in the groups consuming diets with whole- and sifted-pumpkin seed flours, respectively.

- Investigation of the effects of pumpkin seed (*Cucurbita pepo*) on sexual behaviour of inexperienced male rats showed an increase in sexual performance in terms of intromissions and ejaculatory latency, which also improved sexual sensation and coupulatory efficiency (Gundidza et al. 2009).

5 Conclusions & future research

In conclusion, buttercup squash clearly has significant merit in terms of its nutritional composition with a number of vitamins and minerals making a significant contribution to daily intake. Buttercup squash can be considered a good source (>25% RDI) of vitamin A. Although buttercup squash does not contain retinol (vitamin A), it is a good source of vitamin A because it contains high levels of provitamin A carotenoids (α- and β-carotene, as well as β-cryptoxanthin). In addition, it is also a good source of folate and vitamin E and possibly potassium, although for this mineral there is significant variation in levels between raw and cooked that may affect the accuracy of claims. Likewise the large differences in the vitamin C content of raw and steamed buttercup squash require further investigation. In addition to those vitamins and minerals that reach good source levels, buttercup squash can be considered a source of a number of others (i.e. by providing more than 10% RDI). These include iron, niacin, pantothenic acid, riboflavin, thiamine and vitamin B_6. Apart from the core nutrients, phytochemicals are present in squash. The main class of phytochemical present is the carotenoids. The only other phytochemical components noted in the literature for squash are phenolics, polyamines and galactolipids.

Evaluation of the food composition data and the literature clearly show gaps in the information available for buttercup squash. The following ideas are some suggestions for future research that could be conducted.

5.1 Nutritional composition

The first priority for research should be the analysis of New Zealand-grown buttercup squash to provide accurate data for possible nutrient content (and function) claims. As noted earlier in this report there are discrepancies in some of the existing data (discussed in Section 2). In order to provide accurate and relevant data it will be very important to determine: best sampling methods (multiple fruits from multiple locations or a typical location, length of storage before analysis [in order to analyse as the fruit would be as delivered to the consumer] and form in which analysed (whole steamed pieces, flesh alone). The cost of this research will be dependent on the numbers of nutrients analysed and numbers of samples taken but would be expected to be in the range of $5–15k.

Future work could then be conducted to determine the optimal cooking method to retain nutrients for which claims could be made. Research could also be undertaken to tailor recipes to maximise nutrients/health benefits (e.g. use of healthy oils to enhance carotenoid uptake).

5.2 Phytochemical composition

There is very limited specific data on the phytochemical composition of buttercup squash. Early work was done on carotenoid content but there may be some value in using LC_MS to examine the detailed carotenoid composition. It would appear that there are only low levels of phenolics in buttercup squash, although the only data we have are for raw samples. Thus, there is merit in a preliminary investigation of the phenolic levels in squash. If levels are significant then more detail could be looked at. The cost will depend on level of detail required, but for a first step to look at carotenoid composition and total phenolic levels investment required is likely to be around $5k.

There other aspects of phytochemical composition and efficacy that could be invested in. For example, it is suggested that the carotenoids from buttercup squash may be more bioavailable than other carotenoid sources. This could be an area for future examination and would require human study (although relatively simple short-term trials). Investment would be in excess of $20k.

5.3 Health benefits

With the major lack of information on the health benefits of buttercup squash, this is an area for possible future investment but is likely to require leveraged funding. The key areas where there are indications that buttercup squash may have significant benefits include:

- Diabetes/obesity
- Eye health
- Ability to increase iron absorption
- Digestive health.

Investment for this type of research, including human clinical trials, would be in excess of $100k, although it would be possible to conduct a small-scale clinical trial to determine whether buttercup squash enhanced iron absorption from a meal for less investment.

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Appendix 1

Table 7. Detailed composition of buttercup squash as taken from the New Zealand Food Composition Database. Note the letters after the data are the source codes as given below (i.e. where the data was derived).

00 FOOD IDENTIFIER		X192	X225	X178	X229	X263
Food Name	Food Name	Squash,Buttercup, flesh,raw	Squash,Buttercup, flesh,steamed	Squash,Buttercup, skin,raw	Squash,Buttercup, skin, steamed	Squash,Buttercup, flesh & skin, steamed
Ash	g/100 g	0.81[rz]	1.1[z]	0.9[z]	1.2[z]	1.11[cz]
Beta-carotene equivalents	µg/100 g	3180[rz]	2590[cz]	3180[rz]	2590[cz]	2460.5[cz]
Biotin	µg/100 g	0.3[br]	0.3[bcr]	0.1[bg]	0.31[bgr]	0.3[bcgr]
Calcium	mg/100 g	17.9[z]	16[cz]	57.7[z]	147[cz]	26.48[cz]
Carbohydrate, available	g/100 g	11.14[crz]	18.4[cz]	11.15[crz]	12.6[cz]	17.94[cz]
Carbohydrate, total (by difference)	g/100 g	13.9[cdrz]	18.7[cdrz]	12.26[cdrz]	13.08[cdz]	18.25[cdrz]
Carbohydrate, total (by summation)	g/100g	13.44[acrz]	21[acz]	13.05[cruz]	14[cuz]	20.44[acuz]
Carbohydrate,avail (monosaccharide equivalents)	g/100 g	11.78[cdrz]	19.88[cdz]	11.8[cdrz]	13.77[cdz]	19.39[cz]
Chloride	mg/100 g	46.7[rz]	49[grz]	47[rz]	49[grz]	-
Cholesterol	mg/100 g	0[p]	0[p]	0[p]	0[p]	0[p]
Copper	mg/100 g	0.06[z]	0.04[cz]	0.09[z]	0.22[cz]	0.05[cz]
Density	g/cm^3	0.5[z]	0.89[z]	0.8[rxz]	0.9[rxz]	0.6[rxz]
Dietary fibre, (Prosky)	g/100 g	2.3[a]	2.6[a]	1.9[u]	1.4[u]	2.5[acu]
Dietary Folate Equivalents	µg/100 g	50[cdpz]	46[cdpz]	21[cdpz]	133[cdpz]	45.02[cdpz]

00 FOOD IDENTIFIER		X192	X225	X178	X229	X263
Food Name	Food Name	Squash,Buttercup, flesh,raw	Squash,Buttercup, flesh,steamed	Squash,Buttercup, skin,raw	Squash,Buttercup, skin, steamed	Squash,Buttercup, flesh & skin, steamed
Disaccharides, total	g/100 g	0[cz]	0[cz]	0.2[crz]	0[cz]	0[cz]
Disaccharides, total (monosaccharide equivalents)	g/100 g	0[cdz]	0[cdz]	0.21[cdrz]	0cdz	0[cz]
Dry matter	g/100 g	16.3[crz]	21.9[cz]	16.3[crz]	23.9[cz]	22.06[cz]
Edible portion	%	100[br]	100[br]	100[g]	100[g]	82[b]
Energy (kilocalories, incl fibre)	kcal/100 g	56.3[acdprz]	88.21[acdprz]	64.06[cdpruz]	101.09[cdpuz]	89.24[acdpruz]
Energy, total metabolizable (incl fibre)	kJ/100 g	235.54[acdprz]	369.08[acdprz]	268.01[cdpruz]	422.96[cdpuz]	373.39[acdpruz]
Energy, total metabolizable (kcal)	kcal/100 g	51.9[cdprz]	83.24[cdprz]	60.42[cdprz]	98.41[cdpz]	84.45[cdprz]
Energy, total metabolizable (kJ)	kJ/100 g	217.14[cdprz]	348.28[cdprz]	252.81[cdprz]	411.76[cdpz]	353.36[cdprz]
Fat, total	g/100 g	0.22[rz]	0.29[crz]	0.7[z]	2[cz]	0.43[crz]
Fatty acids, tot. monounsat. (per 100 g tot.FA)	g/100 g	-	-	-	-	10.251cdruz
Fatty acids, tot.monounsat	g/100 g	0.019[ruz]	0.025[cruz]	0.06[ruz]	0.173[cruz]	0.035[cruz]
Fatty acids, tot.polyunsat.	g/100 g	0.105[ruz]	0.139[cruz]	0.335[ruz]	0.958[cruz]	0.205[cruz]
Fatty acids, tot.polyunsat. (per 100 g tot.FA)	g/100 g	-	-	-	-	59.899[cdruz]
Fatty acids, tot.sat.	g/100 g	0.051[ruz]	0.068[cruz]	0.164[ruz]	0.469[cruz]	0.1[cruz]

00 FOOD IDENTIFIER		X192	X225	X178	X229	X263
Food Name	Food Name	Squash,Buttercup, flesh,raw	Squash,Buttercup, flesh,steamed	Squash,Buttercup, skin,raw	Squash,Buttercup, skin, steamed	Squash,Buttercup, flesh & skin, steamed
Fatty acids, tot.sat. (per 100 g tot.FA)	g/100 g	-	-	-	-	29.311^{cdruz}
Fatty acids, total	g/100 g	0.176^{cdrz}	0.232^{cdrz}	0.56^{cdz}	1.6^{cdz}	0.341^{cdrz}
Folate food, naturally occuring food folates	µg/100 g	50^{cz}	46^{cdpz}	21^{cdpz}	133^{cdpz}	45.02^{cz}
Folic acid, synthetic folic acid	µg/100 g	0^{p}	0^{p}	0^{p}	0^{p}	0^{p}
Fructose	g/100 g	2.35^{crz}	1.8^{z}	2.2^{rz}	0.4^{z}	1.69^{cz}
Glucose	g/100 g	2.44^{crz}	1.8^{z}	2.4^{rz}	0.5^{z}	1.7^{cz}
Iodide	µg/100 g	0.69^{crz}	0.69^{crz}	0.69^{crz}	0.69^{crz}	0.66^{crz}
Iron	mg/100 g	0.66^{z}	0.39^{cz}	1.3^{z}	3.43^{cz}	0.63^{cz}
Lactose	g/100 g	0^{cz}	0^{z}	0^{cz}	0^{z}	0^{cz}
Lactose (monosaccharide equivalents)	g/100 g	0^{cdz}	0^{cdz}	0^{cdz}	0^{cdz}	0^{cz}
Magnesium	mg/100 g	9.5^{z}	13^{cz}	84.7^{z}	216^{cz}	29.24^{cz}
Maltose	g/100 g	0^{cz}	0^{z}	0^{z}	0^{z}	0^{cz}
Maltose (monosaccharide equivalents)	g/100 g	0^{cdz}	0^{cdz}	0^{cz}	0^{cdz}	0^{cz}
Manganese	µg/100 g	40^{z}	84^{cz}	268^{cdz}	683^{cz}	131.92^{cz}
Monosaccharides, total	g/100 g	4.79^{crz}	3.6^{cz}	4.6^{crz}	0.9^{cz}	3.38^{cz}
Niacin equivalents from tryptophan	mg/100 g	0.3^{auz}	0.5^{auz}	0.5^{auz}	1.7^{auz}	0.57^{acuz}

