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REVIEW

Peanuts as functional food: a review

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Abstract Peanut is an important crop grown worldwide. Commercially it is used mainly for oil production but apart from oil, the by-products of peanut contains many other functional compounds like proteins, fibers, polyphenols, antioxidants, vitamins and minerals which can be added as a functional ingredient into many processed foods. Recently it has also revealed that peanuts are excellent source of compounds like resveratrol, phenolic acids, flavonoids and phytosterols that block the absorption of cholesterol from diet. It is also a good source of Co-enzyme Q10 and contains all the 20 amino acids with highest amount of arginine. These bioactive compounds have been recognized for having disease preventive properties and are thought to promote longevity. The processing methods like roasting and boiling have shown increase in the concentration of these bioactive compounds. In the present paper an overview on peanut bioactive constituents and their health benefits are presented.

Keywords Peanut · Functional ingredients · Health benefits

Introduction

Peanuts or "groundnuts" as they are known in some parts of the world are the edible seeds of a legume. India is second largest producer of peanuts in world, with total production of approximately 7.131 million metric tons per year (USDA, PS&D database 1996–2000). Peanut (*Arachis hypogaea*) is technically considered as pea and belongs to the family (*fabaceae*) of bean/legume. Although a legume; it is generally included amongst the oilseeds due to its high oil content. Peanuts are rich in protein, oil and fibers (Suchoszek-Lukaniuk et al. 2011). Apart from oil, peanuts are widely used for production of peanut butter, confections, roasted peanuts, snack products, extenders in meat product formulation, soups and desserts.

There are thousands of peanut cultivars around the world. Certain cultivars groups are preferred for particular uses because of differences in flavor, oil content, size, shape, and disease resistance. For many uses the different cultivars are interchangeable however, the most popular cultivars are Spanish, Runner, Virginia and Valencia. Most peanuts marked in the shell are of the Virginia type, along with some Valencias selected for large size and the attractive appearance of the shell. Spanish peanuts are used mostly for peanut candy, salted nuts, and peanut butter. Most Runner cultivars are used to make peanut butter (Woodroof 1983). China leads in production of peanuts, having a share of about 45 % of overall world production, whereas India has (16 %) share and the United States of America has (5 %) (USDA 2015)

Peanuts are consumed all over the world in a wide variety of forms, most of which are traditional cuisine. Peanuts are being used as the complete dietary source for people on expeditions to diverse areas like Antarctica, space and trekking. It has notably been the source of elimination of malnutrition amongst the population in many African countries in the recent years (Guimon and Guimon 2012).

History of peanuts

The history of peanuts dates back to the times of the ancient Incas of Peru. They were the first to cultivate wild peanuts and

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offered them to the sun God as part of their religious ceremonials. They used to call peanuts as *ynchic*. The modern history of peanut popularization began with the civil war of the 1860s in America. George Washington Carver who is known as the "father of peanut industry" as he developed more than three hundred products derived from the peanut (Carver 1925).

Peanut butter was created in the 1890s by the St. Louis physician as the soft protein substitute for people with poor teeth. In 1895, Dr. John Harvey Kellogg patented a "Process of preparing nut meal" and used peanuts to serve the soldiers. According to John Mariana's 'Encyclopedia of American food and drink,' a process for roasting shelled peanuts in oil was developed in the early 1900s and packed in the airtight bags under the "Planters" label. Rosenfield J licensed his invention to the pond company, the makers of peter pan peanut butter, in 1928, Rosenfield began making his own brand of peanut butter, this was the beginning of commercialization and popularization of peanut butter in the America which gradually spread all over the Europe and Asia.

Recent developments on peanut based products

Peanut consumption all over the world varies in large proportions hence the commercial products too are variant and generally localized. Peanuts have been developed into a variety of products like roasted peanuts, peanut butter, peanut oil, peanut paste, peanut sauce, peanut flour, peanut milk, peanut beverage, peanut snacks (salted and sweet bars) and peanut cheese analog. Raw peanuts are consumed all over the world. Roasted peanuts are processed by heating the peanuts up to 180 °C for around 12–15 min or at 160 °C for 40–60 min depending on the moisture content. Effect of addition of peanut skin into peanut butter on antioxidant and total phenolic content was studied by Yuanyuan et al. (2014). They observed a significant increase in the fiber, phenolics and antioxidant content of butter prepared.

