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FI105 – The value of almonds in a healthy Australian diet

for

Almond Board of Australia

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AUTHORS

Dr Yasmine Probst, GradCertBus, PhD, APD

National Centre of Excellence in Functional Foods (NCEFF)
ABN: 97 382 208 966
Job No: FI105 – The value of almond in a healthy Australian diet

NCEFF contact: Dr Yasmine Probst
Smart Foods Centre
National Centre of Excellence in Functional Foods
Northfields Avenue
University of Wollongong NSW 2522 Australia
Tel: (61 2) 4221 5302
Fax: (61 2) 4221 4844
Email: yasmine@uow.edu.au

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EXECUTIVE SUMMARY

The Almond Board of Australia (ABA) is aiming to increase the awareness amongst health professionals and consumers of the health benefits of almonds, as well as the consumption of almonds as a daily snack. From previous work, ABA have identified that only half of consumers are aware of the health benefits of almonds and only one tenth eat them on a daily basis. This report has been developed to assist ABA in promoting almond consumption and the benefits of almonds to health professionals and the consumer.

Nutrient and bioactive components of almonds

Almonds on their own are a good source of protein with a very high proportion of monounsaturated and polyunsaturated fatty acids and a favourable ratio of unsaturated to saturated fatty acids. This ratio, alongside their high alpha-tocopherol (vitamin E) content, has linked almond consumption to benefits such as reduced LDL cholesterol and reduced cardiovascular risk. Almonds are also high in beta-sitosterol, a natural phytosterol, which may also assist with the heart health benefits. Comparisons of dry roasted unsalted almonds and raw almonds reveal that the primary differences are in the moisture content, phosphorous and zinc levels, each being lower for the dry roasted almond.

Inclusion of almonds in a healthy diet

A previous study was conducted by the *National Centre of Excellence in Functional Foods* to review the scientific literature relating to almonds for reducing LDL cholesterol and reducing cardiovascular disease (CVD) risk. Cardiovascular disease risk factors include cigarette smoking, poor diet and nutrition, physical inactivity, overweight and obesity, high blood pressure, high blood cholesterol, diabetes and depression or social isolation and are often assessed based on low density lipoprotein levels (LDL) and high density lipoprotein levels (HDL) or good and bad cholesterol. The previous study found a total of 17 human studies that were systematically reviewed for the years 1991-2003. These were a combination of clinical trials addressing almond consumption on its own and in combination with other dietary modifications on blood lipid and lipoprotein parameters. An additional search was conducted for this project for the years 2004-2008 finding eight articles, none of which related to LDL or reduced CVD risk. From the scientific literature, it appears that the dose of almonds required for a 10% reduction in LDL cholesterol levels (under tightly controlled conditions) is between 68-84g/day (57-70 almonds). Epidemiological studies suggest the risk of death from coronary heart disease is reduced by 8.3% for each serving of nuts (~30g) consumed weekly, a figure that is closely aligned with the 28g (one handful/23 almonds) serving suggested by ABA. Overall, the scientific literature shows strong, consistent evidence for the consumption of almonds, in the context of a healthy balanced (low fat) diet, for the reduction of LDL cholesterol. It should be noted, however, that the effect of almonds on LDL cholesterol and CVD risk is largely dependant on the background diet that is being consumed, with less positive outcomes expected for an 'unhealthy' background diet that has almonds added to it.

Fitting almonds in with dietary guideline recommendations

Almonds are found in a number of food groups and dietary guidelines around the world. The Australian Guide to Healthy Eating (AGHE) categorises nuts in the meats, fish, poultry, eggs and legumes food grouping and recommends a serving of approximately 1/3 cup of almonds (approx. 40 almonds). Dietary modelling for adults was conducted and was composed of 70% estimated energy intake (EEI) for the entire recommended food group servings from the AGHE with the remaining 30% EEI composed of snacks and additional 'extra' foods. Almonds were modelled into the diet, both as a meat replacement and also as a replacement for four different snack foods. After the substitution for almonds, an increase in the amount of total fat was observed. This increase was primarily from an increase in the polyunsaturated fatty acids and monounsaturated fatty acids and a decrease in the saturated fatty acid levels for all snack types. Almonds also had a large impact (increase) on magnesium levels and increased the zinc levels to between 91 and 94% RDI across all substitutions. When almonds replaced (matched by energy content) the meat in the diet (lean lamb) a decrease in zinc levels were observed and the RDI for protein remained below 100%. When the replacement was repeated and the almonds were matched for protein levels, the serving of almonds increased up to 164g (one cup) of almonds and delivered 49% energy from total fat alone. This suggests that almonds are best placed in the diet as a snack, in accordance with the objectives of current ABA promotions.

INTRODUCTION

The Almond Board of Australia (ABA) is presently focussed on increasing the level of almond consumption in Australia to align with the levels of supply that have been predicted for future years. Past consumer research efforts by ABA have identified that approximately 77% of Australians eat Almonds of which 57% consume almonds as a snack food and 40% as a component of a meal/in cooking. ABA has identified almonds consumed for snacking as a primary target to increase the consumption levels. Recent research has shown that of those who consume almonds as a snack, 10% eat them once daily and 52% eat them once a week. Of these people, women were significantly more likely than men to consume the nut once a week while men were most likely to consume the nut once a month. It has also been identified that Australians identify almonds as the fourth most preferred nut choice, behind cashews, macadamias and peanuts, although 50% of the consumers surveyed were unaware of the health benefits of Almonds. The ABA is promoting a serving of one handful or 23 almonds per day.

AIM

The aim of this project was to prepare a report on the nutritional value of almonds in a healthy Australian diet to be used by ABA to promote almond consumption and to increase awareness of the benefits of almonds amongst health professionals.

PROJECT OBJECTIVES

Specifically, the objectives of the project were to:

1. Outline the nutritional value of almonds in the Australian diet based on a review of the nutritional properties of Almonds and the links between food components and healthy growth, development and function in the life cycle.

2. Provide a summary of the literature on the evidence supporting the inclusion of almonds in a healthy diet, based on the recommendations for reducing the risk associated with chronic lifestyle related disease. This will relate to the role of almonds in reducing LDL cholesterol, reducing the risk of heart disease and helping maintain healthy weight.

3. Review the position of almonds in current dietary guidelines and discuss the inclusion of almonds in reference material for core food groups in a healthy Australian diet.

METHODS

A review of food databases and authoritative texts to provide a description of nutrient and bioactive actions of almonds

Australian nutrient composition tables for Australia were updated in 2006, therefore the latest food composition information for Almonds was sourced. Where data was deficient, overseas databases were sourced. It must be noted that due to differences in soil conditions the overseas values may not be proportionate to Australian values however they may be used to demonstrate the presence of the nutrient in Almonds in general.

The key nutrients and bioactive components of Almonds are discussed below with reference to their importance in maintaining good health throughout the lifecycle. This information was sourced from authoritative texts, internet searches and the *Journal of Food Composition and Analysis*.

A review of previous reports produced by the Centre along with a brief update to summarise evidence for inclusions of almonds in a healthy diet

The data from the previous *National Centre of Excellence in Functional Foods* (NCEFF) 'Almond Health Claim' report has been summarised. This data included studies from 1991-2003. The search strategy used to source the studies from this report was repeated to determine the number of additional studies relating to Almond consumption and cholesterol lowering or reduction of cardiovascular disease risk. Table 1 shows the search words used in the following scientific databases: MEDLINE, ScienceDirect and Cochrane Database (all limited to years 2004-2008), the number of abstracts reviewed and the final number of studies included for systematic evaluation. All studies included for final evaluation were limited to articles published in English. Exclusion of studies was based on a reference to other nut consumption only, the absence of cardiovascular endpoints or the absence of statistical analysis of the relationship between nut consumption and cardiovascular parameters. Studies that included almonds as part of a portfolio of dietary changes were included.