00 FOOD IDENTIFIER		X192	X225	X178	X229	X263
Food Name	Food Name	Squash,Buttercup, flesh,raw	Squash,Buttercup, flesh,steamed	Squash,Buttercup, skin,raw	Squash,Buttercup, skin, steamed	Squash,Buttercup, flesh & skin, steamed
Niacin equivalents, total	mg/100 g	0.71^{acruz}	1.29^{acuz}	0.9^{acuz}	2.63^{acuz}	1.33^{acuz}
Niacin, preformed	mg/100 g	0.41^{rz}	0.79^{z}	0.4^{rz}	0.93^{z}	0.76^{cz}
Nitrogen, total	g/100 g	0.22^{rz}	0.29^{crz}	0.39^{z}	1.22^{cz}	0.36^{crz}
Pantothenic acid	mg/100 g	0.4^{ru}	0.4^{gru}	0.4^{ru}	0.4^{gru}	0.4^{cgru}
Phosphorus	mg/100 g	31^{z}	22^{cz}	146^{z}	352^{cz}	48.4^{cz}
Polysaccharides, non-starch	g/100 g	1.03^{z}	1.2^{z}	1.71^{z}	2.3^{z}	1.29^{cz}
Polysaccharides, non-starch, water-insoluble	g/100 g	0.67^{z}	1.1^{z}	1.35^{z}	1.7^{z}	1.15^{cz}
Polysaccharides, non-starch, water-soluble	g/100 g	0.36^{cz}	0.1^{cz}	0.36^{cz}	0.6^{cz}	0.14^{cz}
Potassium	mg/100 g	471^{z}	375^{cz}	315^{z}	760^{cz}	405.8^{cz}
Protein, total; calculated from total nitrogen	g/100 g	1.38^{cdrz}	1.81^{cdrz}	2.44^{cdz}	7.63^{cdz}	2.28^{cdrz}
Retinol	µg/100 g	0^{p}	0^{p}	0^{p}	0^{p}	0^{p}
Riboflavin	mg/100 g	0.01^{rz}	0.11^{z}	0.01^{rz}	0.31^{z}	0.12^{cz}
Selenium	µg/100 g	0^{z}	0.81^{crz}	0.7^{rz}	0.8^{grz}	0.81^{cgrz}
Sodium	mg/100 g	0.79^{z}	2^{cz}	1.2^{z}	3^{cz}	2.08^{cz}
Starch, total	g/100 g	6.35^{rz}	14.8^{cz}	6.35^{rz}	11.7^{cz}	14.55^{cz}
Starch, total (monosaccharide equivalents)	g/100 g	6.99^{cdrz}	16.28^{cdz}	6.99^{cdrz}	12.87^{cdz}	16.01^{cz}

00 FOOD IDENTIFIER		X192	X225	X178	X229	X263
Food Name	Food Name	Squash,Buttercup, flesh,raw	Squash,Buttercup, flesh,steamed	Squash,Buttercup, skin,raw	Squash,Buttercup, skin, steamed	Squash,Buttercup, flesh & skin, steamed
Sucrose	g/100 g	0^{cz}	0^{z}	0.2^{rz}	0^{z}	0^{cz}
Sucrose (monosaccharide equivalents)	g/100 g	0^{cdz}	0^{cdz}	0.21^{cdrz}	0^{cdz}	0^{cz}
Sugars, total	g/100 g	4.79^{crz}	3.6^{cz}	4.8^{crz}	0.9^{cz}	3.38^{cz}
Sugars, total (monosaccharide equivalents)	g/100 g	4.79^{cdrz}	3.6^{cdz}	4.81^{cdrz}	0.9^{cdz}	3.38^{cz}
Sulphur	mg/100 g	24.8^{z}	29^{cz}	33.6^{z}	29^{cz}	29^{cz}
Thiamin	mg/100 g	0.08^{rz}	0.1^{z}	0.08^{rz}	0.4^{z}	0.11^{cz}
Total Vitamin A, equivalents	µg/100 g	531.06^{cprz}	432.53^{cpz}	531.06^{cprz}	432.53^{cpz}	410.9^{cpz}
Vitamin B12	µg/100 g	0^{p}	0^{p}	0^{p}	0^{p}	0^{p}
Vitamin B6	mg/100 g	0.1^{rz}	0.06^{z}	0.1^{rz}	0.05^{z}	0.05^{cz}
Vitamin C	mg/100 g	25.5^{rz}	0.59^{z}	26^{rz}	0.74^{z}	0.51^{cz}
Vitamin D; calculated by summation	µg/100 g	0^{p}	0^{p}	0^{p}	0^{p}	0^{cp}
Vitamin E, alpha-tocopherol.equiv.	mg/100 g	1.83^{br}	1.9^{bgr}	1.83^{br}	1.9bgr	1.9^{bcgr}
Water	g/100 g	83.7^{rz}	78.1^{z}	83.7^{rz}	76.1^{z}	77.94^{cz}
Zinc	mg/100 g	0.2^{z}	0.24^{cz}	0.44^{z}	1.12^{cz}	0.31^{cz}

Source Codes	
Code	Explanation
a	Australia DB
b	British DB
c	Calculated
d	Published Source
g	Guessed
l	Less than detection limit
p	Presumed zero
r	Related
u	US DB
z	NZ analytical data

Appendix 2

Table 8. Detailed composition of squash (winter, all varieties, raw) as taken from the USDA Food Composition Database.

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error
Proximates				
Water	G	89.76	13	0.763
Energy	kcal	34	0	
Energy	kJ	143	0	
Protein	G	0.95	5	0.105
Total lipid (fat)	g	0.13	5	0.010
Ash	g	0.57	5	0.027
Carbohydrate, by difference	g	8.59	0	
Fiber, total dietary	g	1.5	0	
Sugars, total	g	2.20	0	
Minerals				
Calcium, Ca	mg	28	5	2.299
Iron, Fe	mg	0.58	5	0.069
Magnesium, Mg	mg	14	5	2.145
Phosphorus, P	mg	23	4	2.885
Potassium, K	mg	350	10	
Sodium, Na	mg	4	9	
Zinc, Zn	mg	0.21	3	0.019
Copper, Cu	mg	0.071	4	0.009
Manganese, Mn	mg	0.163	3	0.035
Selenium, Se	µg	0.4	0	
Vitamins				
Vitamin C, total ascorbic acid	mg	12.3	4	
Thiamin	mg	0.030	5	0.007
Riboflavin	mg	0.062	5	0.002
Niacin	mg	0.500	5	0.053
Pantothenic acid	mg	0.188	3	0.023
Vitamin B-6	mg	0.156	3	0.006

Folate, total	µg	24	9	1.650
Folic acid	µg	0	0	
Folate, food	µg	24	9	1.650
Folate, DFE	µg_DFE	24	0	
Choline, total	mg	10.0	0	
Vitamin B-12	µg	0.00	0	
Vitamin B-12, added	µg	0.00	0	
Vitamin A, RAE	µg_RAE	68	0	
Retinol	µg	0	0	
Carotene, beta	µg	820	6	0.000
Carotene, alpha	µg	0	2	
Cryptoxanthin, beta	µg	0	0	
Vitamin A, IU	IU	1367	0	
Lycopene	µg	0	0	
Lutein + zeaxanthin	µg	38	0	
Vitamin E (alpha-tocopherol)	mg	0.12	0	
Vitamin E, added	mg	0.00	0	
Vitamin D (D2 + D3)	µg	0.0	0	
Vitamin D	IU	0	0	
Vitamin K (phylloquinone)	µg	1.1	0	
Lipids				
Fatty acids, total saturated	g	0.027	0	
4:0	g	0.000	0	
6:0	g	0.000	0	
8:0	g	0.000	0	
10:0	g	0.000	0	
12:0	g	0.001	3	
14:0	g	0.001	3	
16:0	g	0.024	3	
18:0	g	0.002	3	
Fatty acids, total monounsaturated	g	0.010	0	
16:1 undifferentiated	g	0.001	3	
18:1 undifferentiated	g	0.010	3	
20:1	g	0.000	0	
22:1 undifferentiated	g	0.000	0	

Fatty acids, total polyunsaturated	g	0.056	0	
18:2 undifferentiated	g	0.021	3	
18:3 undifferentiated	g	0.035	3	
18:4	g	0.000	0	
20:4 undifferentiated	g	0.000	0	
20:5 n-3 (EPA)	g	0.000	0	
22:5 n-3 (DPA)	g	0.000	0	
22:6 n-3 (DHA)	g	0.000	0	
Cholesterol	mg	0	0	
Amino acids				
Tryptophan	g	0.021	2	
Threonine	g	0.043	2	
Isoleucine	g	0.057	2	
Leucine	g	0.082	2	
Lysine	g	0.053	2	
Methionine	g	0.018	2	
Cystine	g	0.013	2	
Phenylalanine	g	0.057	2	
Tyrosine	g	0.049	2	
Valine	g	0.062	2	
Arginine	g	0.081	2	
Histidine	g	0.027	2	
Alanine	g	0.061	2	
Aspartic acid	g	0.156	2	
Glutamic acid	g	0.254	2	
Glycine	g	0.053	2	
Proline	g	0.052	2	
Serine	g	0.057	2	
Other				
Alcohol, ethyl	g	0.0	0	
Caffeine	mg	0	0	
Theobromine	mg	0	0	

USDA National Nutrient Database for Standard Reference, Release 22 (2009)

Notes:

- Refuse: 29% (Seeds, rind and stem)
- Scientific Name: *Cucurbita* spp.
- NDB No: 11643 (Nutrient values and weights are for edible portion)

Table 9. Detailed composition of squash (winter, all varieties, baked, with without salt) as taken from the USDA Food Composition Database.