Peanut oil is obtained by different extraction methodologies and is mainly consumed in the Asian subcontinent especially India. Maximum amount of the peanut production around the world is utilized for oil production. The world production of peanut oil has risen from 4.53 million metric tons in 2000 to 4.91 in 2010. Production across the countries of the world, where China (44 %), Indian (20 %), and Nigeria (11 %) are the largest producers, is expected to account for almost 75 % of the world's peanut oil (USDA 2015).

Peanut snacks (salted/unsalted) are consumed mainly in the Asian subcontinent, particularly India. These are prepared mainly by frying and coating of the peanut kernel (Varela and Fiszman 2011). Peanut flour, generally produced by grinding the defatted peanut meal after oil extraction is generally used in other preparations like soup, cookies, curries (Tate et al. 1990) due to its emulsifying properties and as a composite flour (Singh and Singh 1991). It is also used for coating meat products. Peanut flour can be used for making composite flours with non-wheat cereals or supplementing its flour with protein-rich sources, such as legume flours, especially in countries in which the production of wheat is insufficient, can improve the nutritional value of bread (McKEE and Latner 2000). Peanut bars are consumed all over the world in different forms. They are prepared after coating the partially ground peanuts with sugar or jaggery after blanching and demoisturizing the kernels. In India, it is popularly called as "*chikki*".

Other peanut products like peanut milk, fermented peanut products, cheese analogs, peanut beverages are still not very popular to be utilized for their production and commercialized for e.g. according to Chandrashekhara et al. (1971), peanut milk is made from sludge produced by grinding one volume of raw peanuts with 6 volumes of water for 30 min. The pH is adjusted to 9.0, and using a cream separator, the fat is removed from the starch and fiber. This process provides a yellow liquid nearly fat free and constitutes high proteins milk. Salunkhe and Kadam (1989), showed peanut milk which can be fermented by lactic acid bacteria and methodology to prepare beverage from the filtrate of the soaked, blanched and grinded peanut (Table 1).

Peanut nutrition profile

Protein, fats, and fiber are the major components that make up peanuts (Table 2). All these components are present in their most beneficial forms. The protein is plant-based: the fat is unsaturated, and the fiber is complex carbohydrate which are all proved to be the best for human nutrition.

Peanuts nutrients

Fat

According to the American peanut council, peanut fat profile contains about 50 % monounsaturated fatty acids (MUFAs), 33 % Paraformaldehyde (PFAs) and 14 % saturated fatty acids which is a heart friendly combination of fatty acids (Feldman 1999). The amount of trans fat in peanut butter with 2 % stabilizer is 156 times less than what is needed to reach the 0 g trans fat cut-off on food labels (Sanders 2001).

Peanut products (raw, butter and oil) are more beneficial to heart health when compared to the low fat diets. The high monounsaturated fat peanut diets lowered their total body cholesterol by 11 % and bad LDL cholesterol by 14 %, while

Table 1 Popular peanut based branded products available in the local market (Mumbai)

Peanut product	Brand and company details	Price in Rs/100 g
Roasted peanuts	Planters	110
	Bhikharam Chandmal Bhujiawala (Plain peanut)	25
	Haldirams (Salted nuts)	25
Peanut snacks	Haldirams tasty nuts	42
	Gardens fried nuts	38
	Snackup Masala peanuts (MTR)	40
Peanut butter	Skippy (Unilever)	78
	Peterpan (ConAgra Foods)	68
	Savoury (Bajaj foods)	58
	American Garden Foods	68
	Navadarshanam handmade peanut butter	60
	Sundrop creamy peanut butter	35
Peanut caramel bars	Paypals (Hersheys)	100
	National Chikki	38

their good HDL cholesterol was maintained with reduction in triglycerides (Pelkman 2004). The benefits of the peanut diets on cholesterol were comparable to the olive oil diet. There is strong evidence supporting an association between monounsaturated fat as well as overall nut intake and reduction in the risk of coronary heart disease (Matilsky et al. 2009).