Table 1: Search terms and outcomes for updated literature search (2004-2008)

Keywords				
Ingredient	**Health Outcome**	**Search combinations**	**Abstracts reviewed**	**Final papers**
Almond	Heart Cardiovascular Coronary CVD CHD Cholesterol LDL Atherosclerosis Lipid Blood Pressure Hypertension	Each term listed under 'Ingredient' (Almond) AND Each term listed under 'Health Outcome' (Heart OR Cardiovascular OR Coronary OR CVD OR CHD OR Cholesterol OR LDL OR Atherosclerosis OR Lipid OR Blood Pressure OR Hypertension)	MEDLINE: 23 Scopus: N/A* ScienceDirect: 1 Cochrane: 0	8

** Scopus database was also used in the original study however is now no longer available to the University of Wollongong.*

A review analysis of current dietary guidelines to show the impact of including almonds in a dietary model, supporting a healthy diet according to NHMRC suggested dietary targets

Dietary modelling was conducted for almonds in a healthy diet. Diets were modelled for key stages of the lifecycle ensuring that the specified number of servings of each food group had been achieved and that 70% of estimated energy requirements (EER) were met by these food groups alone. Additional 'extra' foods were added to the diets to bring the EER to 100%. The 'extra' food items were composed of snack foods of equal caloric value and foods that are traditionally added in the diet such as margarine on bread and salad dressing on salad. An equivalent amount of dry roasted, unsalted almonds (by energy value) were then substituted for each of the snack foods to determine the impact on the nutrient composition of the diets.

NUTRIENT AND BIOACTIVE COMPONENTS OF ALMONDS

The Australian food composition database (NUTTAB) was updated in 2006 and released as both an electronic (PDF) (1) and an online version (2). The previous food composition database was released in 1995 (3) and primarily contained nutrient data from the late 1980s and early 1990s though was updated in 1999 with new sodium values (4). The 2006 database update has meant a broader range of nutrient data is now available for most food sources (2). Table 2 shows the nutrient data for almonds for the Australian NUTTAB 2006 database (2) as well as the United States Department of Agriculture (USDA) food composition (5) values for comparison where Australian values are deficient.

Table 2: Nutrient and bioactive composition of almonds for Australia (NUTTAB) and USA (USDA)

Nutrients per 100g	Measure	NUTTAB 2006 (2)		USDA (5, 6)
		with skin	blanched	blanched
Proximates				
Energy	kcal	598	605	581
Energy	kJ	2503	2534	2431
Moisture	g	3.7	4.2	4.47
Nitrogen	g	3.77	3.94	NA
Protein	g	19.5	20.4	21.94
Fat	g	54.7	55.5	50.62
Ash	g	3	2.8	3.02
Glucose	g	0	0	0.04
Sucrose	g	4.8	3.9	4.78
Maltose	g	0	0	0.14
Sugars, total	g	4.8	3.9	4.96
Starch	g	0	0	1.03
Available Carbohydrate	g	4.8	3.9	19.94
Total Dietary Fibre	g	8.8	8.9	10.4
Minerals				
Antimony	µg	0.4	NA	NA
Arsenic	µg	2.6	NA	NA
Cadmium	µg	0.3	NA	NA
Calcium	mg	250	219	216
Chromium	µg	0.4	NA	NA
Copper	mg	1.097	0.995	1.17
Fluoride	µg	0	0	NA
Iodine	µg	0	0	NA
Iron	mg	3.9	3.1	3.72
Magnesium	mg	260	259	275
Manganese	mg	2.5	1.89	2.24
Molybdenum	µg	24.7	NA	NA
Nickel	µg	60	NA	NA
Phosphorus	mg	480	468	480
Potassium	mg	740	637	687
Selenium	µg	3.2	2	2.8
Sodium	mg	5	5	28
Sulphur	mg	140	129	NA
Zinc	mg	3.7	3.4	3.12
Vitamins				
Vitamin A, IU	IU	NA	NA	7
Retinol Equivalents	µg	2	1	0
Beta Carotene	µg	9	6	4
Vitamin B1 Thiamine	mg	0.19	0.14	0.2
Vitamin B2 Riboflavin	mg	1.4	0.9	0.56
Vitamin B3 Niacin	mg	3.9	3.8	3.66
Vitamin B3 Niacin derived from Tryptophan or Protein	mg	3.8	4	NA
Vitamin B3 Niacin Equivalents	mg	7.7	7.8	NA
Vitamin B5 Pantothenic Acid	mg	0.38	0.3	0.311
Vitamin B6 Pyroxidine	mg	0.13	0.14	0.12
Vitamin B7 Biotin	µg	54	55.7	NA
Vitamin B9 Folate	µg	29	43	30
Dietary Folate Equivalents	µg	29	43	30

Nutrients per 100g	Measure	NUTTAB 2006 (2)		USDA (5, 6)
		with skin	blanched	blanched
Vitamins (cont.)				
Vitamin B12	µg	NA	NA	0
Choline, total	mg	NA	NA	52.1
Vitamin C	mg	0	0	0
Vitamin E	mg	28.1	22.6	0
Alpha Tocopherol	mg	28	22.5	24.71
Beta Tocopherol	mg	NA	0.2	0.41
Delta Tocopherol	mg	NA	0	0.27
Gamma Tocopherol	mg	1.4	0.2	0.8
Vitamin K (phylloquinone)	µg	NA	NA	0
Lipids				
C16:0 Palmitic acid	g	3.19	3.18	3.26
C17:0 Margaric acid	g	0	0.05	0
C18:0 Stearic acid	g	0.47	0.05	0.64
C24:0 Lignoceric acid	g	0	0.05	0
Total Saturated Fatty Acids	*g*	*3.7*	*3.3*	*3.89*
C16:1 Palmitoleic acid	g	0.16	0.16	0.24
C18:1 Oleic acid	g	35.72	35.93	32.05
C20:1 Gadoleic acid	g	0	0.05	0
C22:1 Erucic acid	g	0	0.05	0
Total Monounsaturated Fatty Acids	*g*	*35.9*	*36.2*	*32.29*
C18:2 (undifferentiated) Linoleic acid	g	12.76	13.48	12.05
C18:3 (undifferentiated) Alpha-Linolenic acid	g	0	0	0
Total Polyunsaturated Fatty Acids	*g*	*12.8*	*13.5*	*12.05*
Cholesterol	mg	0	0	0
Amino Acids				
Alanine	mg	976	1020	1033
Arginine	mg	2254	2356	2546
Aspartic Acid	mg	2190	2289	2821
Cystine + Cysteine	mg	324	339	291
Glutamic Acid	mg	5779	6038	5337
Glycine	mg	1414	1477	1515
Histidine	mg	539	563	611
Isoleucine	mg	886	926	714
Leucine	mg	1508	1576	1517
Lysine	mg	675	705	620
Methionine	mg	211	221	194
Phenylalanine	mg	1157	1209	1185
Proline	mg	844	882	1000
Serine	mg	988	1032	1037
Threonine	mg	822	859	700
Tryptophan	mg	226	236	198
Tyrosine	mg	648	678	547
Valine	mg	1037	1083	825
Other				
Oxalic acid	g	0.3	NA	NA
Lutein + zeaxanthin	µg	NA	NA	1
Phytosterols	*mg*	*NA*	*NA*	*116*
Stigmasterol	mg	NA	NA	1
Campesterol	mg	NA	NA	6
Beta-sitosterol	mg	NA	NA	109
Proanthocyanidins				
Monomers	mg	NA	NA	7.77
Dimers	mg	NA	NA	9.52
Trimers	mg	NA	NA	8.82
4-6mers	mg	NA	NA	39.97
7-10mers	mg	NA	NA	37.68
Polymers	mg	NA	NA	80.26

Abbreviations: NA- Not available in database

Almonds, in general, are a good source of protein and when consumed with their skin are able to contribute to a person's intake of dietary fibre. Both protein and fibre are vital throughout the entire lifecycle to enable growth and tissue repair and regular bowel habits, respectively. The last Australian National Nutrition Survey (NNS) found nuts and nut products to contribute 1.5% and 1.2% dietary fibre for men and women aged over 19 years respectively (7). Although this figure is low, it has been suggested that nut consumption in Australia has increased due to the changing meal patterns. The average level of nut and nut products consumed was 4.2g/day for adults in 1995 (7), (less than one-eighth of the recommended amount) with only 11.6% of people consuming nuts and nut products. Figures from ABA suggest that today, almonds alone are consumed by 10% of people on a daily basis. Nuts generally do not appear to be a seasonal food, with the NNS data showing little variation in the average grams consumed between the seasons of the year (7). As a protein and fibre-rich food, almonds have a satiating effect (8) and, as identified by ABA consumer research, are commonly consumed as a snack throughout the day.