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error
Proximates				
Water	g	89.21	11	0.394
Energy	kcal	37	0	
Energy	kJ	154	0	
Protein	g	0.89	9	0.073
Total lipid (fat)	g	0.35	10	0.116
Ash	g	0.69	10	0.051
Carbohydrate, by difference	g	8.85	0	
Fiber, total dietary	g	2.8	0	
Sugars, total	g	3.30	0	
Minerals				
Calcium, Ca	mg	22	3	4.505
Iron, Fe	mg	0.44	10	0.076
Magnesium, Mg	mg	13	3	2.712
Phosphorus, P	mg	19	3	0.408
Potassium, K	mg	241	3	98.528
Sodium, Na	mg	1	2	
Zinc, Zn	mg	0.22	9	0.028
Copper, Cu	mg	0.082	9	0.016
Manganese, Mn	mg	0.187	9	0.023
Selenium, Se	µg	0.4	0	
Vitamins				
Vitamin C, total ascorbic acid	mg	9.6	0	
Thiamin	mg	0.016	2	
Riboflavin	mg	0.067	2	
Niacin	mg	0.495	2	
Pantothenic acid	mg	0.234	2	
Vitamin B-6	mg	0.161	2	
Folate, total	µg	20	2	
Folic acid	µg	0	0	
Folate, food	µg	20	2	

Folate, DFE	µg_DFE	20	0	
Choline, total	mg	10.6	0	
Betaine	mg	0.2	1	
Vitamin B-12	mcg	0.00	0	
Vitamin B-12, added	mcg	0.00	0	
Vitamin A, RAE	µg_RAE	261	0	
Retinol	µg	0	0	
Carotene, beta	µg	2793	12	661.606
Carotene, alpha	µg	682	8	298.288
Cryptoxanthin, beta	µg	0	0	
Vitamin A, IU	IU	5223	0	
Lycopene	µg	0	0	
Lutein + zeaxanthin	µg	1415	7	785.000
Vitamin E (alpha-tocopherol)	mg	0.12	0	
Vitamin E, added	mg	0.00	0	
Vitamin D (D2 + D3)	µg	0.0	0	
Vitamin D	IU	0	0	
Vitamin K (phylloquinone)	µg	4.4	0	
Lipids				
Fatty acids, total saturated	g	0.072	0	
4:0	g	0.000	0	
6:0	g	0.000	0	
8:0	g	0.000	0	
10:0	g	0.000	0	
12:0	g	0.002	0	
14:0	g	0.001	0	
16:0	g	0.062	0	
18:0	g	0.007	0	
Fatty acids, total monounsaturated	g	0.026	0	
16:1 undifferentiated	g	0.002	0	
18:1 undifferentiated	g	0.024	0	
20:1	g	0.000	0	
22:1 undifferentiated	g	0.000	0	
Fatty acids, total polyunsaturated	g	0.147	0	
18:2 undifferentiated	g	0.055	0	

18:3 undifferentiated	g	0.092	0	
18:4	g	0.000	0	
20:4 undifferentiated	g	0.000	0	
20:5 n-3 (EPA)	g	0.000	0	
22:5 n-3 (DPA)	g	0.000	0	
22:6 n-3 (DHA)	g	0.000	0	
Cholesterol	mg	0	0	
Amino acids				
Tryptophan	g	0.013	0	
Threonine	g	0.027	0	
Isoleucine	g	0.035	0	
Leucine	g	0.050	0	
Lysine	g	0.033	0	
Methionine	g	0.011	0	
Cystine	g	0.008	0	
Phenylalanine	g	0.035	0	
Tyrosine	g	0.030	0	
Valine	g	0.038	0	
Arginine	g	0.049	0	
Histidine	g	0.017	0	
Alanine	g	0.037	0	
Aspartic acid	g	0.095	0	
Glutamic acid	g	0.155	0	
Glycine	g	0.033	0	
Proline	g	0.032	0	
Serine	g	0.035	0	
Other				
Alcohol, ethyl	g	0.0	0	
Caffeine	mg	0	0	
Theobromine	mg	0	0	

USDA National Nutrient Database for Standard Reference, Release 22 (2009)

Notes:

- Refuse: 0%
- NDB No: 11644 (Nutrient values and weights are for edible portion)

Appendix 3

Table 10. Summary of papers investigating the composition of pumpkins/squash.

Phytochemical	Reference	Study	Methods	Findings
Violanxanthin (V), antheraxanthin (A), and zeaxanthin (Z)	Adams & Demmig-Adams 1992	To determine the changes in carotenoid composition of leaves in response to diurnal changes in sunlight in the crop species *Cucurbita pepo* L. (pumpkin).	Abstract only so details not available	Large daily changes were observed in relative proportions of the components of the xanthophyll cycle, V, A and Z in the plants grown in full sunlight. In the leaves large amount of Z was formed at peak irradiance, with the changes in Z content closely following changes in incident photo flux density (PFD) over the course of the day. The largest amounts of Z and lowest amounts of V at peak irradiance (full sunlight) were observed in pumpkin which has a lower rate of photosynthesis. Some Z was present in the leaves prior to sunrise.
Lutein & Beta-carotene	Arima & Rodriguez-Amaya 1990	The purpose of the study was to determine the carotenoid composition of a squash and a pumpkin from North-eastern Brazil.	Abstract only so details not available	Nineteen carotenoids were detected in *Cucurbita moschata* cultivar `Baianinha'; beta-carotene was the principal carotenoid, contributing about 74% of an average total carotenoid content. In *C. maxima* variety "Jerimum Caboclo", 11 carotenoids were found with lutein, and beta-carotene as the major pigments accounting for about 60% and 27%, respectively, of an average total carotenoid content. The abundance of beta-carotene in *the C. moschata* cultivar `Baianinha' makes this squash one of the richest sources of provitamin A. The average vitamin A value was 43, 175 IU (International Units) per 100 g or 4,317 RE (retinol equivalents) per 100 g. Its vitamin A values is more than 11 times that of *C. maxima* cultivar `Jerimum Caboclo' and five times that of *C. moschata* cultivar `Menina Verde', the squash found previously to be highest in provitamin A among the Cucurbita vegetables most commercialised in Sao Paulo (South-eastern Brazil).
Lutein	Aruna et al. 2009	Lutein and zeaxanthin content of selected vegetables and vegetable oils commonly used in the Indian diet were determined by high performance liquid chromatography (HPLC). Data generated from this	Fresh vegetables (n=3) were obtained from three different local farms for HPLC analysis for lutein and zeaxanthin content. Fresh vegetables were ground along with sodium sulfate (5 g) and 2 mM a-tocopherol (antioxidant) in ethanol (0.1%). The edible portions were used for the extraction of carotenoids. The homogenised mixture was transferred to a conical flask and	Among vegetables studied, the lutein level (mg/100 g edible portions) was the highest for pumpkin (*Cucurbita maxima*) (10,620). It is suggested that pumpkin should be consumed as rich sources of lutein for health benefits.

Phytochemical	Reference	Study	Methods	Findings
		study are vital for the accurate determination of the dietary intake of lutein and development of comprehensive food tables	carotenoids were extracted in ice-cold acetone (50 ml). Samples were injected (20 ml) for HPLC analysis.	
Lutein, violaxanthin, Beta-carotene & alpha carotene	Azevedo-Meleiro & Rodriguez-Amaya 2007	The carotenoid composition of squashes and pumpkins currently marketed in Campinas, Brazil, were determined by HPLC-DAD, and complemented by HPLC-MS for identification.	The samples were purchased from supermarkets in Campinas, SP, and Brazil. For each variety, five samples of mature squash or pumpkin were taken at random at different times during the second semester of 2001 to the first semester of 2002 and analysed in duplicate. The carotenoids were determined according to the method of Kimura & Rodriguez-Amaya (See paper), adapted to squash and pumpkin samples in terms of weight of analytical samples, volumes of solvents and reagents, number of times extraction was carried out (until the residue was colourless), and chromatographic conditions.	*Cucurbita moschata* 'Menina Brasileira' and *C. moschata* 'Goianinha' had similar profiles, with β-carotene and α-carotene as the major carotenoids. The hybrid 'Tetsukabuto' resembled the *Cucurbita pepo* 'Mogango', lutein and β-carotene being the principal carotenoids. *Cucurbita maxima* 'Exposicũa˜o' had a different profile, with the predominance of violaxanthin, followed by β-carotene and lutein. Combining data from the current study with those in the literature, profiles for the Cucurbita species could be observed. The principal carotenoids in *C. moschata* were β-carotene and α-carotene, whereas lutein and β-carotene dominate in *C. maxima* and *C. pepo*. It appears that hydroxylation is a control point in carotenoid biosynthesis.
Colour (carotenoids)	Bycroft et al. 1999	The effects of heat treatments on the sweetness and flesh colour of the buttercup squash were studied keeping the control fruit at 12°C throughout.	Buttercup squash *(Cucurbita maxima* Duchesne 'Delica') fruit were heated to 30 or 33°C in air for up to 7 days, and then stored at 12°C for up to 7 weeks. Control fruit remained at 12°C throughout. Sucrose and starch concentrations were measured and sweetness of the cooked fruit was evaluated using a trained sensory panel. Enzymes of starch degradation and sucrose metabolism were also extracted and assayed.	There was a strong correlation between sucrose content and panel sweetness rating. Heat treatments also increased the red/ yellow colour of the flesh. Both increased sucrose concentration and redder flesh colour appear to increase the acceptability of buttercup squash to consumers. In a subsequent experiment, found that extractable activities of a-amylase, P-amylase, starch phosphorylase, D-enzyme, sucrose synthase, sucrose phosphate synthase, maltase, and maltose phosphorylase did not differ in samples taken from heat-treated or non-heat-treated squash.
Provitamin A carotenes	Cardoso et al. 2009	It investigated the content of alpha and beta-carotene and the provitamin A value of five vegetables, pumpkin being one of them, raw	Abstract only so details not available	Pumpkin was analysed in the cooked form and the carotenoids were analysed by High Performance Liquid Chromatography (HPLC).The α-carotene wasn't quantified in pumpkin. Beta-carotene was detected in it. It wasn't found statistical differences (alpha=5%) on the contents of α and beta-carotene in pumpkin prepared in different

