

Walnut (*Juglan regia* L.) a complete health and brain food

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Nuts are nutrient dense foods and have been a regular constituent of mankind's diet since prehistoric times. In recent years there is a growing interest in nuts which provide health benefits and are alternative to medicine. Walnut (*Juglan regia* L.) belong to family Juglandaceae have amazing health benefits. They are not only delicious but also a complete functional food because they not only provide nutritional but also medicinal health benefits. They are unique among nuts because they are loaded with omega -3 fatty acids, and various other bioactive compounds, antioxidants, fibre, vitamins, minerals, and phytosterols.

Key words : *Juglan regia* L., Nutraceutical potential, Omega- 3 and 6 fatty acids, Alpha-linolenic acid, Good mood food

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INTRODUCTION

Now a day's plants and their products, indigenous foods and dietary supplements are major constituents of nutraceuticals, which plays a pivotal role in maintaining health against various disease conditions and thus, promote the quality of life. Man's dependence on plants for his existence has been of paramount importance in his life; since human race began. The ethnobotanical data on plant and plant products, however, coevolved with human civilization through the experimental use of plants generation after generation.

Nuts are one of the important and potent of all foods. They should be included regularly in our diet. The origin of world, 'nut' is derived from the Latin word 'nux' refers to fruit inside the shell, the nut kernel itself. Nuts are valuable food materials and have been used as such for a long time in many parts of world. Nuts are nutrient dense foods, rich in unsaturated fatty acids, bioactive compounds, high-quality vegetable protein, fibre, minerals, tocopherols, phytosterols, and phenolic compounds etc. Because of their low water content they are concentrated food and also have been kept and handled well. They can withstand transportation, rough handling and low temperature. If kept cool they rarely spoil; otherwise they may deteriorate by becoming wormy, rancid or musty. Nuts can be marketed in shell or shelled. By virtue of their unique composition, nuts are likely to be beneficial and excellent health outcomes. Nuts are categorized into three major categories: a) those with high fat content; (b) those with high protein content and c) those with high carbohydrate

content. Walnut belongs to category of having high fat content (Hill and Sharma, 1988).

Walnut (*Juglan regia* L.) is the most widespread tree nut distributed all over the world. The walnut trees botanical name *Juglans regia*, comes from the Romans. The word *juglas*, from the Latin, means 'the Acron of Jupiter' while *regia* refers to 'royalty'. Walnut has been described as 'doctrine of signatures', according to which the plants resembling various organs and features of the body made effective remedies especially for those parts of the body. The Greeks called walnuts karyon, or 'head', probably because the shell resembles the human skull and the kernel bears a resemblance to the brain. The Romans thought walnuts looked more like testicles. They consecrated the walnut tree to Jupiter, the king of the Roman gods, and called the nuts 'Glands of Jupiter' (condensed to juglans). This gave rise to the walnut's scientific name, *Juglans regia*, literally, 'royal nut of Jupiter' (Stephen *et al.*, 2006). *Juglan regia* L. is a promising functional food which not only provides nutrition, but also has additional health benefits.

Biology of walnut :

Walnuts (*Juglan regia* L.) are the plants of the family Juglandaceae. These are light demanding species, which have been protected from wind, and are also drought-tolerant. The point of origin for the Persian walnut (*Juglans regia* L.) lies in central Asia, where the tree grows in a wild and semi-cultivated state (Abhaya *et al.*, 2005). In pre-historic times,

they spread to western China, Persia, and Europe. Walnuts were likely an important food gathered by early humans. The last glacial epoch greatly restricted the extent of Persian walnuts in Western Europe, but archaeologists have found their remains in southern France dating to 17,000 thousand years ago (Edward, 1914; William and James, 1985). Neolithic peoples cultivated walnuts by 7,000 years ago, but they were not widely cultivated in the Mediterranean until ancient Roman and Greek times, when economic factors contributed to their dispersion throughout Europe (Paul, 1979 and Sytze, 2000). Walnuts were an item of trade and amphora filled with walnut residue has been salvaged in sunken Roman ships in the Mediterranean (Wilson, 1987-1988).

Walnut trees have been cultivated for thousands of years; therefore, trees are of different types and have varying origins. In the 4th century AD, the ancient Romans introduced the walnut crop into many European countries and till now they are growing walnut as one of the important crop. Throughout its history, the walnut tree has been highly revered; not because of having life span that of humans, but it provide food, medicine, shelter, dye, tooth cleaning, lamp oil and many more benefits to mankind.

There are three different varieties of walnut tree: (a) the most familiar variety being *Juglans regia*, known as the Persian or English walnut. The variety grows to a height of 40-60 feet high and has a life span of about 60 years or more; (b) *Juglans nigra* or black walnut can grow to a height of 150 feet; with a nut bearing a more rounded shape. The black walnut tree is known to be centenarian, living for 100 years or longer; and (c) *Juglans cinerea* refers to Butternut, or white walnut. The butternut tree averages about 30-50 feet in height and bears an oval or egg shaped nut and its life span varies from 50-75 years (Hill and Sharma, 1988).