Further, Almonds contain a combination of essential vitamins, minerals and other bioactive components. As a plant-based food, a serving of almonds can provide a good source of magnesium (important for enzyme activation and plays a role in calcium metabolism) (9), phosphorus (a component of DNA and needed for blood acid/base as well as energy transport) (9), non-haem iron (needed for oxidative metabolism and an essential component of various bodily proteins such as haemoglobin) (9), and niacin equivalents (involved in energy metabolism) (9) and an excellent source of riboflavin (a co-enzyme in the synthesis of various fuel molecules such as fat) (9) to the diet of a healthy adult Australians. The calcium and zinc content (needed for bone strength and enzyme function, respectively) are also notable though in a small serving size may not contribute a large proportion to the diet of a person with a balanced diet who also consumes dairy and red meat products. For persons who are unable to obtain calcium from dairy sources including those who are lactose intolerant or follow a vegan diet, almonds may be useful in combination with other calcium-rich foods.

Almonds have been reported to be the highest alpha-tocopherol (vitamin E) containing nut (10). Alpha-tocopherol is a strong antioxidant that protects the body from free-radical or oxidative damage (11). The alpha-tocopherol content of almonds combined with the high oleic acid (monounsaturated fatty acid) and high linoleic acid (polyunsaturated fatty acid) content means that almonds are an energy dense food as well as a great antioxidant source. The scientific literature has suggested that this antioxidant status of nuts in general may be one of the contributing factors in their link to lowered heart disease risk (12). However, the high alpha-tocopherol levels in almonds are found in their skin (10), a component of the nut that is often removed before consumption. Composed of more than two-thirds (of total fat) monounsaturated fatty acids, with only small amounts of saturated fatty acids, no cholesterol and a favourable polyunsaturated to monounsaturated fat ratio, this nutrient profile has been suggested as a reason for the LDL-lowering properties associated with the nut.

The amino acid profile of almonds illustrates a larger proportion of three non-essential amino acids glutamic acid, arginine and aspartic acid. Essential amino acids are those that need to be obtained from the foods we eat and cannot be made by the body while non-essential amino acids can be made by the body but can also be obtained from the diet. Amino acids have long been linked to immune function playing important roles in enzymatic processes and immune factor composites however some amino acids combine with others (e.g. cysteine, glutamic acid and glycine) to provide an antioxidant function (13).

Some of the more recognised bioactive components of almonds (designating them as a functional food) include the phytosterols beta-sitosterol, coumesterol and stigmaterol and the flavanols proanthocyanidin and procyanidins (14). Almonds contain small amounts of natural phytosterols, compounds known to assist with reducing cholesterol absorption due to their cholesterol-like chemical structure. Studies have found that these compounds can be beneficial for lowering a person's cholesterol levels at amounts of 150mg under test conditions (15) and are found in the greatest quantities when in a fat-based matrix. The phytosterol in the highest proportion for almonds is beta-sitosterol. This bioactive may play an important role in the health benefits of almonds though further research is needed before the health benefits can be attributed to one isolated compound within the nut (16).

Nutrient comparisons have been made between dry roasted unsalted almonds and raw almonds (Appendix A). These values were obtained from the Australian nutrient tables (AUSNUT) 1999 database update (4) as the 2006 database does not contain any new data for these processing methods. It may be seen from the datasets of these two processing methods that the primary differences are in the moisture content, phosphorous and zinc levels, each being lower for the dry roasted almond. Small differences are also seen for the vitamins levels, however to make an accurate comparison between these two processing methods, almond samples would need to be matched prior to the nutrient analyses. Dry roasted almonds, as reported by ABA, are also more accepted for snacking due to the changes in the flavour profile.

Almonds are a good source of protein. They containing essential omega-3 fatty acids and they have a favourable ratio of unsaturated to saturated fatty acids. They also contain important nutrients such as magnesium and phosphorus and bioactive phytosterol components making them a valuable inclusion in a healthy balanced diet.

INCLUSION OF ALMONDS IN A HEALTHY DIET

What is cardiovascular disease risk?

All studies from the previous NCEFF report were in support of almonds consumption and cardiovascular disease (CVD) risk reduction or reduction of low density lipoprotein (LDL) cholesterol, however before detailing these studies it is important to consider what reduced cardiovascular risk can mean. To define this, authoritative documentations were sourced. CVD remains as one of Australia's leading causes of death. The incidence of cardiovascular conditions have been related to age and in 2005 the Australian Bureau of Statistics reported 18% of the population as having a cardiovascular condition (7). This equates to almost one in every five people with more females (20%) reporting a cardiovascular conditions than males (16%) (7). These figures also illustrate the importance of finding a means for reducing CVD risk factors.

CVD is known as any disease of the heart or blood vessels (17) and risk therefore relates to any factors relating to age, gender, socioeconomic status, environmental factors, lifestyle and genetic factors. The American Heart Association classifies persons at <u>high risk</u> of CVD as those with established coronary heart disease, cerebrovascular disease, peripheral arterial disease, abdominal aortic aneurysm, end-stage or chronic renal disease and/or diabetes mellitus. Those <u>at risk</u> are persons with one or more risk factors which include cigarette smoking, poor diet, physical inactivity, obesity, family history or premature CVD, hypertension and displipidaemia. Those also at risk are persons with sub-clinical vascular disease such as coronary calcification, metabolic syndrome and those with poor exercise capacity (18). The Australian Heart Foundation (19) and Australian Institute of Health and Welfare (20) list CVD risks factors as:

- Cigarette smoking
- Poor diet and nutrition
- Physical inactivity
- Overweight and obesity
- High blood pressure
- High blood cholesterol
- Diabetes
- Depression, social isolation

These factors are comparable to those stated by the American Heart Association and may support the reason why almonds as part of a balanced diet may be beneficial i.e. Reversal/reduction of poor diet and nutrition.

How can the diet affect cardiovascular disease risk factors?

CVD risk, alongside other lifestyle diseases, has the potential to be modified by changes to the dietary intake. The mechanism for this process has been outlined below and is an important consideration for understanding how foods can affect health. The main dietary factors to be considered in order to see positive changes to CVD risk are modifications to the dietary fat profile, in particular the saturated fatty acids (21). When dietary fat is consumed in the diet, it is metabolised by the body and absorbed in the intestinal tract. During this process the ratio of saturated to unsaturated fatty acids is very important (lower is better). It is believed that when saturated fatty acids are consumed in the diet, they increase the amount of 'bad' cholesterol in the blood and in turn decrease the amount of LDL (bad) cholesterol clearance by the liver (22). These increased levels of LDL cholesterol in the blood stream increase the risk of atherosclerotic plaque (collection of cells containing fatty acids and cholesterol) formation in the arteries. Decreasing the amount of saturated fatty acid and/or replacing this with unsaturated fatty acid has the potential to reverse this process by decreasing the amount of LDL cholesterol in the blood stream.

Certain types of unsaturated fatty acids can also play a further role in cardiovascular health. Omega-3 fatty acids have been shown to beneficially affect CVD risk, in particular the long chain forms docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), found primarily in marine sources.

Another form of omega-3, docosapenaenoic acid (DPA) commonly found in red meats can be readily converted by the body into EPA and DHA as needed, while the plant based form of omega-3 fatty acid (found in almonds), alpha-linolenic acid (ALA, a shorter chain form), is limited in its conversion to EPA or DHA in the body depending on the other types of fats consumed. The role of omega-3 fatty acids in reducing CVD risk is primarily through an anti-inflammatory effect though increases in good cholesterol have also been observed (23). Anti-arrhythmic effects (regulation of abnormal heart rhythm), anti-thrombotic effects (prevention or interference with the formation of thrombi which may result in vascular obstructions), and lowered blood pressure from omega-3 fatty acid intake have also been reported (24).

In order to achieve changes to the dietary fat profile of the diet, the balance of the overall diet or background diet is an important consideration. Although single foods have been studied and related to reductions in CVD risk, they are not consumed on their own. A food on its own may provide positive benefits to health through the delivery of key nutrients, however if this food is consumed in the context of an unbalanced or unhealthy background diet, it is unlikely that positive effects would be seen. This can be demonstrated when essential nutrients are extracted from foods and consumed on their own. The interactions of all the other nutrients that are normally found in the whole food matrix are no longer there to support the nutrient. Similarly, a 'healthy' food if eaten on its own is unlikely to show the same effect as when it is consumed in conjunction with other 'healthy' food items.