Phytochemical	Reference	Study	Methods	Findings
		and/or cooked served at three Commercial Meal Production Units in Vicosa, MG, and Brazil.		forms at the studied restaurants. Regarding to the vitamin A value, there was a similar behaviour between these results and those found to beta-carotene, since this is the main provitamin A carotenoid found in vegetables.
Beta-carotene	Castagna et al. 2001	This study was done to report the Physiological and biochemical responses of the ozone (O-3)-sensitive pumpkin cultivar (*Cucurbita pepo* 'Ambassador') to O-3 exposure in order to determine critical O-3 concentrations related to duration of pollutant exposure.	Pumpkin plants were exposed to 150 nl l (-1) of O-3 for 5 h d(-1) for 5 d. Gas-exchange, chlorophyll a fluorescence and pigment-content measurements were determined on days 1, 3, 5 for young leaves and days 1, 3, 4 for the mature leaves of control and treated plants.	In the event of O_3-mediated photo-oxidation, the content of β-carotene presumably decreases due to oxidative destruction owing to its role as antioxidant molecule capable of scavenging the harmful singlet oxygen and de-exciting chlorophyll *a*. In addition, a marked decrease in β-carotene levels following acute exposure to the pollutant has been suggested to be one of the possible factors responsible for the higher sensitivity to the pollutant shown by an O_3-sensitive poplar clone.
Beta-carotene	Danilchenko et al. 2000	The study was to determine the biochemical composition and technological characteristics and the suitability to jam making was evaluated by sensory tests for various cultivars of pumpkin.	The material consisted of six *Cucurbita pepo* cultivars (`Yellow Crookneck', `Sunburst', `Mindalnaja', `Jack O'Lantern', `Table Queen', and `Vegetable Spaghetti') and two *Cucurbita maxima* cultivars (`Buttercup' and `Miranda').	Investigated cultivars contained per fresh weight 5.1-24.1% dry matter, 2.9–11.9% soluble dry matter, beta-carotene 16–456 mg/kg and vitamin C 29–505 mg/kg. Among these cultivars, 'Buttercup' showed the highest nutritional quality and 'Jack O'Lantern' the best technological characteristics. 'Vegetable Spaghetti' and 'Yellow Crookneck' were most suitable for jam making.
Beta-carotene	Dutta et al. 2006	The β-carotene content, texture and colour (L, a, b) degradation were studied under the effect of various thermal treatments.	Pumpkin pieces were thermally treated at a temperature from 50 to 100°C for blanching with time intervals of 3, 5, 10, 15 and 20 min and the beta-carotene content, texture and colour (L, a, b) degradation were studied.	Beta-carotene content decreased at all temperatures but the decrease was more at 100°C than at 50°C and it followed zero order kinetics. Firming of the pumpkin tissues was observed at 70°C while softening took place at 80 to 100°C. The texture degradation followed a first order kinetics. A decrease in the 'L' colour parameter was observed which followed a zero order kinetics while an increase in 'a' and 'b' colour parameters was noted and fitted well into a third degree polynomial equation.
Total carotenoids	Dutta et al. 2009	The total carotenoid content and textural properties of thermally treated pumpkin pieces	Pumpkin pieces were thermally treated at 55, 65, 75, 85 and 95°C for different blanch times (3 min, 5 min, and 10 min) and subsequently kept for storage at 0, -18 and	The total carotenoids content increased in the thermally treated pumpkin pieces, the increase being greater at 55 than at 95°C. Storing the pumpkin pieces caused the total carotenoids content to decrease by 35–40% at 0°C, by

Phytochemical	Reference	Study	Methods	Findings
		for a period of 80 days were measured.	-40°C for a period of 80 days.	15–20% at -18°C and by 25–30% at -40°C.
Beta-carotene	Habibunnisa et al. 2001	This investigation was carried out on pumpkin in minimally processed form, packed in different polymeric film bags of varying permeabilities, creating an active equilibrium modified atmosphere within the package for the extension of storage life.	Fully mature whole pumpkins without any damage were procured from the local market. They were pre-cooled for 18 h at 5–6 7°C and then peeled and cut into pieces of 1 ¼" in size and then treated for analyses.	It was observed that minimally processed pumpkin, which has a high respiratory rate at room temperature (155.7 mg CO_2/kg/h) could be stored for a period of 25 days at 5+/-2°C under modified atmosphere packaging conditions with a minimum physiological loss in weight of 0.06% and marginally low changes in biochemical constituents, such as vitamin C, total soluble solids, moisture, carotenoids and titrable acidity, enabling the retention of near-fresh quality
Lutein, Zeaxanthin	Humphries & Khachik 2003	The qualitative and quantitative distributions of lutein, zeaxanthin, and their (E/Z)-isomers in the extracts from some of the most commonly consumed fruits, vegetables, and pasta products were determined.	The analyses were carried out by HPLC, employing a silica-based nitrile-bonded column.	Squash (butternut variety had significant amount of both the carotenoids compared to other yellow vegetables and fruits.
Carotenoids	Itle & Kabelka 2009	The objective of this research was to determine if the carotenoid content within pumpkin and squash measured by HPLC was correlated with colorimeter L*a*b* colour space values.	Cultigens representing white, yellow, and orange flesh colour were grown at multiple locations using a randomized complete block design with two replicates at each location. Fruit flesh of each cultigen was evaluated using HPLC and colorimetric analysis.	Strong correlations were found between colour value a* and total carotenoids (r = 0.91) and colour value b* and chroma with lutein (r = 0.87). Regression equations based on these correlations will be useful for estimating carotenoid type and concentrations. These close associations will also assure that breeding for enhanced carotenoid content within pumpkins and squash can be achieved using an easy-to-use and inexpensive method.
Carotenoids	Kreck et al. 2006	The carotenoid pigments of different cultivars of *Cucurbita maxima* L. (pumpkin) were investigated in pulp, peel and genuine juice by means of HPLC. In		The total carotenoid content (expressed as dry weight) of the pumpkin peel depends on the variety with 12 mg/ka for `Butternut' up to 1751 mg/kg, for `Rouge', whereas total carotenoid contents in the pulp differed from 17 mg/kg for `Baby Bear' to 683 mg/ka for `Rouge'. The cultivar `Hokkaido' showed high total carotenoid contents in pulp (218 mg/ kg) and peel (1048 ma/kg), whereas for

Phytochemical	Reference	Study	Methods	Findings
		dependence of the variety different concentrations and distributions of alpha-carotene, beta-carotene, violaxanthin, neoxanthin, all-trans-lutein, zeaxanthin, lutheoxanthin and the isomers 9-cis-beta-carotene and 13-cis-beta-carotene were obtained.		`Butternut' minor concentrations in pulp (44 mg/kg) and peel (12 mg/kg) were detected. The red and orange coloured *Cucurbita maxima* L. Cultivars are valuable sources of carotenoids among vegetables or vegetable juices.
Total carotenoids	Kumar et al. 2001	The quality of dehydrated carrot and pumpkin pieces produced by combination drying employing partial freeze-drying and hot air-drying were investigated.	The drying rate, the total energy requirement and the physicochemical properties of the combination dried (CD) products were compared with those of hot air-dried (HAD) and freeze-dried (FD) products.	Destruction of carotenoids during storage at different temperatures was less in the CD samples. See Fig. 3. In original paper to see the carotenoid changes in pumpkin during different drying methods.
Cucurbitaxanthin	Muntean 2003	This study was done to obtain data from HPLC analysis of carotenoids from *Cucurbita maxima* for a possible Cucurbitaxanthin A biosynthesis pathway, proposed by Deli et al. in 1992.	This involves some oxidation steps, starting with the oxidation of beta,beta-carotene to beta-cryptoxanthin, then to zeaxanthin, which is further converted to anteraxanthin, the final product being Cucurbitaxanthin A.	Data obtained from HPLC analysis of carotenoids from *Cucurbita maxima* Duch. fruits revealed the intermediates for a possible Cucurbitaxanthin A biosynthesis pathway
Carotenoids	Muntean 2005		A reversed-phase high-performance liquid chromatographic (HPLC) procedure, which utilises gradient elution and detection by a photodiode-array detector, has been developed to analyze carotenoids from the fruits of *Cucurbita maxima* var. maxima Duch. HPLC analysis was performed on a system consisting of APAS pumps model 5 10, a Waters 990 PDA, a computer running WATERS 990 software for data analysis and a Waters 990 plotter. Separations were carried out by using a Vydac 218 TP 54	Eleven carotenoids were identified, the major ones being P-carotene, lutein, cucurbitaxanthin A, violaxanthin and a-carotene; smaller amounts of zeaxanthin, cis-zeaxanthin, beta-cryptoxanthin, lycopene are followed by traces of neoxanthin and zeta-carotene.