Fig. 1(a): Walnut (*Juglans regia* L.)



Fig. 1(b) : Inside picture

Indian scenario :

Walnut (*Juglans regia* L.) is one of the most important temperate nuts grown in India. It is grown in Jammu & Kashmir, Arunachal Pradesh, Himachal Pradesh and Uttarakhand under rain fed and poor soil conditions in marginal lands. Jammu & Kashmir accounts for almost 98 per cent of the country’s output. Walnut is an important crop grown in Jammu & Kashmir. The state produces about 86,263 tonnes from an area of 61,723 hectares (Vigneshwara, 2011).

Walnut is grown in Himachal Pradesh and Uttarakhand to a limited extent. In Himachal Pradesh, it is grown in a couple of some of the districts. India needs to bring in additional area under walnut cultivation to meet the projected walnut demand of around 75,000 tonnes by 2020 (Vigneshwara, 2011).

Varieties grown in different states :

Walnuts produced in India have different sizes and shapes and are categorized into paper-shelled, thin shelled, medium-shelled and hard-shelled (Table 1).

Nutritional composition of walnut :

Many decades ago nuts were considered unhealthy due to their high fat content. However, this perception has changed over the past decade. Nuts are now often recommended because they have a healthy fatty acid profile and are high in protein, vitamins and minerals etc. Walnuts nutrient composition has been investigated by several investigators (Savage *et al.*, 2001; Amaral *et al.*, 2003 and Pereira *et al.*, 2008) from time to time.

One serving *i.e.* about 28 g (one oz) or approximately 14 walnut halves contains 185 calories and 18.5 g of fat. While high in calorie and fat, walnut are low in saturated fat.

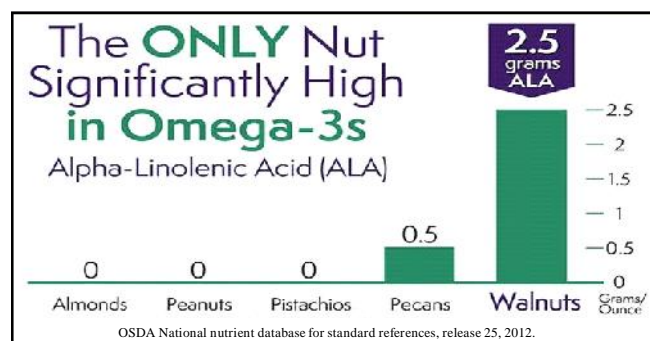
Table 1: Walnut varieties grown in different states of India (Vigneshwara, 2011).

1.	Jammu & Kashmir	Lake English, Drainovsky and Opex Caulchry
2.	Himachal Pradesh	Gobind, Eureka, Placentia, Wilson, Franquetfe and Kashmir Budded
3.	Uttaranchal	Chakrata Selections

Walnut contains 3.9 g carbohydrates per oz including 1.9 gm of fibre. The high fibre content of walnut contribute to health of digestive tract. Walnuts are also a good source of proteins (USDA, 2010).

Fatty acids :

Walnuts are rich in fatty acids. Walnuts contain between 52 - 70 per cent oil. More than 90 per cent of this oil contains unsaturated fatty acids and the oleic acid (a monounsaturated fatty acid) content ranges from 12-20 per cent . Walnuts are exceptional source of alpha-linolenic acid (ALA). They contain both omega - 3 and 6 fatty acids. Most people do not get enough omega-3 fats in the diet. Being unique among nuts, walnuts contain the highest amount of ALA, the plant-based omega-3 fatty acid required by the human body (USDA, 2010). In fact, the omega-3 fatty acid content of walnuts is nearly 10 times greater than pecans, the next highest nut, and 40-500 times greater than other nuts. Peanuts contain negligible amounts, and almonds contain no omega-3 fatty acids (USDA, 2012).



Sterols :

Walnuts, like many plant products, contain no cholesterol. Nuts are cholesterol-free, but their fatty fraction contains sizeable amounts of chemically related non-cholesterol sterols belonging to a heterogeneous group of compounds known as plant sterols (PS) or phytosterols (Segura *et al.*, 2006). They are non-nutritive components of all plants that play an important structural role in membranes, where they serve to stabilize phospholipids bilayer just as cholesterol does in animal cell membranes (Hartmann, 1998). Phytosterols interfere with cholesterol absorption and thus helps in lowering blood cholesterol when present in sufficient amounts in the intestinal lumen (Garrido *et al.*, 2008). The levels of sterols found in walnuts may be enough to exert a positive effect on human metabolism but this depends on the amount of walnuts eaten on a regular basis. Savage and Dutta (2002) observed that sterol levels found in different cultivars grown under similar conditions vary considerably.