Food-based clinical studies: Breaking down the evidence

Randomised controlled clinical trials are ranked the highest in the levels of evidence for effects on health. These studies include the randomisation of participants into intervention groupings and comparing the intervention group (for example one consuming a food product) against a control group (not consuming the food product). In pharmaceutical clinical trials, the researchers and participants are often double-blinded, a step to reduce the bias, to both the randomisation and to the intervention as well. This process is rather straightforward due to the ability to manufacture the drug treatment and placebo (inactive pill) to appear identical. These trials are considered the highest level of evidence for clinical research. Food-based clinical trials may have both the participants and researchers blinded to the randomisation process however blinding the intervention is a little more difficult due to the challenges of disguising food products that may have distinctive appearances, tastes or smells. Food based clinical trials therefore need to ensure other important factors are included in the trial to achieve the highest quality rating. These include factors such as:

- the statistical calculation of the number of participants needed in the study based on the clinical outcomes that the study aims to achieve (power calculation)
- clearly defined inclusion and exclusion criteria (medical and social conditions) for the participants
- careful screening of the participants to be included in the study to ensure the least number of variables can impact on the outcomes of the study.

High quality studies will include all of these factors under carefully controlled study protocols while low and medium quality studies may only include a selection of these factors as shown in Table 3.

Table 3: Criteria for rating a study as high, medium and low quality clinical trial

Criteria	Quality and Relevance Rating		
	High	Medium	Low
Control group	Yes	Yes	No
Power calculation if non-significant results	Yes	No	No
Assessment of dietary compliance	Yes	Perhaps	No
Accurate and valid intake methods	Yes	Yes	Perhaps
Appropriate outcome measures	Yes	Perhaps	Perhaps
Appropriate statistical measures - confounders	Yes	Perhaps	No
Design directly relevant to the claimed relationship	Yes	Perhaps	No

When evaluating clinical trials relating to CVD risk, the biomarkers (molecular indicators) that can be measured in the body should also be considered. The most common of these biomarkers is the LDL cholesterol level which is expected to decrease as CVD risk decreases. LDL is a transport protein which carries triglycerides and cholesterol molecules from the liver to the tissues of the body. It is therefore often referred to as 'bad' cholesterol. Two similar types of molecule, though less often reported in studies are the very low density lipoprotein (VLDL) and intermediate density lipoprotein (IDL) cholesterol molecules or the precursors of LDL cholesterol. These play a similar role in the body to LDL but are composed largely of triglyceride molecules. As VLDL is broken down, it forms IDL and then finally LDL (the smallest of the molecules). Similarly, as triglyceride levels in the bloodstream decrease VLDL levels and IDL levels should also decrease.

A similar transport protein, high density lipoprotein (HDL) cholesterol is usually measured in association with LDL and should increase as CVD risk decreases. HDL has the opposite effect to LDL as it transports cholesterol molecules from the bloodstream to the liver. For this reason it is often referred to as 'good' cholesterol. The combination of LDL, VLDL, IDL and HDL cholesterol levels are used to determine total cholesterol.

Other slightly larger protein molecules may also be measured in clinical studies relating to CVD risk. The apolipoproteins are lipid-binding proteins that transport dietary lipids in the plasma of the blood. Apolipoprotein B is associated with transportation of LDL cholesterol, while the different variants of apolipoprotein A transport HDL cholesterol. The ratio of these two lipoproteins may so be addressed when measuring CVD risk clinically.

Effect of almond consumption on LDL reduction (High quality studies)

The previous study conducted by NCEFF in February 2007 reviewed 17 studies relating to almond consumption. These 17 focused, human studies comprised eleven human clinical trials addressing almond consumption on blood lipid and lipoprotein parameters and a further six human clinical trials investigating almond consumption and other dietary changes on blood lipid parameters. These studies were published between 1991 and 2003.

Of the eleven studies that investigated almond consumption on its own, six were focused on persons with elevated cholesterol levels while the remaining five varied between healthy subjects, overweight and obese subjects and persons with type two diabetes mellitus. Only two high quality studies were identified and both appear to relate to the role of almonds in reducing LDL cholesterol. The first, a randomised cross-over controlled feeding trial for 25 eligible healthy men and women aged 20-60 years of age of which two subjects did not complete the study. The study tested three different diet treatments (25). Participants were excluded if they had:

- fasting serum cholesterol level of less than the 15th percentile or higher than the 95th percentile
- triglyceride levels of greater than 2.26mmol/L
- consumption of nuts more than twice weekly
- consumption of caffeinated beverages more than three times daily
- consumption of alcoholic beverages more than twice weekly
- had a history of chronic metabolic disease
- used lipid modifying medications
- a BMI greater than 30kg/m²
- food allergies, or
- for females had an irregular menstrual cycle or had used hormones in the past five years.

- 34grams per day = approx. 28 almonds
- 68 grams per day = approx. 57 almonds

The first diet type, used as the control diet, was the American Heart Association's Step 1 diet. This diet contains 30% energy from fat, less than 10% energy from saturated fat and a high amount of carbohydrate. It is aimed at reducing an individuals cholesterol levels. The second diet type, the low almond diet, replaced 10% of energy in the Step 1 diet with whole or slithered almonds and the final diet type replaced 20% of energy in the Step 1 diet with almonds. The low almond diet ended up with 35% of energy from fat from the addition of 34 grams of almonds per day and the high almond diet with 39% of energy from fat from the addition of 68 grams of almonds per day.

This study found that incorporation of almonds into the diet resulted in a decrease in serum saturated fatty acids and an increase in monounsaturated fatty acids. A significant dose-response was also observed for total and LDL cholesterol, the ratio of HDL to LDL cholesterol, apolipoprotein-B, and the ratio of apolipoprotein A to B.

When compared with the Step 1 diet, the high almonds diet resulted in a 0.24mmol/L reduction in total cholesterol and a 0.26mmol/L reduction in LDL cholesterol. The study also compared the high almond and the low almond diets and discovered a significant reduction of 0.19mmol/L total cholesterol and 0.22mol/L LDL cholesterol. Overall the high almond diet found a 7% decrease in total and a 9% decrease in LDL cholesterol when compared with the baseline figures and the low almond diet found a 4% decrease in total and a 3% decrease in LDL cholesterol. No significant reductions were found for the Step1 diet alone.

Although the reduction from the high almond diet was greater than that of the low almond diet, the additional energy from the almonds should also be considered. Consuming 68g of almonds or replacing 20% of energy with almonds to ensure an isocaloric diet would give little room for other essential food groups and would mean participants would need to be on a tightly controlled and quite prescriptive diet for the duration of the study. This appears to have been controlled for in the study by providing meals to the participants from a metabolic kitchen. This type of study would need to be repeated under free-living conditions to determine whether such a large dose of almonds could be safely incorporated or whether the smaller dose, which is closer to the Almond Board of Australia recommendations would be more easily incorporated.

The second high quality study followed 100, healthy, 25-70 year old participants for a period of 12 months (26). The first six months was considered a control diet and was each participant's habitual diet. The second six month period included the addition of almonds to the diet consisting of 15% of each participant's average energy intake from their habitual diet. The amounts of almonds were then divided into tertiles (one of three divisions of observations) of intake with the lowest being 42g of almonds (approx. 1000kJ), the middle 57g of almonds (approx. 1400kJ) and the highest 71g of almonds (approx. 1800kJ). The almonds were either dry roasted or raw or a combination of the two and provided in pre-packaged portions labelled for each day of the week. For this study, participants were excluded if they:

- 42 grams per day = approx. 35 almonds
- 57 grams per day = approx. 48 almonds
- 71 grams per day = approx. 59 almonds

- had a medical condition that would affect their body weight
- were below the 95th percentile for age and gender specific BMI
- had gained more than 9kg weight in the past six months
- ate nuts more than twice weekly or more than seven grams per week
- were regularly doing rigorous exercise
- were consuming an atypical diet
- drink more than two glasses of alcohol per week, or
- were pregnant.