Phytochemical	Reference	Study	Methods	Findings
			column (250 x 4.6 mm, 5 Pm particle size), under gradient conditions involving the following mobile phases: MeOH : H2O = 9:1 and MeOH : THF : TEA = 94:5:1. The flow rate was 1 ml/min and the solvent gradient was as follows: from 0 to 16 min 100% A, from 16 to 20 min. -100 to 0% A, from 20 to 45 min. -0% A then from 45 to 70 min. - 100% A.	
Carotenoids	Muntean et al. 2004	The effects of brining on carotenoids from *Cucurbita maxima* Duch. var. maxima. were assessed using high performance liquid chromatography.		As a consequence of exposure to heat, light, oxygen and brine, a differential degradation of carotenoids occurred, with loss of vitamin A activity. The most unstable carotenoid proved to be violaxanthin, but high percentages of degradation were recorded also for anteraxanthin and neoxanthin. Lutein, zeaxanthin and beta-carotene were influenced in a smaller degree, while the most stable carotenoid was cucurbitaxanthin A. Two types of behavior were recorded for carotenoids: violaxanthin, anteraxanthin and neoxanthin were strongly affected by brining (especially during the initial processing stages), while storage had a smaller influence on their degradation. beta-carotene and its 15Z isomer, lutein, cucurbitaxanthin A and zeaxanthin were degraded mostly during storage. From a nutritional point of view, brining brings only relatively small changes in provitamin A value: from 28.19 mu g RE/g dry weight to 23.45 mu g RE/g dry weight.
Carotenoids	Murkovic et al. 2002	Pumpkins were analysed for their content of a-carotene, beta-carotene, and lutein due to the increasing interest in the supply with antioxidants and especially carotenoids in food.	A wide range of varieties of pumpkins that are commercially available in Austria was analysed. For this study the pumpkins were grown in Austria to obtain data that are relevant for local nutrition. This analysis was carried out by HPLC.	The varieties analysed derived from three species i.e. *Cucurbita pepo*, *C. maxima* and *C. moschata*. Additionally, a cross breed of *C. maxima* and *C. moschata* was tested. The content of the carotenoids ranged from 0.06 to 7.4 mg/100 g for beta-carotene, from 0 to 7.5 mg/100 g for alpha-carotene and from 0 to 17 mg/100 g for lutein.
Colour (carotenoids)	Noseworthy & Loy 2008	The fruit of most cultigens of *Cucurbita maxima* and C. moschata squash are high in carotenoids, especially B-carotene and	In the summer of 2007, seven inbred lines of *C. maxima* and two op cultivars and five inbred lines of *C. moschata* were grown in replicated plots at research farms in Durham and Madbury, New Hampshire	At harvest, 49 to 57 days after pollination (DAP), mean mesocarp DW varied from 25.5 to 37% and SS from 9.3 to 10.8 % among the seven *C. maxima* breeding lines. After storage for 30 days, four of the seven lines had SS levels above 11%, deemed acceptable for good eating quality. In

Phytochemical	Reference	Study	Methods	Findings
		lutein, both of which are important nutritionally. However, there have been no systematic Studies to quantify the amount and types of carotenoids in fruit tissues of breeding germplasm and Popular cultivars.	(USA). Data were recorded at harvest and after 30 and 60 days of storage at 15°C on % mesocarp dry weight (DW) and soluble solids (SS), both major attributes for determining acceptable eating quality. A visual estimation of carotenoid content was made using a Roche egg yolk color fail, with color hues numbered one (light yellow) to 15 (dark orange).	five lines with green rind, Roche colour fan carotenoid values varied from 7 to 9 (medium yellow), while two lines with orange rind showed yellow-orange hues (11 to 12). After 30 days of storage all lines showed colour values of 11 to 11.5, and colour remained fairly stable up to 60 d of storage. In *C. moschata* cultigens, mean DW at harvest ranged between 20 and 24.3 % for all but one cultigen having low dry matter (16.8 %). Average SS was low, 7.0–8.7% among all cultigens. Even after 60 days of storage, SS values were only above 11% for three of the seven cultigens. At harvest Roche colour values were 9 or lower for all but one cultigen. For most cultigens, colour values increased progressively during 30 and 60 days of storage, and after 60 days all cultigens displayed a colour value of 11 or greater.
Beta Carotene	Seo et al. 2005	Purpose of the study was to extract carotenoids and find their concentration in pumpkins.	Carotenoids were extracted from pumpkin by liquid-liquid extraction and by supercritical fluid extraction and were measured by reversed-phase chromatography with diode array detection	The major carotenoid in pumpkin (>80%) is [beta]-carotene, with lesser amounts of lutein, lycopene, [alpha]-carotene and cis-[beta]-carotene. Pumpkin is a rich source of [beta]-carotene and might be useful for preventing Vitamin A deficiency.
Beta Carotene	Shi et al. 2010	Pumpkin is a traditional food that is grown extensively worldwide and is beneficial to human health due to its high contents of carotenoids. The carotenoids in pumpkin were extracted and were identified, quantified, and compared.	The experiment was carried out performing the extraction by organic solvents and by supercritical carbon dioxide.	Beta-carotene was the predominate carotenoid in pumpkin. Lutein and lycopene contents were much higher in SC-CO2 extracts than those in organic solvent extract. Cis-beta-carotene increased by more than two times in the SC-CO_2 extracts, even at a relatively low temperature of 40°C, over those in the solvent extracts, indicating both enhanced solubility and isomerisation from trans- to cis-beta-carotene. The influences of modifier, temperature, and pressure of SC-CO_2 extraction on the change of carotenoid yields were also investigated. The highest yield was obtained at 70°C and 35 MPa, with a 73.7% recovery. Selective extraction could be achieved by adjusting the temperature and pressure. Higher proportions of all-trans-beta-carotene extracts were achieved at 40°C under both 25 MPa and 35 MPa conditions. In order to extract more cis-isomers, a higher temperature of 70°C was preferred

Appendix 4

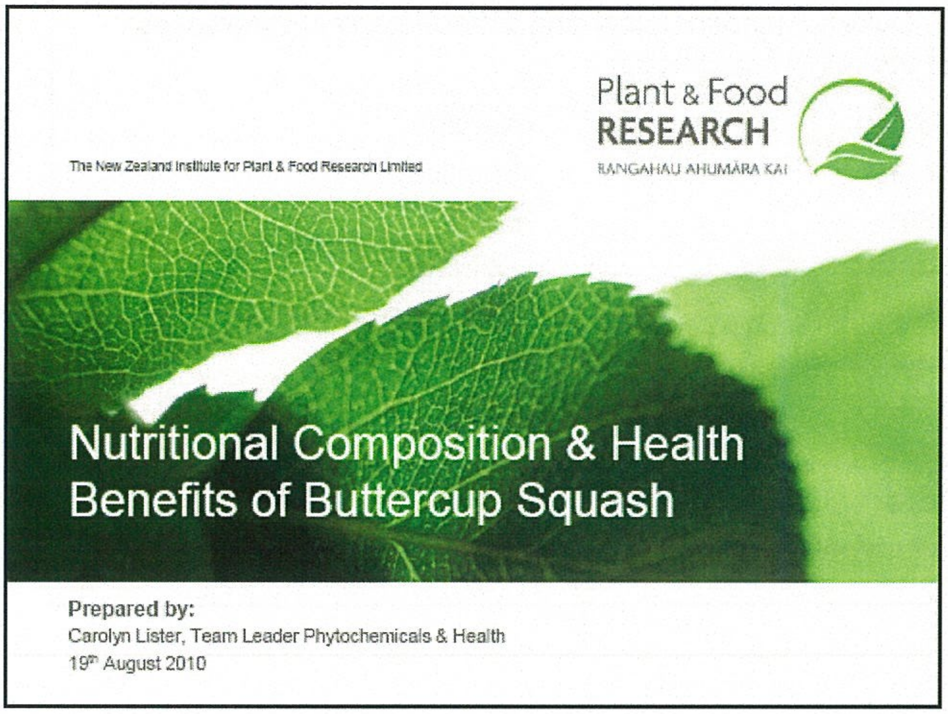
Table 11. Summary of papers investigating the health benefits of *Cucurbita maxima*.