Tocopherols (Vitamin E) :

A large proportion of the fatty acids in walnuts are unsaturated and the oxidation of unsaturated lipid is linked to the appearance of unpleasant odours and flavours. The oxidation of the polyunsaturated fatty acids occurs slowly even in nuts stored under favourable conditions (Savage *et al.*, 2001). The vitamin E isomers provide some protection against oxidation of the unsaturated fatty acids. The measurement of vitamin E isomers is important due to their antioxidative and other positive nutritional effects in human metabolism. So far the measurement of these isomers in walnut oil has not been well documented. Lavedrine *et al.* (1999) has presented some data on the vitamin E content of walnuts grown in France and the USA. They identified α , β tocopherol in fresh and stored walnuts and noted the significant losses that occurred after three months storage at 4°C. They identified α tocopherol as the main tocopherol in walnut oil (Savage *et al.*, 1999).

Amino acids :

Walnuts are an excellent source of protein ranging from 13.6 to 18.1 g crude protein/100 g dry matter (Savage, 2001). Walnuts contain a relatively low content of lysine and high levels of arginine (Ruggeri *et al.*, 1996). The high levels of arginine in walnuts have already been identified as a positive feature as arginine can be converted into nitric oxide, a potent vasodilator, which can inhibit platelet adhesion and aggregation (Sabaté and Fraser, 1993). A low ratio of lysine/arginine in a protein has been identified as a positive feature in the reduction of the development of atherosclerosis in laboratory animals (Kritchevsky *et al.*, 1982).

Dietary fibre :

The total dietary fibre content of 12 different cultivars of walnuts harvested in New Zealand ranged from 3.1 to 5.2 g/100g dry matter (Savage, 2000). Lintas and Cappelloni (1992) were able to identify both insoluble and soluble fibre using the Prosky method (Prosky *et al.*, 1988). The insoluble fibre content of the nuts they analyzed ranged from 15.8 g/100g for macadamia nuts to 3.8 g/100g for pine nuts. In contrast the soluble fibre contents of nuts they analyzed appear to be quite low.

Vitamin and minerals :

Walnuts are also a good source of magnesium (44.79 mg/oz) and phosphorus (98.09 mg/oz)—both important minerals involved the body's processes and necessary for achieving optimal wellness. Walnuts provide more than 10 per cent of the daily recommendation of magnesium and phosphorus as well. Walnuts also contain 450 mcg of copper per oz., over 20 per cent of the daily intake of this mineral. Other micronutrients present in walnuts include vitamins C,

Table 2 : Detailed nutritional composition of walnut nutrition facts (weight: 100 g)		
Nutrients	Amount	% DV*
Basic components		
Water	4.1g	
Ash	1.8g	
Phytosterols	72.0 mg	
Calories		
Total calories	654 (2738 KJ)	33%
Calories from carbohydrates	55.4 (232KJ)	
Calories from fats	546 (2286KJ)	
Calories from proteins	52.9 (221KJ)	
Carbohydrates		
Total carbohydrates	13.7 g	5%
Dietary fiber	6.7g	27%
Starch	0.1 g	
Sugar	2.6 g	
Fats and fatty acids		
Total fat	65.2 g	100%
Saturated fat	6.1 g	31%
Monounsaturated fat	8.9 g	
Polyunsaturated fat	47.2g	
Total omega-3 fatty acids	9079 mg	
Total omega-6 fatty acids	38092 mg	
Proteins and amino acids		
Protein	15.2g	30%
Tryptophan	170mg	
Threonine	596mg	
Isoleucine	625mg	
Leucine	1170mg	
Lysine	424mg	
Methionine	236mg	
Cystine	208mg	
Phenylalanine	711mg	
Tyrosine	409mg	
Valine	753mg	
Arginine	2278mg	
Histidine	391mg	
Alanine	696mg	
Aspartic acid	1829mg	
Glutamic acid	2816mg	
Glycine	816mg	
Proline	706mg	
Serine	934mg	

Table 2 : Contd.....

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Vitamins		
Vitamin A	20.0 IU	0%
Vitamin C	1.3 mg	2%
Vitamin E	0.7 mg	4%
Vitamin K	2.7 mcg	3%
Thiamin	0.3 mg	23%
Riboflavin	0.2 mg	9%
Niacin	1.1 mg	6%
Vitamin B ₆	0.5 mg	27%
Folate	98.0 mcg	25%
Pantothenic Acid	0.6 mcg	6%
Choline	39.2 mg	
Minerals		
Calcium	98 mg	10%
Iron	2.9 mg	16%
Magnesium	158 mg	40%
Phosphorus	346 mg	35%
Potassium	441 mg	13%
Sodium	2.0 mg	0%
Zinc	3.1 mg	21%
Copper	1.6 mg	79%
Manganese	3.4 mg	171%
Selenium	4.9 mcg	7%

Source: U.S. food and drug administration's SR-21 - Reference values for nutrition labeling; USDA, 2012) (*%DV- %DV are for adults or children aged 4 or older and are based on a 2000 calorie reference diet)

E, B₆ and K, folate, pantothenic acid, riboflavin, choline, betaine, niacin, calcium, iron, potassium, thiamin, zinc and selenium (Lavedrine *et al.*, 2000).