Emerging data clearly shows that type of fat can impact health in various ways at different stages of life. The fat in peanuts and peanut butter provides healthy calories to malnourished infants and children at their time of need (Fig. 1).

Proteins

Peanuts are actually a legume and have more protein than any other nut with levels comparable to or better than serving of beans. After the peanut oil is extracted, the protein content in the cake can reach 50 % (Zhao et al. 2011). Peanuts contain all the 20 amino acids in variable proportions and is the biggest source of the protein called "arginine" (USDA 2014). According to Protein Digestibility Corrected Amino Acid Score (PDCAAS) peanut proteins and other legume proteins such as soy proteins are nutritionally equivalent to meat and eggs for human growth and health (FAO 2002). The amino acid profile of the peanut meals shows that it can be an ingredient for protein fortification (Yu et al. 2006). Since the proteins in peanuts is plant based, it carries with it additional components that have positive health benefits like fiber and unique bioactive components, unlike animal protein. The peanut proteins have been found to have good emulsifying activity, emulsifying stability, foaming capacity, excellent water retention and high solubility, and can also provide a new high protein food ingredient product formulation and protein formulation in food industry (Wu et al. 2009). Based on these observations, recently peanut protein has been incorporated into noodles (Wu et al. 2007) and infant formula, (Nimsate et al. 2010). There is a renewed interest in the studies related to the flavors in the peanut kernel and skin (Fig. 2).

Peanut digestibility

The components in peanuts are highly digestible. The true protein digestibility of peanuts is comparable with that of animal protein (Singh and Singh 1991). The limiting amino acid in peanuts varies based on the study i.e. lysine, methionine or threonine, (Venkatachalam and Sathe 2006). Protein quality is defined based on the amino acid pattern and percent of digestibility of proteins. The PDCAAS for peanuts has been estimated to be about 0.70 out of 1 where as for whole wheat PDCASS is 0.46 (Table 3).

Fat digestibility varies based on the structure of different fatty acids. Peanuts contain over 50 % monounsaturated fats, which are easily digested due to single unsaturated hydrogen bond which is easily broken (Feldman 1999). Since peanuts are legumes, they contain phytic acid which is associated with decreasing the bioavailability of other nutrients due to their binding properties, but the amount in peanuts is lower than compared to other legumes such as soybean (Schlemmer 2009). The fiber in peanuts is mainly insoluble, with lower amounts of soluble fiber (Higgs 2003). It contributes to daily intake, but has not been shown to bind nutrients and restrict their absorption. In fact, the small amount of soluble fermentable fiber may improve adsorption of some minerals (Greger 1999).

Fiber

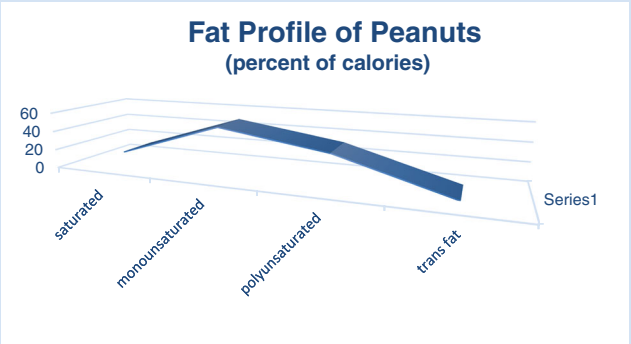
Peanuts are also a good source of fiber, according to the Food and Drug Administration. Sucrose and starch constitute the

Table 2 Groundnuts (*Arachis hypogaea*), All types, Nutritional value per 100 g

Principle	Nutrient value	Percentage of RDA
Energy	567 Kcal	29
Carbohydrates	16.13 g	12
Protein	25.80 g	46
Total Fat	49.24 g	165
Cholesterol	0 mg	0
Dietary Fiber	8.5 g	22
Vitamins		
Folates	240 µg	60
Niacin	12.066 mg	75
Pantothenic acid	1.767 mg	35
Pyridoxine	0.348 mg	27
Riboflavin	0.135 mg	10
Thiamin	0.640 mg	53
Vitamin A	0 IU	0
Vitamin C	0	0
Vitamin E	8.33 mg	55.5
Electrolytes		
Sodium	18 mg	1
Potassium	705 mg	15
Minerals		
Calcium	92 mg	9
Copper	1.144 mg	127
Iron	4.58 mg	57
Magnesium	168 mg	42
Manganese	1.934 mg	84
Phosphorus	76 mg	54
Selenium	7.2 µg	13
Zinc	3.27 mg	30