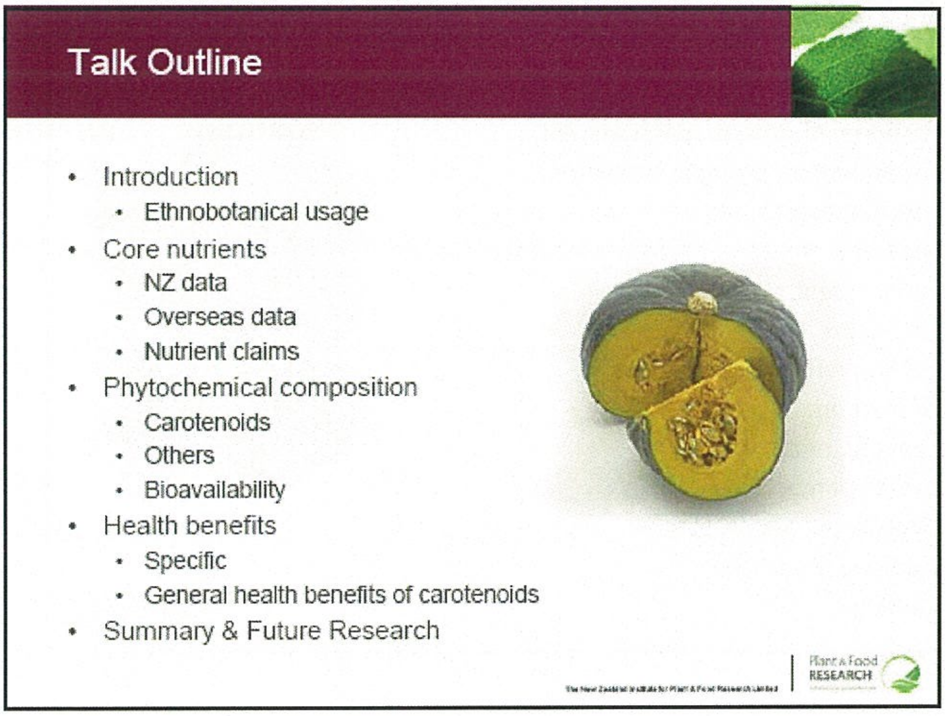
Health condition/ Activity	Reference	Study	Methods	Findings
Antioxidant	Attarde et al. 2010	The present study was undertaken to evaluate *in vitro* antioxidant activities of petroleum ether, chloroform and methanolic extract of pericarp of *C. maxima*.		Total polyphenolic, flavonoid and flavonol content of MECM found 12 mg/gm (gallic acid equivalent), 3.8 mg/gm and 0.8 mg/gm (rutin equivalent) respectively. All extract were tested for DPPH radical scavenging, Nitric oxide radical scavenging and Hydrogen peroxide scavenging activity. IC-50 value for DPPH method of PECM, CECM and MECM were found to be 393 µg/ml, 355 µg/ml and 155 µg/ml, while for nitric oxide scavenging activity 280 µg/ml, 303 µg/ml and 211 µg/ml and for hydrogen peroxide scavenging activity 545 µg/ml, 273 µg/ml and 619 µg/ml respectively. MECM shows good antioxidant activity as compare to PECM and CECM.
Antioxidant	Nara et al. 2009	Evaluated the antioxidative activity of a water soluble polysaccharide fraction (WSP) from pumpkin fruits (*Cucurbita maxima* Duchesne).		In the WSP, DPPH radical scavenging and superoxide dismutase-like activity increased depending on the total sugar content. Furthermore, the WSP can serve as an inhibitor of ascorbic acid oxidation. The efficacy was also affected by the total sugar content.
Diabetes/blood glucose control	Suzuki et al. 2002	The present study investigated the relationship between hyperglycemia and both serum carotenoids and intake of vegetables and fruits	Subjects with a history of diabetes mellitus (DM group, n = 133) or with hyperglycemia diagnosed using a 5.6% cutoff value for hemoglobin A1c (High HbA1c group, n = 151) were recruited from among inhabitants of a rural area in Hokkaido, Japan. Intake frequencies of vegetables and fruits were assessed using a questionnaire administered by public health nurses.	The odds ratio (OR) for high HbA1c was 0.49 (95% confidence interval: 0.29–0.85) on high intake frequency of carrot and pumpkin and the OR for DM was 1.21 (95% CI: 0.79–1.84). No significant relationships were observed between high HbA1c and intake frequencies of other vegetables and fruits. The ORs on high serum levels of alpha- and beta-carotenes, lycopene, beta-cryptoxanthin and zeaxanthin and lutein were 0.38 (0.22–0.65), 0.35 (0.21–0.59), 0.57 (0.35–0.93), 0.35 (0.20–0.59), and 0.88 (0.54–1.46) for high HbA1c, respectively. In conclusion, intake of vegetables and fruits rich in carotenoids might be a protective factor against hyperglycemia.

Health condition/ Activity	Reference	Study	Methods	Findings
Diabetes/blood glucose control	Quanhong et al. 2005	Investigated hypoglycemic substances from pumpkin, protein-bound polysaccharide was isolated by activity-guided isolation from water soluble substances of the fruits.	The protein-bound polysaccharide from pumpkin fruits (PBPP) was identified to consist mainly of polysaccharide (approximately 41.21%) and protein (approximately 10.13%) by anthrone test and Lowry-Folin test. Different doses of PBPP were evaluated for hypoglycemic activity and the effect on serum insulin levels in alloxan diabetic rats.	The results indicated that PBPP can obviously increase the levels of serum insulin, reduce the blood glucose levels and improve tolerance of glucose. The hypoglycemic effect of big dose PBPP group (1000 mg/kg body weight) excelled that of small dose PBPP group (500 mg/kg body weight) and antidiabetic agent group. The results suggest that the hypoglycemic effect of PBPP depends on the dose and PBPP possesses the possibility of being developed from a new antidiabetic agent.
Hyperglycemia and hypertension	Kwon et al. 2007	Antidiabetic- and antihypertension-relevant potentials of phenolic phytochemicals were confirmed in select important traditional plant foods of indigenous communities such as pumpkin, beans, and maize	using *in vitro* enzyme assays for a-glucosidase, a-amylase, and angiotensin I-converting enzyme (ACE) inhibitory activities. *In vitro* inhibitory activities of these enzymes provide a strong biochemical rationale for further *in vivo* studies and dietary management strategy for NIDDM through the control of glucose absorption and reduction of associated hypertension. These enzyme inhibitory activities were further compared to total soluble phenolic content and antioxidant activity of the above-targeted plant foods.	Pumpkin showed the best overall potential. Among the varieties of pumpkin extracts P5 (round orange) and P6 (spotted orange green) had high content of total phenolics and moderate antioxidant activity coupled to moderate to high a-glucosidase and ACE inhibitory activities. Therefore this phenolic antioxidant-enriched dietary strategy using specific traditional plant food combinations can generate a whole food profile that has the potential to reduce hyperglycemia-induced pathogenesis and also associated complications linked to cellular oxidation stress and hypertension.
Prostate Cancer	Jian et al. 2005	Determined whether dietary intake of lycopene and other carotenoids has an etiological association with prostate cancer, a case-control study was conducted in Hangzhou, southeast China during 2001-2002.	The cases were 130 incident patients with histologically confirmed adenocarcinoma of the prostate. The controls were 274 hospital in patients without prostate cancer or any other malignant diseases. Information on usual food consumption, including vegetables and fruits, was collected by face-to-face interviews using a structured food frequency questionnaire. The risks of prostate cancer for the intake of carotenoids and selected vegetables and fruits rich in carotenoids were assessed using multivariate logistic regression, adjusting for age, locality, education, income, body mass index, marital status, number of children, family history of prostate cancer, tea drinking, total fat and caloric intake.	The prostate cancer risk declined with increasing consumption of lycopene, alpha-carotene, beta-carotene, beta-cryptoxanthin, lutein and zeaxanthin. Intake of tomatoes, pumpkin, spinach, watermelon and citrus fruits were also inversely associated with the prostate cancer risk. The adjusted odds ratios for the highest versus the lowest quartiles of intake were 0.18 (95% CI: 0.08–0.41) for lycopene, 0.43 (95% CI: 0.21–0.85) for alpha-carotene, 0.34 (95% CI: 0.17–0.69) for beta-carotene, 0.15 (95% CI: 0.06–0.34) for beta-cryptoxanthin and 0.02 (95% CI: 0.01–0.10) for lutein and zeaxanthin. The corresponding dose-response relationships were also significant, suggesting that vegetables and fruits rich in lycopene and other carotenoids may be protective against prostate cancer.

Appendix 5

Powerpoint Presentation to NZ Buttercup Squash Council – 19th August 2010. Note I have left this presentation as given on the day – there are some differences in the nutrition data presented as at this stage did not have access to the Burlingame report, thus the main body of this report and Tables 1-3 plus Appendix one should be used for nutrient data.





Ethnobotanical usage

Dr. Duke's Phytochemical and Ethnobotanical Databases list the following usages:

- Boil
- Breast
- Burn
- Cancer
- Carbuncle
- Cataplasm
- Chest
- Diuretic
- Fever
- Inflammation
- Nervine
- Poultice
- Rash
- Refrigerant
- Taenicide
- Teething
- Tonic
- Tumor
- Vermifuge
- Wart

Ethnobotanical usage...

- laxative
- used on diarrhoea management
- treatment for prostate problems
- dermatologica
- used for digestive problems including ulcers
- antidiabetic
- antihypertensive
- antitumour
- immunomodulation
- antibacterial
- antihypercholesterolemia
- intestinal antiparastia
- anti-inflammatory
- antalgic

Ethnobotanical usage...

- expels all tape-worms from the intestine and the stomach will be cleaned
- good for leucorrhoea
- revered as an aphrodisiac and sexual stimulant
- contains agents which help fight jaundice when eaten raw
- used during birth and for indigestion in cattle
- alleviates cardiovascular diseases
- treats constipation of stomach or intestines
- having high K:Na ratio, it is a good diuretic
- used in treatment of diabetes, rheumatism, eczema and burns, and against worms and other parasites
- seeds are antithelmintic
- a stomachic
- antirheumatic
- treatment for eye problems

El Monte: Afro-Cuban tradition

- Oshún's golden pumpkin (*Cucurbita maxima*) is closely related to her aspect as "owner of wombs":

After she had given birth several times, Oshún noticed that she was losing her figure. She went weeping through the countryside, making rogations with different ewe along the way. She made the first request-offering with calabash, but when it dried out its seeds shook noisily, the way they do in maracas, and the noise bothered her. She found pumpkin growing in a field; claiming it as her own, she passed it over her belly. This is how she got herself back into shape

...To cure someone with stomach problems, either pain or poor digestion, Oshún takes a pumpkin and passes it over the patient's midsection, first in a criss-cross motion and then with circular movements.

...Since the goddess is "owner of bellies", she can cure a recent hernia with three nice round pumpkins.

Factors influencing composition

- A number of factors combine to determine the levels of both core nutrients and other phytochemicals in a food.
- These include:
  - the variety/cultivar of the plant
  - agronomy involved – soils, cultivation protocols (irrigation, pest control, use of fertiliser),
  - degree of ripeness at harvest
  - processing practices (harvesting, storage, method of processing)
  - form in which the food was analysed – raw, fresh, canned, boiled, frozen
  - analytical techniques and variations between the laboratories doing the analysis.

Proximates

Buttercup squash flesh, steamed

Nutritional value per 100 g	
Energy	83 kcal
Carbohydrates	18.4 g
- sugars	3.6 g
Dietary fibre	1.2 g
Fat	0.3 g
Protein	1.8 g
Water	78 g

- Of the carbohydrate the majority is starch with smaller amounts of sugars.
- Dietary fibre is present at moderate levels (discrepancies in data).