Uses of walnut :

In view of the increasing production of walnut globally, there is a need for an increased utilization of the walnut, especially the nutritious walnut kernel. Besides walnut oil and protein, it contain 12 ~16 per cent carbohydrates, 1.5 ~ 2.0 per cent cellulose, 1.7 ~ 2.0 per cent mineral (Lavedrine *et al.*, 2000; Prasad, 2003; Savage, 2000; Sze-Tao and Sathe, 2000b; Wardlaw, 1999; Gharibzahedi *et al.*, 2011). Other proposed benefits of walnuts include magnesium, copper, folic acid, potassium, fibre and vitamin E (Anderson *et al.*, 2001).

Ethnobotanical uses of walnut :

The walnut has been the most important nut from a health standpoint in the ancient Mediterranean world. Its medicinal virtues were detailed in many Greek and Roman medical writings. Walnuts along with honey and rue helped with 'inflammation of the breasts, abscesses and dislocations'. Walnut mixed with onions, salt and honey

helped in healing the wound bitten by dogs. When burnt, they assuaged colic. Walnut kernels if burned and ground with wine and oil, and applied to an infant's head, the child's hair would grow abundantly and bald spots would disappear. A walnut if chewed and lay on as a plaster; cures gangrene, carbuncles, sty in the eye, and hair loss. They were also mixed with garlic and applied as a poultice to remove bruises on the body (Dioscorides, 1890).

Galen, a Greek physician, lived in Pergamum and Rome recommended that they be combined with garum (a fermented fish sauce widely used as a condiment) to produce a laxative (Mark, 2000). Pliny the Elder, the first century Roman author of Natural History, wrote extensively of the walnut. He recommended walnuts as a breath freshener; when eaten after a dish containing onions, he wrote, walnuts act as a corrective, and thus prevent the disagreeable smell (Bostock and Riley, 1890). In 12th century German medical handbook, touted walnuts were considered as a cure for a number of ailments, including sexual impotence (Daniel, 1997). This shows that walnuts have been an important food source from prehistoric times and its medicinal and nutritional properties were well utilized at that time too.

Culinary use of walnut :

Walnuts have a versatile nature and hence they complement both as appetizers, main course, desserts and also as condiments. Walnuts have vast culinary uses not now but from prehistoric times. In the seventeenth century, cookbook authors shifted their focus from the medicinal benefits of the walnut to its culinary applications.

Walnuts were readily available, cheap and easily preserved, and during the eighteenth and nineteenth centuries they were incorporated into a vast array of recipes from salads, sauces, and soups to pickles, preserves, and pies. Among the more common uses were in salads - in combination with apples, bananas, cherries, chicken, cream cheese, dates, or pineapple - culminating in the highly popular Waldorf salad. In the eighteenth and nineteenth centuries formulas for unusual walnut-based alcoholic beverages, such as mead and wine emerged. One favorite way of preserving walnuts was to make ketchup from them. Walnut ketchup was, in turn, employed to flavor sauces for fish, meat, poultry, puddings, and savory pies. Walnuts proved to be one of the most versatile ingredients in both the English and American larder (Richard, 1788). This shows that walnuts have been one of the most popular and versatile of all the nuts.

Now a days walnuts are good to be eaten raw / cooked in either sweet / savories dishes, and are particularly useful for baking. Walnut oil has strong flavour and is not suitable for preparing many foods. Walnut leaves are also used for wrapping cheese and many other products. Walnuts can be utilized as ingredients of many foodstuffs such as bakery products to enhance the nutrition value and sensory properties of the final product (Mexis *et al.*, 2009). Walnut oil is major product of walnut production and is one of the important special oils used for salad dressing and cooking (Oliveira *et al.*, 2002).

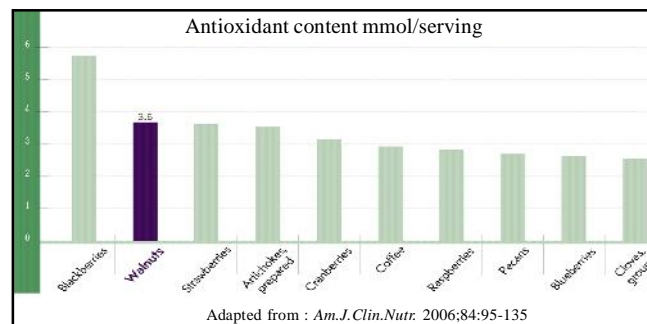
Walnuts are a good source of high quality protein and contain 18~24 per cent protein on a dry weight basis (Sze-Tao *et al.*, 2000a). As a by-product of oil production, walnut protein products are therefore, being considered as an additional source of plant protein for use in human food products. When incorporated with other foods, walnuts can add and intensify flavour. They also have rising or puffing properties, and can lighten foods by fluffing or foaming when used in place of egg whites as finely ground walnut meal. One of the simplest ways to incorporate walnuts into the diet is to add them to foods eaten regularly such as breakfast cereals, yogurt, sandwiches, salads, pasta and rice, or have them readily available for snacking.