Source: USDA National Nutrient data base

major while reducing sugars form the minor proportion of the peanut carbohydrates (Tharanathan et al. 1975). This may contribute to the fact that peanut have a low glycemic index (GI) and glycemic load (GL) (Foster and Powell 2002). On a 100 –point scale, the GI of peanuts is 14, and the GL of peanuts is one. Additional research has shown that when peanuts or peanut butter are added to a high glycemic load meal, such as with a bagel and a glass of juice, they actually keep the blood sugar stabilized so that it does not rise too high too quickly (Johnston et al. 2007). Peanuts contain carbohydrates, and all foods that contain carbohydrates elevate blood-glucose levels. Some carbohydrates, such as simple sugars, have a swift, dramatic effect on your blood sugar. Carbohydrates that contain fiber or starch, these two types of carbohydrates have a slower, less pronounced effect on blood sugar. The American Diabetes Association ranks peanuts and other nuts as diabetes superfoods. To make the list, foods must supply



Source: Modified figure from *American Journal of Clinical Nutrition*,1999

Fig. 1 Fat Profile of Peanuts. *Source*: Modified figure from *American Journal of Clinical Nutrition*,1999

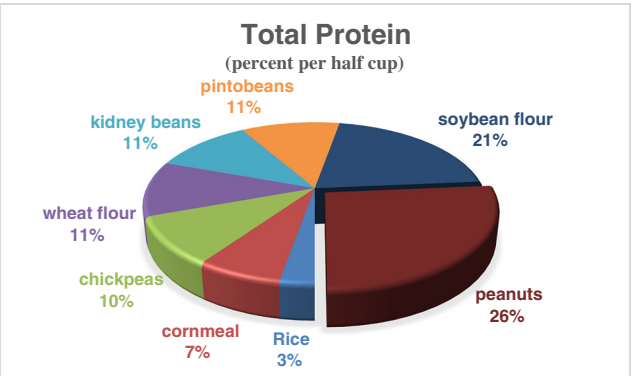
important nutrients such as fiber, calcium, potassium, magnesium and vitamins A, E and E. Foods on the list must also rank low on the glycemic index. Peanuts make the list because they contain magnesium, fiber and heart-healthy oils and do not overly affect your blood glucose.

Vitamins

Table 2 provides the detail regarding the amounts of vitamin present in 100 g of peanuts and their levels as per the RDA.

According to the Table 2, 100 g peanuts consumption is capable of providing up to 75 % RDA of Niacin, 60 % RDA of folate, 53 % RDA of thiamin, 10 % RDA of Riboflavin, 35 % RDA of pantothenic acid, 27 % RDA of pyridoxine, 55.5 % RDA of vitamin E.

It has been recognized as a great source of niacin, which is important for functioning of the digestive systems, skin, nerves, helps in conversion of food to energy and supposed to protect against Alzheimer's disease and cognitive decline (Morris 2004). Peanut is an excellent source of vitamin E is



Source: Modified figure from *American Journal of Clinical Nutrition*,1999

Fig. 2 Total Protein in Various Grains and Legumes Per Half Cup. *Source*: Modified figure from *American Journal of Clinical Nutrition*,1999

Table 3 Percent digestibility and average PDCAAS for peanuts and other grains

Food item	True digestibility	PDCAAS	References
Peanuts	94	0.70	Suárez López (2006)
Soy	86	0.91	Schaafsma (2000)
Whole wheat	86	0.46	Schaafsma (2000)
Maize	85	0.43	Gibney et al. (2013)

considered a hard-to-get nutrients as it was shown that over 90 % of men and women were not meeting the recommendations for intake (Gao et al. 2006). Vitamin E consumption in low quantities can lead to benefits against coronary heart disease (Bramley et al. 2000). Peanut also contains good amounts of folate which is especially important in infancy and pregnancy, in production and maintenance of cells.