Vitamins & minerals

- In addition to the core energy providing components buttercup squash is packed with vitamins and minerals.
- The significance of the vitamin and mineral content is best looked at in terms of contribution to recommended daily intakes (RDIs):
  - 'Source' claims can be made where at least 10% of the recommended daily intake of a vitamin/mineral is present in a food.
  - 'Good source' claims can only be made when a food contains no less than 25% of the recommended daily intake for that vitamin/mineral.

Vitamins & minerals..

- So what claims can be made for buttercup squash?
- Look at values for steamed flesh (raw values also cited where major differences or no data).
- Note skin is often a richer source of vitamins and minerals so if analysis was done on whole pieces values may be higher.

Folate

- Amount in buttercup squash:
  - 46 µg per 100 g
  - 102 µg per serve (1 cup diced)
  - RDI: 400 µg
  - 26% RDI per serve (Good Source)

- Functions:
  - Coenzyme in DNA synthesis and amino acid synthesis.
  - Important for preventing neural tube defects
  - Key role in preventing stroke and heart disease, including reducing blood homocysteine levels with vitamin B12
  - May protect against colonic and rectal cancer
  - Involved in the formation of blood cells
  - May have benefits for bone health, cognitive function and diabetes

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Iron

- Amount in buttercup squash:
  - 0.4 mg per 100 g
  - 0.9 mg per serve (1 cup diced)
  - RDI: 8 mg
  - 11% RDI per serve (Source)

- Functions:
  - Component of haemoglobin and myoglobin in blood, needed for oxygen transport
  - Role in cellular function and respiration

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Niacin

- Amount in buttercup squash:
  - 1.3 (0.7) mg per 100 g
  - 2.9 (1.6) mg per serve (1 cup diced)
  - RDI: 16 mg
  - 18 (10) % RDI per serve (Source)

- Functions:
  - Coenzyme or cosubstrate in many biological reduction and oxidation reactions required for energy metabolism and fat synthesis and breakdown
  - Reduces LDL cholesterol and increases HDL cholesterol

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Pantothenic acid

- Amount in buttercup squash:
  - - (0.4) mg per 100 g
  - - (0.9) mg per serve (1 cup diced)
  - RDI: 6 mg
  - - (15%) RDI per serve (Source)

- Functions:
  - Coenzyme in fatty acid metabolism and synthesis of some hormones
  - Maintenance and repair of cell tissues

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Potassium

- Amount in buttercup squash:
  - 471 mg per 100 g
  - 1046 mg per serve (1 cup diced)
  - RDI: 3,800 mg
  - 28% RDI per serve (Good Source)

- Functions:
  - Major ion of intracellular fluid
  - Maintains water, electrolyte and pH balances
  - Important in preventing high blood pressure
  - Role in cell membrane transfer and nerve impulse transmission

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Riboflavin (vitamin B2)

- Amount in buttercup squash:
  - 0.11 (0.01) mg per 100 g
  - 0.24 (0.02) mg per serve (1 cup diced)
  - RDI: 1.3 mg
  - 19 (2)% RDI per serve (Source?)

- Functions:
  - Important for skin and eye health
  - Coenzyme in numerous cellular redox reactions
  - involved in energy metabolism, especially from fat and protein

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Thiamin (vitamin B1)

- Amount in buttercup squash:
  - 0.08 mg per 100 g
  - 0.18 mg per serve (1 cup diced)
  - RDI: 1.2 mg
  - 15% RDI per serve (Source)

- Functions:
  - Coenzyme in the metabolism of carbohydrates and branched-chain amino acids
  - Needed for nerve transmission
  - Involved in formation of blood cells

Vitamin A equivalents

- Amount in buttercup squash:
  - 531 µg per 100 g
  - 1179 µg per serve (1 cup diced)
  - RDI: 900 µg
  - 131% RDI per serve (Good Source / provides all your daily requirement)

- Functions:
  - Important for normal vision and eye health
  - Involved in gene expression, embryonic development and growth and health of new cells
  - Aids immune function and resistance to infection
  - May protect against epithelial cancers and atherosclerosis
  - Carotenoids have antioxidant activity

Vitamin B6

- Amount in buttercup squash:
  - 0.1 mg per 100 g
  - 0.22 mg per serve (1 cup diced)
  - RDI: 1.3 mg
  - 17% RDI per serve (Source)

- Functions:
  - Coenzyme in nucleic acid metabolism, neurotransmitter synthesis, haemoglobin synthesis.
  - Involved in neuronal excitation
  - Reduces blood homocysteine levels
  - Prevents megaloblastic anemia

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Vitamin C

- Amount in buttercup squash:
  - 0.6 (26) mg per 100 g
  - 1.3 (57.7) mg per serve (1 cup diced)
  - RDI: 45 mg
  - 3 (128)% RDI per serve (Good Source? / provides all your daily requirement?)

- Functions:
  - Necessary for healthy connective tissues – tendons, ligaments, cartilage, wound healing and healthy teeth
  - Assists in iron absorption
  - A protective antioxidant – may protect against certain cancers
  - Involved in hormone and neurotransmitter synthesis
  - May lower the risk of stroke

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Vitamin E

- Amount in buttercup squash:
  - - (1.8) mg per 100 g
  - - (4.0) mg per serve (1 cup diced)
  - RDI: 10 mg
  - - (40)% RDI per serve (Good Source?)

- Functions:
  - Provides dietary support for heart, lungs, prostate, and digestive tract
  - Reduces peroxidation of fatty acids
  - Non-specific chain-breaking antioxidant
  - May protect against atherosclerosis and some cancers

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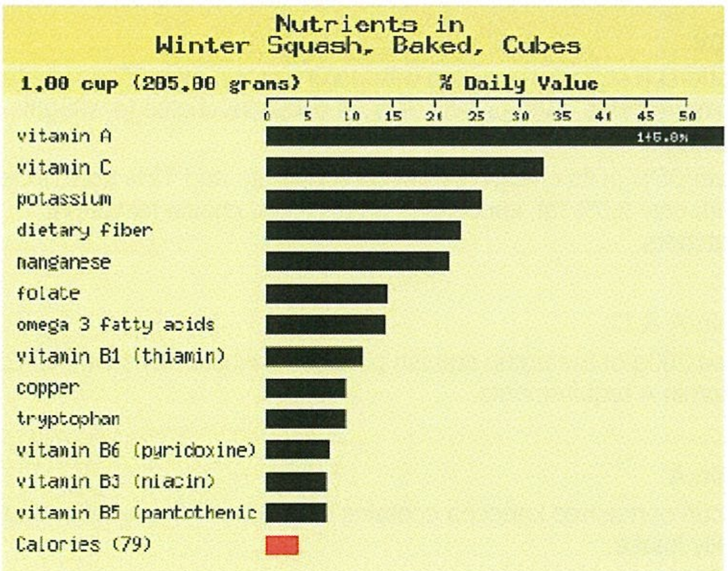
Overseas nutritional data



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Content claims

- The most common "claims" with regards to nutritional composition of squash are with regards to its vitamin A equivalents. There is little doubt about these because the carotenoid (provitamin A) content is so high.

- Other claims have also been made - NZ Buttercup Squash Council and LeaderBrand websites.
  - New Zealand Buttercup Squash is rich in beta carotene, with iron, vitamin C, potassium, and smaller traces of calcium, folic acid, and minute amounts of B vitamins. ✗

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Current claims...

- Energy:
  - Buttercup squash is packed with good energy: over 85% complex carbohydrates, 12% protein. It is an excellent choice for weight watchers. ✓
  - Over 85% of its energy is from carbohydrate and 12% from protein. With only 2.5% fat, kabocha is an excellent choice for weight watchers.

- Vitamin A & C:
  - Just 200g of Buttercup squash provides a whole day's vitamin C and vitamin A requirements. ?

- Vitamin A:
  - 1 cup of mashed kabocha contains over 90% of the recommended daily intake. ✓

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Current claims...

- Calcium:
  - Buttercup squash skin packs 22% more calcium than the same weight of milk. It is ideal for helping prevent osteoporosis.
  - LeaderBrand kabocha packs 22% more calcium than the same weight of milk. Calcium is an essential mineral, especially for woman.

  ✗

- Iron:
  - The skin also compares with the best source of iron - lean red meat.
  - The iron content of the LeaderBrand kabocha is comparable to red meat, the best source of iron!

  ✗

- Dietary fibre:
  - Buttercup squash has more dietary fibre than potatoes, carrots or even kiwifruit.
  - LeaderBrand kabocha has more dietary fibre than traditional "high fibre" vegetables like potatoes, carrots and kiwifruit

  ?

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Current claims...

- Beta-carotene:
  - Buttercup squash is one of the best sources of beta-carotene, comparable to carrots.
  - LeaderBrand kabocha is an excellent source of beta-carotene, comparable to carrots.

  ?

- Magnesium: Just 1 cup of kabocha provides your daily magnesium needs. Magnesium is a major mineral involved in activating enzymes and muscle and nerve function. ✗

- Other minerals contained in the flesh and skin include: zinc, copper, manganese and thiamine. ✗

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Current claims...

- Current claims may need to be revised
  - Remove: calcium & magnesium
  - Reword: iron, vitamin C, fibre, beta-catotene, general
- Other claims possible that are not currently made
  - Folate
  - Niacin
  - Pantothenic acid
  - Potassium
  - Riboflavin
  - Thiamin
  - Vitamin B6
  - Vitamin E?
- Ideally need to update nutritional data as there are some anomalies.

Phytochemical composition

- Apart from the core nutrients there are phytochemicals present in buttercup squash.
- A Phytochemical is *"a plant-derived chemical that is not considered an essential nutrient in the human diet but is believed to have beneficial health effects"*.
- Searches were conducted in the scientific literature to determine what investigation there has been of the phytochemical composition of squash.