During the course of the study, 13 participants withdrew leaving 87 participants to complete the study. Unannounced dietary recalls (as opposed to planned recalls as is generally the protocol in clinical studies) were included at three week intervals which found almonds to be reported in 90.2% of the recalls. Food diaries were also requested at four and six months of the control diet and eight and 12 months of the intervention period. Of these diaries 89.2% included almonds. During the second six month period, the study found an increase in total energy with a decrease in the total weight of food eaten, increased total fibre intake and higher insoluble to soluble fibre ratios than compared with the control diet period.

The addition of the almonds also saw a reduction in total carbohydrate intake and dietary cholesterol intake by 11, 13 and 17% in each of the tertiles. There was an increase in total fat intake by 20%, a decrease in saturated fat intake by 3%, an increase in both polyunsaturated fat intake by 24% and monounsaturated fat intake by 42%. The outcome from this study was that the average intake of 52g of almonds per day can favourably modify the nutrient profile and by making these changes could help to prevent CVD. The portion size of almonds in this study is closer to the amount recommended by the ABA indicating that regular almond consumption in smaller doses over a long-term period may also have beneficial effects. This study did not specifically measure LDL or HDL cholesterol levels but rather demonstrated that dietary modification can have a significant impact upon the nutrient profile of the diet.

Effect of almond consumption on LDL reduction (medium and low quality studies)

Six medium quality studies for almonds on their own and three medium quality studies for almonds plus other dietary modifications were identified during the previous review. Of these studies four were cross-over designed studies (27-30) and five were parallel interventions trials (31-35). The cross-over trials ranged from a comparison of 37g and 147g of almonds in 27 postmenopausal women and men with high cholesterol (27), comparing 66g almonds with 35g almond oil in 22 healthy participants (28) and adding 84g of almonds to the normal Australian 39% fat diet of 16 healthy men and women (29) through to the addition of 99g of almonds to a high vegetable, fruit and nuts diet in healthy men and women (30). Each of these studies found a reduction of LDL cholesterol levels however most were also testing an amount of almonds which is more than double the recommended serving size suggested by ABA. The study with the closest comparable serving size testing 37g of almonds found a 3.1% decrease in LDL levels and an increase in HDL levels (Table 4) over a period of four weeks, however this was with participant who already had elevated cholesterol levels (27).

Table 4: High and medium quality study outcomes

Study	Study Quality	No. of almonds	LDL cholesterol	HDL cholesterol
Jaceldo-Siegl *et al.* (2004) (26)	High	35-59	NA	NA
Sabate *et al.* (2003) (25)	High	28-57	↓4-9%	↓0-3%
Abbey *et al.* (1994) (29)	Medium	70	↓10%	No change
Hyson *et al.* (2002) (28)	Medium	55	↓6%	↑4.3%
Jenkins *et al.* (2001) (30)	Medium	83	↓33%	No change
Jenkins *et al.* (2002) (27)	**Medium**	**31**	**↓3.1-5.6%**	**↑3.8-4.6%**
Jenkins *et al.* (2003) (34)	Medium	23	↓35%	No change
Lamarche *et al.* (2004) (36)	Medium	~25	↓28.6%	No change
Noakes and Clifton (2000) (35)	Medium	NA	↓20%	No change
Spiller *et al.* (1998) (31)	Medium	83	↓19%	No change
Spiller *et al.* (2003) (32)	Medium	83	↓7-12%	No change
Wein *et al.* (2003) (33)	Medium	70	↓10%	↓6%

The medium quality parallel intervention trials also provided high levels of almond intake, ranging between 87g and 100g per day (31-33). In all studies, these values were calculated based on the percentage of fat in the diet. Each of these studies then also found between a 10% and 19% reduction in LDL cholesterol levels with a greater reduction not necessarily linked to participants with previously high cholesterol levels. When the almonds were combined with other dietary modifications such as a high unsaturated fat diet from canola shortbread biscuits (35) or from the combination with plant sterols and soy protein in the portfolio diet (34), 20% (35) to 35% reductions in LDL cholesterol levels were observed (34), which may suggest the importance of incorporating almonds into a balanced diet. All of the medium quality studies were also in support of the role of almonds in reducing LDL cholesterol levels.

The studies with almonds alone which were ranked as lower quality studies also tested large amounts of almond consumption (>100g) (37, 38), similar to the medium and high quality studies, however these studies either did not include a control group to determine whether the effect seen was a result of the intervention (37, 38) or did not have a large enough sample size for the outcome they were measuring (37). Of the studies with almonds alone, one study (37) was not supportive of the role of almonds in reducing LDL cholesterol as they did not find a clear reduction in LDL cholesterol or total cholesterol but did see a decrease in HDL cholesterol levels. This study was testing 10% fat from almonds (57-113g) in either a high fat (37%) or low fat (25%) diet for four weeks. The participants were male and female with type 2 diabetes mellitus. When almonds were included with another form of dietary modification, the almond quantity was either not specified (39, 40) or it was included with other foods that have cholesterol lowering potential making the conclusion difficult to relate to almonds alone (36).

Additional research 2004-2008

To determine whether any additional studies for almonds had been published since the previous NCEFF report, the literature search was repeated for the years 2004-2008, a result of which identified an additional eight studies, however after obtaining the full text versions of these articles, it was determined that none of these were high quality human clinical trials relating to LDL reduction or reduced CVD risk. One study assessed almond oil consumption in a sample of five postmenopausal women to determine changes in their VLDL and IDL blood lipid concentrations over a period of 12 hours (41). Another two studies looked at glycaemic response (42) and body weight (43) respectively with no measures of blood lipids, and two tested bioactive components of almonds on human LDL in vitro (44, 45). One of the remaining studies were focused on the nutrient changes to dietary intake with the addition of almonds though had already been captured in the previous report (26) and two on the effects of alpha-tocopherol on blood lipid levels (46, 47).

Two of the additional eight studies were of note. One of these studies looked at almond consumption in n=60 male habitual smokers to determine the effects on biomarkers of oxidative stress. They were randomised into two groups and provided with either 84g almond powder or 120g pork for four weeks with a four-week run-in phase before the intervention and a four-week wash-out phase between the different diet types. The almond powder was consumed with steamed bread, steamed rice or water and the pork was consumed with steamed bread or vegetables provided from a canteen. The study found an increase in serum alpha-tocopherol (vitamin E) levels of 8.6% on the almond diet compared with no change on the pork diet (47).

The other study included 16 health participants who were randomised into a feeding trial. They were required to consume 0% almond, 10% energy from almond (low almond diet) and 20% energy from almond (high-energy diet) on an isocaloric diet for four weeks each. The results from this study showed the LDL cholesterol levels for the low almond consumption to be 3.79mmolL while the high almond consumption was 3.54mmol/L (P>0.001). Similarly the HDL levels were 1.21mmol/L and 1.23mmol/L respectively with the triglyceride levels following a similar pattern of 1.42mmol/L and 1.29mmol/L respectively though both the HDL and triglyceride results were not significant. The study was primarily focused on the alpha-tocopherol levels and hence primarily presented results for plasma and red blood cell alpha-, beta- and gamma-tocopherol levels and tocopherol to cholesterol ratios. This study suggests that almond consumption may be a way of increasing the alpha-tocopherol levels in the blood, a protective agent for CVD (46).

From the scientific literature, it appears that the dose of almonds required for a 10% reduction in LDL cholesterol levels is between 68-84g/day (48-50).[*] These changes however, are under tightly controlled conditions and would need to be replicated in a free-living environment to determine the effectiveness for the general population. Epidemiological studies suggest that 'the average reduction in risk of coronary heart disease (CHD) death is 8.3% for each serving of nuts (~30g) consumed weekly' (51) which is much closer to the recommended serving size promoted by the ABA.

> The scientific literature shows strong, consistent evidence for including almonds, in the context of a healthy balanced (low fat) diet, for the reduction of LDL cholesterol

[*] *Meta-analysis required for confirmation*

FITTING ALMONDS IN WITH DIETARY GUIDELINE RECOMMENDATIONS

On a worldwide scale, nuts may be found in a number of country's core food groupings. The USA Food Guide Pyramid includes nuts within the meat and beans grouping (1oz/30g serving) with the suggestion that nuts are also a source of oils in the diet. The Canadian Food Rainbow includes nuts under a meat and alternatives grouping (1/4 cup/60mL serving) (52) and the UK Eatwell Plate includes nuts with the meat, fish, eggs and legumes group suggesting them as a snack (no serving size) but warning that they are also high in fat and shouldn't be consumed in excess (53). The guidelines for New Zealand also specifically mention nuts in the lean meat, poultry, chicken, seafood, eggs, nuts, seed and legumes group based on their protein composition (54). In Europe, the Spanish food groups refer to nuts on their own as a high energy, low saturated fat food which are rich in fibre and can be used as a substitute to animal-origin proteins and fats (55). They appear in the Spanish food guide pyramid with the lean meats, fish, eggs and legumes and are recommended to be consumed twice daily. Other European countries including the Netherlands (56), Germany (57) and Denmark (58) do not specifically refer to nuts.