Nutraceutical potential of walnuts :

Antioxidant potential :

Juglans regia L. exhibits greater antioxidant capacity than any other nuts (Wu *et al.*, 2004; Pellegrini, *et al.*, 2006). According to an evidence-based review, antioxidants help to

protect from certain chronic diseases of aging, including cardiovascular, neurological and anticarcinogenic ailments due to their ability to control free radicals—known to negatively influence healthy aging (Ferrari, 2004). Walnuts contain many antioxidants (13.126 mmol/100 g).



According to the study, a handful of walnuts have significantly more phenols than a glass of apple juice (117 mg), milk chocolate bar (205 mg), or a glass of red wine (372 mg) (Anderson *et al.*, 2001). Halvorsen *et al.* (2002) revealed that among common plant foods consumed worldwide, walnuts (*Juglans regia*) were ranked second only to rose hips (*Rosa canina*) in their antioxidant activity, as determined by the ferric reducing antioxidant power (FRAP) assay. Compared with other tree nuts, walnuts were also ranked highest when measured with the FRAP, total radical-trapping antioxidant parameter (TRAP), and Trolox equivalent antioxidant capacity (TEAC) assays (Pellegrini *et al.*, 2006). Most of this antioxidant activity can be attributed to the polyphenolic constituents, including the ellagitannins, present primarily in the pellicle (Blomhoff *et al.*, 2006).

Polyphenols isolated from walnuts, including ellagic acid monomers, polymeric tannins, and other phenolic compounds, are potent inhibitors of plasma and LDL oxidation *in vitro* (Anderson *et al.*, 2001), and have been found to decrease biomarkers of oxidative stress in diabetic mice (Fukuda *et al.*, 2004). Melatonin, another antioxidant constituent present in walnuts, has been positively correlated with increased plasma antioxidant capacity in rats (Reiter *et al.*, 2005). A limited number of human feeding trials, conducted in subjects at high risk for CVD, indicate that walnuts improve endothelial function (Ma *et al.*, 2010), and affect some measures of antioxidant status (Canales *et al.*, 2007), but not others (Davis *et al.*, 2007). Eder (2011) claimed that, 'eating a handful of walnuts contain almost twice as many antioxidants as an equivalent amount of any other commonly consumed nut'.

Anti-inflammatory effects of walnuts :

Various researches data from Penn State University

shows that substituting walnuts (37 g) and walnut oil (15 g) for half the fat found in the average American diet (typically 35 per cent total fat, 13 per cent saturated fat, 8 per cent PUFA) not only lowered cholesterol, LDL, and TG, but it also produced cardioprotective anti-inflammatory effects after six weeks (Zhao *et al.*, 2004; 2007). In hypercholesterolemic men and women this walnut-rich, ALA containing diet high in PUFA (13 per cent of calories) and low in saturated fat (8 per cent of calories) reduced levels of CRP, pro-inflammatory cytokines, and key cell adhesion molecules involved in the atherogenic process. This shows that walnut also have anti-inflammatory effects.

Therapeutic uses of walnut :

Therapeutic uses of walnut have a long history. Eighteenth century physicians determine walnut to be helpful in treating various medical problems. The English physician Robert James, in his *Pharmacopoeia Universalis*, noted that candied nuts were 'gently emetic'. The nuts were used to cure colic and counteract diarrhea, and to prevent 'contagious distempers', while the tree's leaves were recommended for treating gout, ulcers, and even cancer. Walnuts even cured hiccups, "perhaps more effectually, than any other Medicine" (Richard, 1788). For more than two millennia, medical practitioners have known that the walnut has health-giving qualities. Researchers have shown the diverse benefits of the walnut through many clinical studies. Because of the strong evidence of the walnut's potential role in cardiovascular health, the U.S. Food and Drug Administration approved one of the first qualified health claim for a whole food in March of 2004 as "Supportive but not conclusive research shows that eating 1.5 ounces of walnuts per day, as part of a low saturated fat and low cholesterol diet, and not resulting in increased caloric intake, may reduce the risk of coronary heart disease" (USDA, 2004). In addition to heart health, studies have also shown its benefit to people with diabetes and cancer. It promotes bone health, assist with weight management, improve cognitive performance, and counteract some effects of aging. Various uses of walnuts have been summarized as below :

Smart heart food :

Walnuts are receiving increasing interest as a healthy foodstuff because their regular consumption has been reported to decrease the risk of coronary heart disease (Blomhoff *et al.*, 2006; Davis *et al.*, 2007; Albert *et al.*, 2002; Sabate *et al.*, 1993; Lavedrine *et al.*, 1999). Eating a handful of walnuts every day is an easy way to boost the daily nutrition. Walnuts are known for their benefits to the heart and circulatory system.