Minerals

Table 2 illustrates that small amounts of peanut consumption can meet the most part of RDA of many minerals which are crucial for health and proper functioning of the body. It is clear from the dates that 100 g of peanut can provide RDA levels of 127 % copper, 84 % manganese, 57 % iron, 54 % phosphorus, 42 % magnesium intake is associated with reduced inflammation (King 2005: Song et al. 2005) and a decreased risk of metabolic syndrome (Song et al. 2005) and type II diabetes (Larsson and Wolk 2007).

Compact source of energy

Peanuts provide high energy levels for lesser consumptions level (Kirkmeyer and Mattes 2000; Burton-Freeman 2000). They are also referred to as energy-dense (Alper and Mattes 2002). Peanuts contains about 50 % fat (Table 3), which at 9 cal per gram, contribute more calories than traditional foods used in humanitarian relief such as milk, corn, soybean, wheat and other grains. The majority of fat in peanuts is heart healthy monounsaturated fat, with balanced levels of polyunsaturated and saturated fats (Feldman 1999).

Nutrient dense

Peanuts are rich in multiple natural micronutrients (Table 2) including vitamins, minerals, and bioactive compounds such as resveratrol that are beneficial to health, making them a viable option for improving the nutrition status of those who are malnourished, developing, growing, or in need of critical nutrients in peanuts are integral to growth, development, metabolism, and immunity (Geulein 2010). It is likely that the individual nutrients in peanuts work by multiple mechanisms and that they have synergistic effects toward improving towards improving health status. In more than 15,000 people who consumed peanuts and peanut products, it was found that levels of vitamin A, vitamin E, folate, magnesium, zinc, iron, calcium, and dietary fiber were higher than those who did not consume peanuts (Griel et al. 2004).

Recent focus is on the proper utilization of the by-products from peanut processing. It has been found that peanut hull, peanut skin, peanut leaves, and stems are all nutrients rich parts of the crop with their own functional component. It has been reported that for 1000 kg of peanut for the cold procedure can generate 700 kg of peanut meals, while the hot crushing procedure can produce 500 kg. Usually, only a little peanut skin are utilized to extract polyphenolic compounds or make the cattle feed, most of the skins are as the wastes of peanut processing industry and discarded (Sobolev and Cole 2003). While peanuts skins can provide an inexpensive source of polyphenols for use as functional ingredients in food or dietary supplements, and make a positive contribution to nation's health (Yu et al. 2006). An estimated 35–45 g of peanut skin is generated per kg of shelled peanut kernel. Over 0.74 million metric tons of peanut skins are produced annually worldwide as a by-product of the peanut processing industry (Sobolev and Cole 2003). The production of peanut hull has been estimated to be 230–300 g of peanut hull per kg of peanut. The production of peanut vine from harvested peanut has been estimated to be 60−65 %of the peanut production peanut vines are rich in dietary fibers and flavonoid components (Du and Fu 2008). The peanut vines include roots, stem, leaves and flowers.

Peanut as a functional food

Research has identified numerous compounds in peanuts and in their skins that may have added health benefits beyond basic nutrition. Peanuts have been touted as a functional food with numerous functional components like Coenzyme Q10 which protects the heart during the period of lack of oxygen example high altitudes and clogged arteries. peanuts are also a good source of dietary fiber and provide a wide range of essential nutrients, including several B group vitamins, vitamin E, minerals such as iron, zinc, potassium and magnesium, antioxidant minerals (selenium, manganese and copper), plus other antioxidant compounds (such as flavonoids and resveratrol) (Geulein 2010). These bioactive components have been recognized for having disease preventative properties and some are antioxidants while other is to promote longevity. The antioxidant capacity in peanut is due to the total biological matters in peanut seed such as vitamin E in oil or chlorogenic acid, caffeic acid, coumaric acid, ferulic acid, flavonoids and stilbene (resveratrol) (Yu et al. 2006). Fermented peanut meal (Zhang et al. 2011) has been used to study the antioxidant activity and free radical scavenging activity.