- USA = approx 25 almonds or 760kJ
- Canada = approx 30 almonds or 920kJ
- Australia = approx. 40 almonds or 1225kJ

The *Australian Guide to Healthy Eating* categorises nuts in the meats, fish, poultry, eggs and legumes food grouping similar to the UK. This categorisation is based upon the distinguishing nutrients of protein, iron and zinc followed by a significant contribution of fat, cholesterol (not applicable to nuts), niacin equivalents and vitamin B12 (not applicable to nuts) (59). In order to obtain these nutrients, the Guide recommends a serving of approximately 1/3 cup of almonds. Furthermore, the Australian Dietary Guidelines (60) support the inclusion of nuts as part of a healthy balanced diet. Nuts are referred to under the third recommendation "Include lean meat, fish, poultry and/or alternatives" and are considered to be an alternative alongside seeds, crustaceans and seafood, offal meats, eggs and legumes. It should be noted however that the Australian core food groups are scheduled for review in 2008 and new core food groups may become public within a few years (61).

Dietary modelling, based on the recommended number of servings for Australians from each of the current core food groups, found that almonds can easily be included in the diet as a replacement snack food. Table 5 shows the composition of the diet of a 19+ year old adult for one day meeting all food group requirements. These foods were selected to maximise the nutrient profile of the modelled diet with the aim of achieving at least 100% RDI for key nutrients. Additional 'extra' (snack) foods were added to the diet to achieve 100% of the estimated energy requirement. Despite this careful process and with both snack options A and B (Table 6), the requirement for zinc only reached 88% of RDI.

Almond Board of Australia recommends 23 almonds per day = approx. 28 grams or 700kJ

Table 5: Dietary modelling for 19+ year adults minus additional snack foods (Menu 1)

Meal	Amount	Food	AGHE Serves
Breakfast	2 biscuits (40g)	Whole wheat breakfast cereal	2
	1/2 cup (125mL)	Skim milk	1
Extras	1 coffee cup (180ml)	White coffee	Extra
Morning Tea	1	Orange	1
Lunch	2 Slices	Wholemeal Bread	1
	1 tsp	Polyunsaturated Margarine	Extra
Extras	4 slices	Tomato	
	2, sliced	Baby beetroots	1
	8 slices	Cucumber	
Afternoon tea	200g tub	Reduced fat yoghurt	1
Dinner	1 cup	Coleslaw salad	1
	2 tsp	Reduced fat coleslaw dressing	Extra
	2 Slices	Wholemeal bread	1
	100g	Trim lamb, grilled	1
	75g	English spinach	1
	75g (1/2 Cup)	Steamed carrots	1
	75g (3 Florets)	Steamed cauliflower	1
	1 small	Boiled potato	1
Supper	150g	Banana	1

Table 6: Additional snacks for adults 19+ yrs (Menu 1) used as substitutes for 28.5g almonds

Option	Amount	Food
Extras (A)	1/2 Cup (95g)	Chocolate mousse
	3 biscuits	Chocolate chip biscuits
Extras (B)	1 row (34g)	Dark chocolate
	1 Cup (33g)	Potato crisps

Almonds were used as an equicaloric substitution for potato crisps, dark chocolate, chocolate mousse and chocolate chip biscuits snack foods in an adult diet. The most notable differences in the nutrient profile after the addition of almonds was an increase in the amount of total fat (11.99-23.16%). When the fat types were considered, however, it was found that there was an increase in the polyunsaturated fatty acids (55.72-71.31%) and monounsaturated fatty acids (18.71-77.08%) and a decrease in the saturated fatty acids levels (12.17-52.04%) for all snack types (Tables 7 and 8). These changes show that a fat profile which is better aligned with good heart health may be achieved through a simple change in snacking behaviours. For the micronutrients, the substitution of almonds also had a large impact on magnesium levels, increasing across all substitutions (10.57-13.47%). The zinc levels in the diets also increased to between 91 and 94% RDI when the almonds were added to the diet.

Table 7: Nutrient profile of Menu 1 with snack option A (19+ year adults)

	Option A	Almonds/ crisps sub	% Difference	Almonds/ chocolate sub	% Difference	RDI[a]	SDT[b]	AI[c]
Energy (kJ)	7059.97	7058.93	-0.01	7059.97	0.00			
Protein (g)	85.66	89.48	4.45	90.23	5.33	64		
Protein (%E)	20.63	21.55	4.47	21.73	5.33		15-25	
Fat (g)	43.02	48.18	11.99	48.54	12.82			
Fat (%E)	422.95	449.08	6.18	453.68	7.27		20-35	
SFA (g)	18.23	17.93	-1.64	9.86	-45.89			
SFA (%F)	42.36	37.21	-12.17	20.32	-52.04			
PUFA (g)	5.42	8.43	55.72	9.19	69.67			
PUFA (%F)	12.59	17.51	39.04	18.94	50.39			
MUFA (g)	14.77	17.53	18.71	25.14	70.26			
MUFA (%F)	34.32	36.38	6.00	51.80	50.92			
Cholesterol (mg)	133.80	133.80	0.00	132.78	-0.76			
Carbohydrate (g)	220.21	205.79	-6.55	202.12	-8.22			
Carbohydrate (%E)	53.03	49.56	-6.54	48.67	-8.22		45-65	
Fibre (g)	39.54	38.24	-3.30	40.60	2.68		28-38	25-30
Thiamine (mg)	2.09	2.09	0.15	2.13	1.72	1.1-1.2		
Riboflavin (mg)	2.78	3.08	10.86	3.05	9.74	1.1-1.3		
Niacin equiv. (mg)	38.75	39.45	1.81	40.62	4.85	14-16		
Vitamin C (mg)	227.20	212.68	-6.39	227.20	0.00	45		
Folate (µg)	544.50	543.64	-0.16	552.78	1.52	400		
Vitamin A (µg)	1839.28	1839.57	0.02	1833.11	-0.34	700-900		
Sodium (mg)	1663.81	1454.03	-12.61	1649.93	-0.83			460-920
Potassium (mg)	4723.77	4532.68	-4.05	4707.68	-0.34			2800-3800
Magnesium (mg)	450.79	511.53	13.47	498.45	10.57	310-420		
Calcium (mg)	1078.90	1140.48	5.71	1122.21	4.01	1000-1300		
Phosphorus (mg)	1527.43	1597.39	4.58	1585.89	3.83	1000		
Iron (mg)	20.24	20.45	0.99	20.59	1.71	8-18		
Zinc (mg)	12.33	12.98	5.31	12.93	4.92	8-14		

[a] Recommended Dietary Intake, [b] Suggested dietary target, [c] Adequate intake

Table 8: Nutrient profile of Menu 1 with snack option B (19+ year adults)