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 human body and are present solely as a result of ingestion from other sources, either the plant source itself or a product from an animal that has consumed that plant source.
- Carotenoids are fat-soluble compounds and thus are best absorbed in the body if accompanied by some form of oil or fat in the meal. It has also been shown that chopping and cooking assists in releasing carotenoids from the food matrix which also increases their bioavailability.

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Carotenoid content of yellow/orange vege

Food	β-carotene	α-carotene	β-cryptoxanthin	Lycopene	Lutein + zeaxanthin
Carrot, boiled	8332	3776	202	0	687
Corn, boiled	66	23	161	0	967
Pumpkin, boiled	2096	348	1450	0	1014
Squash, winter, baked	2793	682	0	0	1415
Sweet potato, boiled	9444	0	0	0	0

Carotenoids in buttercup squash

- Variation in both levels and composition of carotenoids
- Some reports give β-carotene as the major carotenoid others lutein – some of this may be due to particular type of squash analysed.
- The carotenoids of fully ripe Japanese squash were analysed at maturity:
  - The total carotenoid content was 6,200 µg/100 g fresh weight
  - The carotenoids were lutein (63.9%), α-carotene (10.9 %), β-carotene (7.8%), antheraxanthin (6.0%), vioalaxanthin (4.3%), α-cryptoxanthin (2.6%) and minor other components

Phenolics

- One of the main phytochemical groups in fruit and vegetables is the phenolics.
- Phenolic compounds are a large group of secondary plant products that differ in chemical structure and reactivity.
- Their contribution to the pigmentation of plants is well recognised, although not all phenolics are coloured.
- There are numerous different groups of phenolics, but the most common phenolics found in foods generally belong to phenolic acids, flavonoids, lignans, stilbenes, coumarins and tannins.
- They are of interest primarily because of their radical scavenging and antioxidant activities, which are determined by their structure, particularly the number and configuration of H-donating hydroxyl groups.

Phenolics in buttercup squash

- Little is known about the phenolic compounds of pumpkin and squash, let alone buttercup squash.
- Small amounts of vanillic acid, p-coumaric acid, and sinapic acid were found in pumpkin peel.
- The flavone luteolin was found in pumpkin puree at the concentration of 1.6 mg/100 g.
- A more recent study found the major phenolic compounds in squash to be chlorogenic and syringic acids with smaller amounts of caffeic acid. The levels of these phenolic acids were very low though at less than 5 mg/100 g FW.
- The total phenolic content of squash is around 35 mg/100 g

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Phenolics in buttercup squash...

- A recent report examining the antioxidant activity of the pericarp of *C. maxima* Duch. ex Lam found:
  - total polyphenolic content 1200 mg/100 g (gallic acid equivalent)
  - Flavonoid content 380 mg/100 g
  - flavonol content 80 mg/100 g (rutin equivalent)
- However, the full paper was not available to establish the validity of this data and if the results were expressed on a fresh weight basis.
- Unlikely phenolics significant contributors to health benefits but simple check of total levels before any further investigation.

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Other phytochemicals

- The only other phytochemical components noted in the literature were polyamines and galactolipids.
- Foods found to be rich in polyamines include Japanese pumpkin. It is unclear if this is buttercup squash and further details were unavailable. Polyamines may be important in the diet especially as we age.
- Galactolipids are a class of compounds widely found in the plant kingdom and are an important part of the cell membranes. It has been demonstrated that a galactolipid may be important for the anti-inflammatory activity of dog rose (*Rosa canina*), a medicinal plant with documented effect on anti-inflammatory diseases such as arthritis. This galactolipid also occurs in relative high concentrations in pumpkin. No further details could be found.

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Bioavailability

- In addition to the actual content of phytochemicals it is important to consider their bioavailability as for many compounds this is considered a limiting factor.
- The area of bioavailability broadly addresses the issue of how well a compound is absorbed so that it can be utilised by the body It involves the degree and rate at which a substance is absorbed into a living system or is made available at the site of physiological activity.
- Absorption may be determined by a range of variables, such as the chemical structure and nature of the compound, the amount consumed, the food matrix in which it is contained, the presence of other compounds within the meal and the nutrient status of the subject.

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Bioavailability of squash carotenoids

High bioavailability

- Formulated carotenoids in water-dispersible beadlets (natural or synthetic)
- Carotenoids – oil form (natural or synthetic)
- Fruits (peach, apricot, melon)
- Tubers (sweetpotato, yam, **squash**)
- Processed juice with fat containing meal (e.g. tomato)
- Lightly cooked yellow/orange vegetables (carrots, peppers)
- Raw juice without fat (tomato)
- Raw yellow/orange vegetables (carrots peppers)
- Raw green leafy vegetables (spinach, silver beet)

Low bioavailability

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Bioavailability of squash carotenoids...

- This relatively high bioavailability means that carotenoids in buttercup squash may have advantages over other common dietary sources of carotenoids (e.g. carrots, tomatoes).
- Relative bioavailability of beta-carotene from pumpkin was found to be 1.8 times greater than that from spinach.
- Another bioavailability study showed that the contribution to the recommended daily allowance is greater when pumpkins are prepared as a curry with coconut milk.
- Potential to make recommendations on usage to enhance the health benefits.

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Health benefits of buttercup squash

- There have been few studies examining the health benefits of *Cucurbita maxima*.
- As noted earlier the core nutrients have a wide range of health benefits:
  - The potassium may help to lower blood pressure
  - Vitamin C may be able to reduce the severity of conditions like asthma, osteoarthritis, and rheumatoid arthritis and also to prevent the progression of conditions like atherosclerosis and diabetic heart disease.
  - Fibre may help to fight heart disease and colon cancer. In addition to its ability to lower high cholesterol levels, which reduces the risk of heart disease, the fibre found in winter squash is also able to prevent cancer-causing chemicals from attacking colon cells. This is one of the reasons why diets high in fibre-rich foods have been associated with a reduced risk of colon cancer.

Health benefits of buttercup squash..

- In addition to the core nutrients the phytochemicals may carry other benefits.
- There have been studies showing *C. maxima* have
  - Antioxidant activity
  - Anti-cancer activity
  - Benefits for diabetes and its complications

Anti-cancer

- Although not as potent as root vegetables like burdock, garlic or onion, winter squash has been found to have anti-cancer type effects.
- Prostate cancer risk declined with increasing consumption of lycopene, alpha-carotene, beta-carotene, beta-cryptoxanthin, lutein and zeaxanthin. Intake of tomatoes, pumpkin, spinach, watermelon and citrus fruits were also inversely associated with the prostate cancer risk.
- Phenolic acids such as those found in buttercup squash skin have been found to have some antioxidant/radical quenching activity. In particular some phenolic acids are believed to help combat the effects of carcinogenic nitrosamines, such as those in some processed meats and cigarette smoke.
- In general carotenoids have also been shown to have anti-cancer benefits.

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Diabetes

- Over the centuries, Chinese herbal drugs have served as a major source of medicines for the prevention and treatment of diseases including diabetes mellitus (known as 'Xiao-ke'). It is estimated that more than 200 species of plants exhibit hypoglycaemic properties, including many common plants, such as pumpkin, wheat, celery, wax guard, lotus root and bitter melon.
- Other cultures have also used Cucurbita spp. for the treatment/prevention of diabetes.
- There has been some report in the scientific literature to substantiate these benefits

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Diabetes...

- Benefits of squash may be wider than just blood glucose control with phenolics reduce hyperglycemia-induced pathogenesis and also associated complications linked to cellular oxidation stress and hypertension.

- Antidiabetic effects have been attributed to the phenolics but also protein-bound polysaccharide fractions from the fruits. Another study showed trigonelline and nicotinic acid from the flesh of pumpkins suppressed both triglycerides and the accumulation and the progression of diabetes

Other benefits of Cucurbita spp.

- Extracts from *Cucurbita pepo* have also been found to help reduce symptoms of a condition occurring in men called benign prostatic hypertrophy.
- Rat studies suggested gastroduodenal protective and anti-ulcerogenic properties of *C. pepo*.
- *Cucurbita moschata* contains potent anti-obesity activities in a high fat diet-induced obesity mouse model.
- *Cucurbita ficifolia* fruit extract resulted in a significant reduction in blood glucose, glycosylated haemoglobin, and an increase in plasma insulin and total haemoglobin.
- *Cucurbita andreana* fruits showed anti-cancer effects.

- These studies back up some of the traditional usages of pumpkins/squash.

Health benefits of carotenoids

- Carotenoids have been shown to have range of activities/health benefits:
  - Anti-cancer
  - Improve vascular health and lower cardiovascular disease risk
  - protect against diabetic heart disease
  - improve iron absorption
  - anti-inflammatory effects may help to reduce the severity of conditions like asthma, osteoarthritis, and rheumatoid arthritis, which all involve inflammation
  - Eye health

- Thus buttercup squash may have more benefits that what has been investigated to date.

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Summary & potential areas for research

- Core nutrients:
  - Considerable potential for claims around vitamin & mineral content:
  - Anomalies – need for updated composition data
  - Lack of solid data on effects of cooking – can make recommendations/recipes to maximise vitamin/mineral content

- Phytochemicals:
  - Carotenoids are the major phytochemical: questions over exact composition need LC-MS identification
  - Investigation of polyamine/galactolipid content to see if any merit

- Bioavailability:
  - Carotenoids – squash may have advantages over other dietary sources
  - Potential to develop recipes that enhance bioavailability

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Summary & potential areas for research...

- Health benefits:
  - Greatest evidence for benefits for diabetes – needs specific investigation with regards buttercup squash
  - Other possibilities:
    - Eye health
    - Ability to increase iron absorption
    - Digestive health

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Buttercup Squash and Hemp Tea:

Product description

Our new product 'Buttercup squash and hemp tea' is a powder mix drink blending buttercup squash and hemp ideally and making them enjoyable to drink.

It is a sweet and soft drink that people at any ages from children to the aged would love to have.