Bioactive components in peanuts

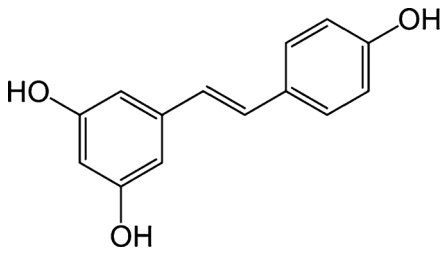
Arginine

Arginine or L-arginine is an amino acid that is needed to keep the liver, skin, joints, and muscles healthy. Arginine helps to strengthen the body's immune system, regulates hormones and blood sugar and promotes male fertility. In addition, research has shown that this amino acid may improve circulation and treat impotence and heart disease. Arginine is also considered as a semi-essential amino acid because, although the body manufactures its own supply, there are times when dietary supplementation may be required, such as in the case of severe wounds or illness. Arginine stimulates the immune system by increasing the output of T lymphocytes (T- cells) from the thymus gland. Recent studies have focused on the potential of arginine in treatment of AIDS, cancer, and other diseases linked to a depressed immune system. Arginine helps to detoxify the liver by neutralizing the effects of ammonia and other toxic substances in the body. Peanuts have the highest level of arginine among foods (USDA SR-21). Arginine is an amino acid that is a precursor to nitric oxide that helps to keep the arteries relaxed, improving blood flow and healing time in tissues in the body (Moncada and Higgs 1993). In context of functional activity, Duggan et al. (2002) claimed arginine to be one of the protective nutrients for the gastro intestinal tract.

Resveratrol

Resveratrol (3,4′,5-trihydroxystilbene) belongs to a class of polyphenolic compounds called stilbenes. Some types of plants produce resveratrol and other stilbenes in response to stress, injury, fungal infection, or ultraviolet (UV) radiation (Jeandet et al. 2012). Resveratrol is a fat-soluble compound that occurs in a trans and a cis configuration. Both cis- and trans-resveratrol also occur as glucosides (bound to a glucose molecule). Resveratrol-3-*O*-beta-glucoside is called piceid. Scientists became interested in exploring potential health benefits of resveratrol in 1992 when its presence was first reported in red wine, leading to speculation that resveratrol might help explain the "French Paradox" (Fig. 3).

Peanuts are excellent source of resveratrol, a polyphenol antioxidant (Geulein 2010) which have been found to have protective function against cancers (Gagliano et al. 2010), heart disease (Juan et al. 2002), degenerative nerve disease, Alzheimer's disease (Chen 2005), tumor (Bishayee et al. 2010) and inflammation (Kang et al. 2010) This bioflavonoid is believed to improve blood flow in the brain by much as 30 %, thus reducing the risk of stroke (Fazel Nabavi et al. 2014). Besides the antioxidant properties that provide protection against cardiovascular diseases such as arteriosclerosis, it has been demonstrated that resveratrol acts as chemopreventive agent against several types of cancer by modulating tumour initiation, promotion and progression phases (Delmas et al. 2006). Moreover, resveratrol seems to extend the lifespan of diverse species including *Saccharomyces cerevisiae, Drosophila melanogaster* and mouse (Baur et al. 2006).



Source: Sarfaraz S BSE and Arora R MD (2009)

Fig. 3 Resveratrol (3,5,4′-trihydroxystilbene). *Source*: Sarfaraz S BSE and Arora R MD (2009)

All parts of the peanut contain resveratrol from the roots to the skin and even the shell (Francisco and Resurreccion 2008). Resveratrol content in peanut butter is very close to grape juice with about three times more resveratrol than roasted peanut with skins (Sobolev and Cole 2003). Studies are now showing that stressing peanut in various ways, resveratrol content can be increased (Rudolf and Resurreccion 2006).

Phytosterols

Phytosterols (referred to as plant sterol and stanol esters) are a group of naturally occurring compounds found in plant cell membranes. Because phytosterols are structurally similar to the body's cholesterol, when they are consumed they compete with cholesterol for absorption in the digestive system. As a result, cholesterol absorption is blocked, and blood cholesterol levels reduced.

As part of a heart-healthy eating plan, consuming phytosterols in recommended quantities has been shown to lower total cholesterol up to 10 % and LDL or "bad" cholesterol up to 14 %. There is increasing evidence that the reintroduction of plant foods providing phytosterols into the modern diet can improve serum lipid (cholesterol) profiles and reduce the risk of cardiovascular disease.