	Option B	Almonds/ mouse sub	% Difference	Almonds/ biscuits sub	% Difference	RDI[a]	SDT[b]	AI[c]
Energy (kJ)	7058.59	7060.39	0.03	7044.37	-0.20			
Protein (g)	91.03	90.31	-0.79	94.66	3.99	64		
Protein (%E)	21.92	21.74	-0.82	22.84	4.20		15-25	
Fat (g)	37.54	46.23	23.16	44.73	19.15			
Fat (%E)	391.96	439.17	12.05	432.60	10.37		20-35	
SFA (g)	16.59	12.89	-22.28	13.24	-20.19			
SFA (%F)	44.19	27.89	-36.89	29.60	-33.01			
PUFA (g)	5.17	8.85	71.31	8.45	63.57			
PUFA (%F)	13.77	19.15	39.10	18.90	37.29			
MUFA (g)	11.44	20.25	77.08	18.90	65.28			
MUFA (%F)	30.47	43.81	43.79	42.26	38.72			
Cholesterol (mg)	163.65	138.00	-15.67	158.43	-3.19			
Carbohydrate (g)	229.55	209.27	-8.84	207.95	-9.41			
Carbohydrate (%E	55.29	50.39	-8.86	50.18	-9.23		45-65	
Fibre (g)	34.81	37.34	7.26	36.72	5.50		28-38	25-30
Thiamine (mg)	2.12	2.11	-0.22	2.13	0.67	1.1-1.2		
Riboflavin (mg)	3.04	3.03	-0.25	3.35	10.27	1.1-1.3		
Niacin equiv. (mg)	39.17	39.80	1.63	40.65	3.78	14-16		
Vitamin C (mg)	213.63	212.68	-0.44	213.63	0.00	45		
Folate (μg)	536.69	542.68	1.12	545.74	1.69	400		
Vitamin A (μg)	1930.63	1839.72	-4.71	1924.30	-0.33	700-900		
Sodium (mg)	1630.68	1557.05	-4.51	1513.76	-7.17			460-920
Potassium (mg)	4465.25	4357.62	-2.41	4620.64	3.48			2800-3800
Magnesium (mg)	438.88	488.56	11.32	508.14	15.78	310-420		
Calcium (mg)	1267.78	1132.40	-10.68	1317.93	3.96	1000-1300		
Phosphorus (mg)	1647.29	1584.40	-3.82	1716.76	4.22	1000		
Iron (mg)	19.78	20.43	3.27	20.13	1.75	8-18		
Zinc (mg)	12.39	12.71	2.61	13.24	6.90	8-14		

[a] Recommended Dietary Intake, [b] Suggested dietary target, [c] Adequate intake

Generally the replacement of crisps, biscuits and dark chocolate with almonds also improved the riboflavin levels by between 9.74 and 10.86% but little effect was found for riboflavin when almonds replaced chocolate mousse. This is due to the high riboflavin content of dairy milk, a common ingredient in mousse. This replacement also resulted in a 10.68% decrease in calcium levels. As the diets were modelled for energy and micronutrient RDIs, the RDI for calcium remained above 100% however this demonstrates the importance of a balanced intake across all food groupings. A decrease in dietary cholesterol levels were also observed for this substitution. The replacement of potato crisps for almonds resulted in an additional decrease in sodium levels as did the replacement of chocolate chip biscuits. Similar diets (almonds substituted for potato crisps) were also modelled for 8-18 year old children/adolescents and pregnant women (Appendix B) and likewise, the polyunsaturated and monounsaturated fatty acids levels as well as the riboflavin and magnesium levels increased while the saturated fatty acids levels and sodium levels decreased.

Further dietary modelling was conducted to determine the impact of almonds on the diet when used as a meat alternative. The initial modelling was conducted with an equicaloric replacement of the meat in the diet (lean lamb) with almonds (28g). This replacement had a large impact upon the zinc levels in the diet, decreasing down to 60% RDI. The RDI for protein was also not achieved, only reaching 94%. The modelling was therefore repeated for matched protein levels. This increased the serving of almonds up to 164g (one cup) of almonds. This amount of almonds still only achieved 92% of the RDI for zinc and at the same time is delivering 49% energy from total fat alone. From this modelling alone, it appears that almonds are best suited to be eaten as a snack throughout the day.

Dietary modelling with 28.5grams of almonds shows that they are best included as a snack in a balanced diet.

CONCLUSION

Almonds contain a number of essential vitamins and minerals as well as a number of bioactive components which are yet to be studied further. Almonds, on their own, are a great protein food containing essential ALA fatty acid an important omega-3 fatty acid. Almonds also contain a favourable profile of unsaturated to saturated fatty acids and larger amounts of Vitamin E than most other nuts. They also contain important nutrients such as magnesium and phosphorus and the bioactive phytosterols beta-sitosterol. This combination of nutrients make almonds a beneficial inclusion in a balanced diet. Like all foods, the individual benefit lies in the nutrients they deliver, and the health benefit lies in their inclusion in an overall healthy diet.

A number of scientific studies have been conducted with almonds with varying information on dietary modifications. These studies were reviewed and although they are primarily under tightly controlled conditions, all showed reduced LDL cholesterol levels at the conclusion of the study period. The dose of almonds also varied widely. Overall, the scientific evidence for almonds shows strong, consistent evidence for the consumption of almonds, in the context of a healthy balanced (low fat) diet, for the reduction of LDL cholesterol.

To further expose how a balanced diet might look, the dietary modelling that was conducted and this supported the inclusion of almonds in a healthy balanced diet. Almonds were modelled as both as snack food and as a meat alternative. The dietary profile for almonds as a snack was favourable and showed that almonds are best included as a convenient snack in a balanced diet. This finding supports the objectives of the ABA promotional activities showing that 23 almonds (or one handful) may be a useful serving size to increase consumption levels in Australia.

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APPENDIX A: NUTRIENT COMPOSITION OF RAW AND DRY ROASTED ALMONDS (UNSALTED)

		AUSNUT 1999 (4)		
Nutrients per 100g	Measure	Raw	Dry roasted, no salt	% Difference
Proximates				
Energy	kcal	603.58	610.04	1.1
Energy	kJ	2526.0	2553.0	1.1
Moisture	g	3.7	1.8	-105.6
Protein	g	20.0	20.8	3.8
Fat	g	55.2	55.5	0.5
Sugars, total	g	4.4	4.5	2.2
Starch	g	0.0	0.0	*0.0*
Available Carbohydrate	g	4.4	4.5	2.2
Total Dietary Fibre	g	8.8	9.2	4.3
Minerals				
Calcium	mg	235.00	245.00	4.1
Iron	mg	3.50	3.60	2.8
Magnesium	mg	260.00	271.00	4.1
Phosphorus	mg	475.00	396.00	-19.9
Potassium	mg	690.00	719.00	4.0
Sodium	mg	5.00	5.00	0.0
Zinc	mg	8.00	3.80	-110.5
Vitamins				
Vitamin A	µg	2.00	1.00	-100
Retinol Equivalents	µg	0.00	0.00	*0.0*
Beta Carotene	µg	8.00	6.00	-33.3
Vitamin B1 Thiamine	mg	0.17	0.15	-13.3
Vitamin B2 Riboflavin	mg	1.15	1.14	-0.9
Vitamin B3 Niacin	mg	3.80	3.80	0.0
Vitamin B3 Niacin Equivalents	mg	7.80	7.90	1.3
Vitamin B9 Folate	µg	49.00	41.00	-19.5
Vitamin C	mg	0.00	0.00	*0.0*
Lipids				
Total Saturated Fatty Acids	g	3.60	3.70	*2.7*
Total Monounsaturated Fatty Acids	g	36.00	37.60	*4.3*
Total Polyunsaturated Fatty Acids	g	13.10	13.60	*3.7*
Cholesterol	mg	0.00	0.00	*0.0*

Abbreviations: NA- Not available in database

APPENDIX B: REPLACEMENT OF POTATO CRISPS WITH ALMONDS FOR CHILDREN AND PREGNANT WOMEN

Table 9: Dietary modelling for 8-11year old children (Menu 2) showing shaded foods for substitution with 28.5g almonds

Meal	Amount	Food	AHGE Serves
Breakfast	2 biscuits (40g)	Whole wheat breakfast cereal	1
	½ cup (125mL)	Reduced Fat Milk	0.5
Morning Tea	1	Orange	1
Lunch	2 slices	Wholemeal Bread	1
	2 tsp	Polyunsaturated margarine	Extra
	4 slices	Tomato	
	2 sliced	Baby beetroots	1
	8 slices	Cucumber	
Afternoon tea	2 slices	Wholemeal Bread	1
	2 tsp	Polyunsaturated margarine	Extra
	40g	Reduced fat cheese	1
	33g (1 cup)	Potato crisps	Extra
Dinner	100g	Trim lamb, grilled	1
	75g	English spinach	1
	75g (1/2 cup)	Steamed carrots	1
Dessert	34g (1 row)	Dark chocolate	Extra
Supper	125mL	Reduced fat milk	1
	1 tb	Chocolate beverage flavouring	Extra

Table 10: Nutrient profile of Menu 2 (8-11year old children)