The chart below summarizes some important uses of

walnuts for heart health :

Cardio-vascular aspect	Walnut benefit
Blood quality	decreased LDL cholesterol; decreased total cholesterol; increased gamma-tocopherol; increased omega-3 fatty acids in red blood cells (alpha-linolenic acid)
Vasomotor tone	decreased aortic endothelium; improved endothelial cell function
Risk of excessive clotting	decreased maximum platelet aggregation rate; decreased platelet activation
Risk of excessive inflammation	decreased C reactive protein (CRP); decreased tumor necrosis factor alpha (TNF-a)

Although walnuts are rich in fat, a diet supplemented with walnuts had a beneficial effect on blood lipids, lowering blood cholesterol and reducing the ratio of serum concentrations of low density lipoprotein: high density lipoprotein by 12 per cent (Sabate *et al.*, 1993). The positive results of these experiments have been confirmed in cross-sectional surveys on the effect of walnut consumption on blood cholesterol (Lavedrine *et al.*, 1999). In a study, regular consumption of nuts has been associated with a reduced risk of both fatal coronary heart disease and non-fatal myocardial infarction (Hu *et al.*, 1998).

These results are consistent with an earlier epidemiological study (Fraser *et al.*, 1992) which showed that people who consumed nuts five or more times a week had a 50 per cent reduction in risk of coronary heart disease compared to those who never consumed nuts. A similar reduction in relative risk was observed in a cohort of women in the Nurses' Health Study (Hu *et al.*, 1998; Colditz *et al.*, 1997). Because walnuts contain multiple health-beneficial components, such as having low lysine: arginine ratio and high levels of arginine, folate, fibre, tannins and polyphenols, evidences have shown reduction and prevention of coronary heart disease. A low ratio of lysine/arginine in a protein has been identified as a positive feature in the reduction of the development of atherosclerosis in laboratory animals (Kritchevsky *et al.*, 1982).

Researchers have long been aware of the relationship between healthy blood pressure and intake of specific minerals, including potassium, calcium and magnesium. In multiple studies, these minerals have a much greater impact on blood pressure than the mineral sodium. Walnut has these key blood pressure-regulating minerals as follows :

Mineral	Natural range found amongst different walnut varieties (milligrams per 100 grams)
Potassium	375-500
Calcium	13-91
Magnesium	189-278

They help to maintain proper blood compositions, correct balance in inflammation-regulating molecules and proper composition and flexibility in the blood vessel walls. Walnuts are high in omega-3 fatty acids, including the alpha-linolenic acid (ALA). These acids are essential for improving a wide variety of cardio-vascular functions, including blood pressure. Apart from improving the ratio of good and bad cholesterol, preventing cholesterol from turning into plaque within the arteries and precluding erratic heart rhythms these acids are also effective in preventing heart attacks by making it less likely for the blood to clot in arteries (Feldman, 2002).

Anti-cancerous effects :

As walnut have high amounts of antioxidants and nutrients; many researches has shown that eating walnuts can help against cancer. A form of vitamin E called gamma-tocopherol, found in high abundance in walnuts, has been found to help fight breast, prostate and lung cancer. Men with prostate cancer are known to have higher levels of endothelin, prompting further research into the relationship between walnuts and prostate cancer (Grotto, 2008).

The omega-3 fatty acids along with phytosterols in walnuts have been proven to curb breast cancer tumor growth. Hardman and Ion (2008) in their study formulated two groups: one group of mice was fed a daily diet that included the equivalent of 2 ounces of walnuts in humans, while another group was fed a regular diet. The mice that ate the walnuts had a much lower incidence of breast tumors, slowing the growth by half, basically the phytosterols bind to estrogen receptors, so they would be expected to slow the growth of breast cancers.

Anti-diabetic effects :

Although type II diabetes is primarily related to blood sugar control and insulin metabolism, persons diagnosed with type II diabetes typically have health problems in other related systems and are at special risk for cardio-vascular problems. A relatively small amount of daily walnut intake (1-2 ounces) provides significant benefits in this area for persons with type II diabetes. Better blood fat composition (including less LDL cholesterol and less total cholesterol) has also been demonstrated in persons with type II diabetes.

Regular intake of walnuts is helpful in the treatment of type - II diabetes as it helps maintain blood sugar levels and insulin metabolism (Fukuda *et al.*, 2004). Tapsell *et al.* (2004) conducted study on 58 men and women ages between 35 – 75yrs and observed that a positive effect of a moderate-fat diet, inclusive of walnuts, on blood lipid profiles in patients with type II diabetes has been reported in a parallel randomized controlled trial included diagnosed with type II diabetes at least one year prior. The researchers concluded that adding walnuts to the diet improved the blood lipid levels

of the patients with type II diabetes.

Jiang *et al.* (2002) had done a prospective cohort study on 83,818 women aged 34–59; with no history of diabetes, cardiovascular disease or cancer. They found that women who ate one-ounce portions of nuts, such as walnuts, or peanuts five times or more each week had a significant lower risk of developing type II diabetes compared to the women who rarely or never ate nuts. Based on these findings, the researchers concluded that higher nut and peanut butter consumption may have helped lower the risk of type II diabetes in these women. However, to avoid increasing caloric intake, regular nut consumption can be recommended as a replacement for refined carbohydrate products or red or processed meats.