Peanuts, peanut butter, peanut flour, and peanut oil are all filled with phytosterols (beta sitosterol, campesterols and stigmasterol) that block the absorption of cholesterol from the diet (Lopes et al. 2011). Emerging evidence is showing that they also decrease the inflammation and reduce the growth of various cancers i.e. lung, stomach, ovarian, prostrate, colon and breast cancer (Woyengo et al. 2009) in addition to the healthy fats, proteins and fibers in peanuts, phytosterols may also be contributing to the decrease risk of heart disease that has been

shown in population groups who eat a small amount of peanut daily (Awad et al. 2000).

Phenolic acids and flavonoids

Research clearly shows that peanuts and their skin are exceptional sources of functional compounds, including phenolic acids (Francisco and Resurreccion 2008). Research studies have been shown that peanuts contains high concentrations of polyphenolic antioxidants, primarily in p-coumaric acid levels, boosting it overall antioxidant content by as much as 22 % (Duncan et al. 2006). They further elaborated that roasted peanut skin has greater antioxidant capacity than the roasted whole peanut Lopes et al. (2011) have also described the role of phenolic acids as antioxidants. Flavonoids are in all parts of the peanut plants. A high intake of flavonoids is thought to be protective against heart disease and cancer by various mechanisms. Research in emerging as to how these bioactive compounds are benefiting health peanuts and peanut butter are considered a major food source of flavonoids and contain same types found in green and black tea, apples red wine, and soybeans (Francisco and Resurreccion 2008)

Health benefits of peanuts

The consumption of either peanuts or processed peanuts has been shown to be beneficial to health, due to their desirable lipid profile, which is higher in unsaturated fatty acids than in saturated fatty acids peanut oil is naturally trans- fat-free, cholesterol-free, and low in saturated fats. It shows many positive biological effects, which are mostly connected with its high oleic acid content. Many studies have revealed that consumption of peanuts or peanut oil is associated with reduced cardiovascular disease (CVD) risk and may improve serum lipid profiles, decrease LDL oxidation, and exert a cardioprotective effect. Frequent intake of peanut and its products may reduce the risk of colorectal cancer. Some people have allergic reactions to peanuts (Woodroof 1983).

Apart from the daily nutrition peanut consumption leads to long term health benefits. Compared to well-known foods like green tea and red wine, peanuts have higher antioxidant capacity (Halvorsen et al. 2006). Peanut skins contain potent rich antioxidants. It has been noted that the when peanuts are consumed with their skins, their antioxidant capacity doubles and roasting can at times actually increase this capacity as well (Craft et al. 2010; Yu et al. 2006). Recent research studies suggest that boiling enhances antioxidant concentration in the peanuts. It has been found that boiled peanuts have two and four fold increase in isoflavone antioxidants biochanin A and genistein content, respectively (Craft et al. 2010).

As much as 40 % reduction in mortality due to any factor has been reported when peanuts were included as an integral part of the routine diet (Fraser et al. 1992). Reduction in deaths due to cardio vascular diseases in particular was found in population who consume peanut or peanut butter regularly (Fraser et al. 1992). It has been reported that peanut consumption reduces the risk factors of heart diseases amongst all ages, across both genders and even in patients who have multiple risk factors including diabetes (Fraser et al. 1992). High blood pressure is associated with greater risks of heart disease and stroke . Scientists have learned that the dietary choices we make can have an impact on the blood pressure . Peanuts and peanut butter contain health monounsaturated fatty acids, plant proteins, magnesium, potassium , fiber arginine , and many bioactive components, each of which could be contributing to lowering blood pressure. Population studies consistently showed the risk of heart disease when peanuts were consumed in small amounts on a daily basis (Sabate and Ang 2009).

Diabetes and inflammation

Jiang et al.(2002) have reported reduced risks of diabetes by a quarter when peanuts were incorporated in diet on a daily basis . Magnesium (King et al. 2007) and dietary fibers (Gartside et al. 1998) have been attributed as the main contributory factors for improved health status. Inflammatory factors in the blood like C-reactive proteins (CRP) have been identified as predictors of cardiovascular disease. Dietary factors may play a role in reducing inflammation (Nettleton et al. 2006). Certain fats, antioxidants, dietary fiber, arginine, and magnesium are components that have been showed to help regulate inflammation (Salas-Salvadó 2008).