	Without almonds	With almonds	% Difference	RDI[a]	SDT[b]	AI[c]
Energy (kJ)	5493.76	5497.02	0.06			
Protein (g)	72.60	76.42	5.26	40		
Protein (%E)	22.47	23.63	5.19			
Fat (g)	48.55	53.77	10.76			
Fat (%E)	380.66	406.94	6.90			
SFA (g)	17.77	14.17	-20.25			
SFA (%F)	36.60	26.35	-28.00			
PUFA (g)	9.93	12.69	27.72			
PUFA (%F)	20.46	23.60	15.31			
MUFA (g)	16.05	22.61	40.85			
MUFA (%F)	33.06	42.05	27.17			
Cholesterol (mg)	132.83	132.83	0.00			
Carbohydrate (g)	133.12	118.69	-10.84			
Carbohydrate (%E)	41.19	36.71	-10.89			
Fibre (g)	28.16	26.86	-4.63			24
Thiamine (mg)	1.76	1.76	0.18	0.9		
Riboflavin (mg)	1.86	2.16	16.25	0.9		
Niacin equiv. (mg)	32.06	32.76	2.19	12		
Vitamin C (mg)	123.51	108.99	-11.76	40		
Folate (µg)	432.89	432.04	-0.20	300		
Vitamin A (µg)	1921.87	1922.15	0.01	600		
Sodium (mg)	1873.37	1663.59	-11.20			400-800
Potassium (mg)	2801.78	2610.70	-6.82			3000
Magnesium (mg)	339.61	400.34	17.88	240		
Calcium (mg)	868.26	929.84	7.09	1000		
Phosphorus (mg)	1186.74	1256.70	5.90	1250		
Iron (mg)	17.33	17.53	1.16	8		
Zinc (mg)	10.91	11.56	6.00	4-6		

[a] Recommended Dietary Intake, [b] Suggested dietary target (Not applicable to this age group), [c] Adequate intake

Table 11: Dietary modelling for 12-18year old girls and 16-18 year old boys (Menu 3) showing shaded foods for substitution with 28.5g almonds

Meal	Amount	Food	AHGE Serves
Breakfast	2 biscuits (40g)	Whole wheat breakfast cereal	1
	1 tsp	Sugar	Extra
	½ Cup (125mL)	Reduced Fat Milk	0.5
Morning Tea	40g	Muesli bar, plain no topping	1
	1	Orange	1
Lunch	2 slices	Wholemeal Bread	1
	2 tsp	Polyunsaturated margarine	Extra
	4 slices	Tomato	
	2, sliced	Baby beetroots	1
	8 slices	Cucumber	
Afternoon tea	200g tub	Reduced fat yoghurt	1
	33g (1 cup)	Potato crisps	Extra
Dinner	100g	Trim lamb, grilled	1
	75g	English spinach	1
	75g (1/2 Cup)	Steamed carrots	1
	75g (3 Florets)	Steamed cauliflower	1
Dessert	34g (1 row)	Dark chocolate	Extra
Supper	125mL	Reduced fat milk	1
	1	Banana	1

Table 12: Nutrient profile of Menu 3 (12-18year old girls and 16-18 year old boys)

	Without almonds	With almonds	% Difference	RDI[a]	SDT[b]	AI[c]
Energy (kJ)	6992.20	6991.17	-0.01			
Protein (g)	76.33	80.14	5.00	45		
Protein (%E)	18.56	19.49	5.01		15	
Fat (g)	50.65	55.81	10.18			
Fat (%E)	405.06	431.18	6.45		20	
SFA (g)	21.98	21.68	-1.36			
SFA (%F)	43.39	38.85	-10.48			
PUFA (g)	6.28	9.30	48.04			
PUFA (%F)	12.40	16.66	34.36			
MUFA (g)	18.03	20.79	15.32			
MUFA (%F)	35.60	37.26	4.66			
Cholesterol (mg)	123.05	123.05	0.00			
Carbohydrate (g)	215.93	201.51	-6.68		45	
Carbohydrate (%E)	52.50	49.00	-6.67			
Fibre (g)	32.26	30.95	-4.05		28	20-28
Thiamine (mg)	1.71	1.71	0.18	0.9-1.3		
Riboflavin (mg)	2.63	2.93	11.48	1.1-1.3		
Niacin equiv. (mg)	34.42	35.12	2.04	12-14		
Vitamin C (mg)	185.76	171.24	-7.82	40		
Folate (µg)	500.34	499.49	-0.17	300-400		
Vitamin A (µg)	1687.77	1688.05	0.02	700-900		
Sodium (mg)	1293.54	1083.77	-16.22			400-920
Potassium (mg)	4065.93	3874.84	-4.70			2500-3600
Magnesium (mg)	400.06	460.80	15.18	240-410		
Calcium (mg)	944.73	1006.30	6.52	1300		
Phosphorus (mg)	1414.58	1484.54	4.95	1250		
Iron (mg)	18.70	18.90	1.07	11-15		
Zinc (mg)	11.33	11.99	5.77	6-13		

[a] Recommended Dietary Intake, [b] Suggested dietary target, [c] Adequate intake

Table 13: Dietary modelling for pregnant (2nd trimester) women (Menu 4) showing shaded foods for substitution with 28.5g almonds

Meal	Amount	Food	AHGE Serves
Breakfast	4 biscuits (80g)	Whole wheat breakfast cereal	2
	125mL	Orange juice	1
	½ cup (125mL)	Reduced Fat Milk	0.5
Morning Tea	1	Pear	1
	12	Rice crackers	Extra
	3 tsp	Tomato salsa	Extra
Lunch	2 slices	Wholemeal Bread	1
	2 tsp	Polyunsaturated margarine	Extra
	50g	Tuna	0.5
	1 cup	Mixed garden salad	1
Afternoon tea	200g tub	Reduced fat yoghurt	1
	1	Apple	1
	33g (1 cup)	Potato crisps	Extra
Dinner	100g	Trim lamb, grilled	1
	1 medium	Wholemeal bread roll	1
	1 tsp	Polyunsaturated margarine	Extra
	75g	English spinach	1
	75g (1/2 cup)	Steamed carrots	1
	75g (3 Florets)	Steamed cauliflower	1
	75g	Green peas	1
	1 cup	Coleslaw salad	1
	2 tsp	Reduced fat coleslaw dressing	Extra
Dessert	34g (1 row)	Dark chocolate	Extra
Supper	125mL	Reduced fat milk	1
	1	Peach	1

Table 14: Nutrient profile of Menu 4 (Pregnant women)

	Without almonds	With almonds	% Difference	RDI[a]	SDT[b]	AI[c]
Energy (kJ)	8458.34	8461.60	0.04			
Protein (g)	101.91	105.73	3.74	60		
Protein (%E)	20.48	21.24	3.70		15-25	
Fat (g)	51.03	56.25	10.24			
Fat (%E)	426.70	452.98	6.16		20-35	
SFA (g)	20.96	17.36	-17.17			
SFA (%F)	41.08	30.87	-24.86			
PUFA (g)	10.61	13.37	25.95			
PUFA (%F)	20.80	23.76	14.25			
MUFA (g)	13.78	20.33	47.61			
MUFA (%F)	27.00	36.15	33.90			
Cholesterol (mg)	148.05	148.05	0.00			
Carbohydrate (g)	265.85	251.42	-5.43			
Carbohydrate (%E)	53.43	50.51	-5.46		45-65	
Fibre (g)	47.83	46.53	-2.73		28-38	28
Thiamine (mg)	2.74	2.74	0.12	1.4		
Riboflavin (mg)	3.34	3.64	9.04	1.4		
Niacin equiv. (mg)	51.06	51.76	1.37	18		
Vitamin C (mg)	202.00	187.48	-7.19	60		
Folate (µg)	571.70	570.84	-0.15	600		
Vitamin A (µg)	1786.40	1786.69	0.02	800		
Sodium (mg)	1878.01	1668.24	-11.17			460-920
Potassium (mg)	4610.31	4419.22	-4.14			2800
Magnesium (mg)	483.10	543.84	12.57	350-360		
Calcium (mg)	1047.92	1109.49	5.88	1000		
Phosphorus (mg)	1780.08	1850.04	3.93	1000		
Iron (mg)	24.23	24.43	0.83	27		
Zinc (mg)	13.38	14.04	4.89	11		

[a] Recommended Dietary Intake, [b] Suggested dietary target (shown for 19+ years adults, no special SDT for pregnant women), [c] Adequate intake