Weight management :

The good fat (2.6 grams ALA/omega-3s per ounce), fibre (2 g per ounce) and protein (4 g per ounce) in walnuts aid in satiety, an important factor in successful weight management. In a 28-month prospective study of the SUN cohort conducted in Spain in 8865 university graduates, a significant inverse association between nut consumption and weight gain was reported. Compared with those who never or almost never ate nuts, participants who ate nuts ≥ 2 times/wk had a 31 per cent lower risk of gaining ≥ 5 kg during follow-up, while participants who frequently consumed nuts had an average 0.42 kg less weight gain than did those who rarely consumed nuts after multivariate adjustment (Bes-Rastrollo *et al.*, 2007).

Muñoz *et al.* (2001) conducted a clinical study and has found that regular walnut consumption does not lead to weight gain in study participants. This randomized crossover feeding trial included 10 men with hypercholesterolemia. Participants followed one of three diets to follow over a six week period: i) control, ii) Mediterranean-type cholesterol-lowering diet and iii) a diet of similar composition in which walnuts replaced 35 per cent of energy from unsaturated fat. The result of the study has found that after six months the walnut eaters had not gained weight also the walnut diet reduced serum total and LDL (bad) cholesterol by 4.2 per cent and 6.0 per cent, respectively. Overall, individuals in this study who substituted walnuts for other calories did not gain weight and showed improvements in cholesterol levels.

McManus *et al.* (2001) evaluated weight loss patterns of overweight men and women and found improved weight loss with consumption of foods such as walnuts. A prospective trial, evaluated weight loss patterns of 101 overweight men and women for 18-month. The researchers suggested that adding nuts may help provide satiety which is a factor in successful dieting. Hence, the tasty foods like walnuts can be a good option for many who want to maintain

their weight. Weight gain can be avoided if they are used as a substitute for certain other foods.

Protecting bone health :

The anti-inflammatory properties of walnuts are helpful in protecting bone health. These are further effective in curing conditions, like rheumatoid arthritis, asthma, psoriasis and eczema. A clinical research study has shown that bone health improved with alpha-linolenic acid (ALA) omega-3 consumption. This first controlled human feeding study evaluated the effect of dietary ALA/omega-3s provided by walnuts and flaxseed, on bone turnover, as assessed by measurements of biomarkers. 23 participants followed three different diets over a six week time frame for each: 1) Average American Diet, 2) Linoleic Diet and 3) ALA Diet. Specific markers measuring bone metabolism and resorption were measured during each diet. The results indicated that the plant sources of dietary omega-3 polyunsaturated fatty acids may have a protective effect on bone metabolism via a decrease in bone resorption in the presence of consistent levels of bone formation (Griel *et al.*, 2007).

Cognitive function :

The brown skinned kernel has a ridged surface, which looks like two halves of brain. The Doctrine of Signatures is an old-fashioned philosophy that states that a food's appearance can tell us what part of the body its nutrients are good for. Walnuts can be used to treat brain injuries and enhance cognitive function, which is why it's referred to as a "brain food." The reason they are so good for the brain health is the high concentration of omega-3 fatty acids. The human brain consists of more than 60 per cent structural fat, and for the brain cells to function properly, omega-3 fats need to be a primary component. The vegetarian's diet is almost devoid of all omega-3s. A study done at Purdue University has shown that children with a lower concentration of omega-3 fatty acids have a higher risk of being hyperactive, having learning disorders, and displaying behavioral problems.

According to the US department of Agriculture Nutrient Database, walnuts have a high protein content (26.1 g/100 g of raw walnut) and the tryptophan (TRP) content of this nut is about 24 mg/g of protein (Brufau *et al.*, 2006). Walnut is also enriched with omega-3 fatty acid, which is an essential fatty acid; approximately 100 g of walnut contain 9 g of omega-3 fatty acid (Willis *et al.*, 2009). Both TRP (Haider *et al.*, 2006) and omega-3 fatty acids (de Wilde *et al.*, 2003; Solfrizzi *et al.*, 2006) are reported to be involved in memory improvement process. TRP is an essential amino acid and its source is dietary only. Increased brain TRP availability has been shown to increase brain serotonin (5-hydroxy tryptamine; 5HT) synthesis (Young *et al.*, 1981; Fernstrom,

1985). It has been well documented that 5-hydroxy tryptamine has an important role in memory function (Yasuno, 2004). Decreased 5-HT is involved in impaired memory function, as found previously, the continued use of methamphetamine, which selectively destroys central 5-HT axons and axon terminals, results in an impairment of memory (Schroder *et al.*, 2003). Collectively these data indicated that pharmacological manipulation of 5-HT receptors or reuptake sites might modulate memory consolidation (Meneses, 1999).

Haider *et al.* (2011) demonstrate that the long term intake of walnut may be highly beneficial as it enhances memory function and decreases food intake. As walnuts are rich source of tryptophan, an essential amino acid, the findings suggest that increase in brain 5-hydroxy tryptamine (5-HT) function may be involved in the memory enhancing and appetite decreasing effects. The decrease in food intake following walnut administration in the present study suggests that the use of walnuts may have implication in the treatment of overweight and obesity in humans. Walnuts possess a significant nootropic action; the present findings, therefore, suggest that long term walnut intake may have a significant facilitatory effect on learning and memory processes. These findings also emphasize the use of walnut as a supplement in learning and memory deficits.

Walnuts as good mood foods :

Walnuts are being considered as excellent good mood foods. Walnuts have long been thought of as a 'brain food' because of their wrinkled, bi-lobed (brain like) appearance. Walnuts are an excellent source of omega 3 essential fatty acids. In addition, walnuts contain good amounts of uridine. Walnuts also contain some other compounds like vitamin B₆, tryptophan, protein, and folic acid which contribute to a good mood. Higher blood levels of omega 3 fatty acids have been linked with better mood and lower rates of depression, while lower blood levels of omega 3 fatty acids have been associated with higher rates of depression and negative feelings. The standard dosage of omega 3 fatty acids recommended by many experts is one gram per day that may be obtained from about half an ounce of walnut (Thakur *et al.*, 2012).

Harvesting and post harvesting of walnut :

Nuts are collected in the months of September and October. After collecting, these are cleaned, washed and dried by spreading them on sheets or floor. Sometimes in order to improve the appearance of nuts, these are bleached with either alkali or acid solution. Nuts which fall down with their husks intact are generally second-grade. After removal of the husks, cleaning and drying, they should be stored and marketed separately to fetch a higher price. Delay in drying

causes rapid loss in nut quality and makes walnuts susceptible to the mold. Drying of nuts stabilizes the product's weight and prolongs storage life. Walnuts are stored in gunny bags in a small ventilated room free from excess humidity. For export purpose, these are packed in double gunny bags. Walnuts are consumed in the winter season, so the problem of their shelf life is seldom felt. The quality of nut meat, however, deteriorates due to darkening and rancidity which are affected by air, moisture, heat and light.

Walnut storage and handling :

Walnuts kept in their shell have a shelf life of 12 months when stored in a cool, dry environment. An unopened package of shelled walnuts has a similar shelf life. Opened packages and chopped walnuts should be kept refrigerated or frozen in an airtight container for no longer than 6 to 12 months.

Marketing :

Walnuts are marketed as nuts or kernels. These arrive into the market from September month onwards and the kernels follow two to three weeks afterwards; the peak arrival season being from November to January. Walnuts produced in Himachal Pradesh and Uttarakhand are consumed almost locally, whereas in Jammu & Kashmir the produce is brought to the assembly market in Jammu, which is the biggest market for walnuts in India. Efforts have been made to assemble quality nuts in Shahia market of Chakrata hill (Dehradun) and send to Delhi market. The nuts in the market are roughly sorted out and empty, stony, highly blighted, shriveled, moldy and darkened nuts removed. Thin shelled nuts are packed in wooden boxes, while medium-shelled nuts are packed in gunny bags. The product then moves either to the commission agents or the exporters' godowns.

On a global basis, walnuts rank second behind almonds in tree nut production. Walnuts are generally grown in USA, Europe and Asia. Over 1.5 million tons are produced annually in the world (FAO, 2005). According to the FAO (2005) statistics, China leads production with 420,000 t, followed

by the USA (322,000 t), Iran (150,000 t) and Turkey (133,000 tons). India is an important world producer of walnut. According to the 2000-2005 statistics, India ranks sixth in world walnut production yielding approximately 31,500 tons.

In 2010, global production of walnuts was 1,500,000 tons. China leads the world production of walnuts, followed by the US. In 2010, China accounted for 33.33 per cent of global walnut production. Moreover, walnut is not only an agricultural commodity, but its leaves, barks, stems, pericarps, fruits, flowers and ligneous membranes are all applied for different medicinal uses in China.

Conclusion :

In the present scenario human beings are constantly in search of new food resources that can prove to be a complete health food. Walnut have been the first health food to receive a health claim from FDA. This review aims to explore all the health benefits and nutraceutical potential of walnut so that complete awareness can be generated. This nut has immense potential to contribute to nutrition, dietary, culinary and food sector diversification with income generation and nutraceutical potential.

Health benefits of walnuts are being accentuated to rise in shell walnut consumption all over the country. In recent five years, consumption of in shell walnut has increased. As a result, walnut germplasm is open for international researchers. Collaborative researches could be implemented for collection and protection of walnut germplasm, determining the effects of walnut consumption on human nutrition and on human health. Owing to the increasing health benefits of nuts and the readiness with which nut-bearing trees can be grown in non-agricultural land, considerable attention is being directed to them with a view of improvement. Although nuts clearly have many health benefits but there potential is still not aware to each and every human being. Consequently, more research needs to be conducted includes *in vitro*, animal, and clinical studies to further add to our understanding of the health effects of walnuts and the underlying mechanisms involved.

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