Cancer

Unsaturated fats, certain vitamins and minerals, and the bioactive components have shown to have cancer-preventive effects, which are all packaged into a peanut kernel (Gonzalez and Salvado 2006) In particulars, the phytosterols in peanuts that have been studied in regards to cancer (Woyengo et al. 2009), they have been reported to reduce prostrate tumor growth by over 40 % and cut the occurrences of cancer spreading to other parts of the body by almost 50 % (Awad et al. 2000). Like phytosterols, resveratrol has also been shown to cut off the blood supply to growing cancers and to inhibit cancer cell growth (Fazel Nabavi et al. 2014).

Alzheimer's and gallstone disease

Peanuts have a high content of niacin and are an excellent source of vitamin E (Table 2), both of which have been shown to protect against Alzheimer's disease and age-related cognitive decline In almost 4000 people 65 years or older, niacin from food slowed the rate of cognitive decline (Morris 2004). It has also been found that the consumption of vitamin E from

supplements had no effect on the incidence of Alzheimer's, vitamin E intake from food has been was protected (Morris 2002). In those who were in the top fifth of intake, incidence of Alzheimer's disease was reduced by 70 %. Resveratrol has also been recognized as beneficial in Alzheimer's disease and other nerve degeneration disease (Chen 2005). It has been found that those who eat peanuts and peanut butter five times a week or more have a reduced risk of gallbladder disease by as much as 25 % (Tsai et al. 2004).

Peanuts and weight management

Considerable evidences show that incorporating peanut and peanut butter into the diet does not lead to weight gain or higher body weight (Mattes et al. 2008). In the research related to the weight loss, diets incorporated with peanuts, peanut butter and peanut oil have more acceptability amongst the subjects of all age groups and have shown to provide long term weight maintenance (McManus et al. 2001). In another research exclusively on school children it was found that there was weight loss in peanut fed group whereas the control group gained weight in a span of 2 years (Johnston et al. 2007). Similar data has been published in many more epidemiological studies where it was found that peanuts reduced the total and LDL cholesterol (Pelkman 2004).

Hunger maintenance

Research data show that peanut and peanut butter consumption improved the feeling of fullness and satisfied the consumers better than the carbohydrates snacks like rice cakes in equal quantities (Kirkmeyer and Mattes 2000). Another study showed that peanut consumption curbed the appetites of the subject due its fullness effect (Alpher and Mattes 2002). Emerging evidence is also showing that the type of healthy monounsaturated fat in peanuts may stimulate a hormone that helps to feel satisfied after consumption (Schwartz et al. 2008).

Body mass index (BMI)

Peanut and peanut butter eaters tend to have a lower body mass index (BMI) (2007). Alpher and Mattes (2002) showed that despite being energy dense, peanuts have a high satiety value and chronic ingestion evokes strong dietary compensation and little changes in energy balance . The mechanism behind this conversation could be enhanced satiety (Kirkmeyer and Mattes 2000; Burton-Freeman 2000) the hunger and energy compensation, inefficient absorption of whole peanuts or increased resting energy expenditure (Kirkmeyer and Mattes 2000).

Malnourishment

Peanut milk although not very popular is used extensively in cases of emergencies and malnutrition for rapid recovery and gain of health. In the past Peanut based product like "Plimpynut", a RUTF (Ready-to-Use Therapeutic Food) has been formulated to overcome severe malnourishment in the African nations. It is a lipid based mix containing ground, roasted peanuts. In addition, vegetable oil, powdered milk, vitamins, minerals, and sugar are added. Peanuts as the basis for RUTF enable better delivery of a full range of balanced lipids, essential amino-acids, minerals and vitamins required by developing children. African nations like Malawi, Sudan and Haiti, treatment with RUTF in children has repeatedly shown superior recovery rates and shorter duration to reach weight-to-growth goals compared to standard World Health Organization (WHO) therapies for malnutrition rehabilitation (Patel et al. 2005) in 2003, Diop (2003) showed that moderately malnourished RUTF-users had higher intake of energy, fat, iron and zinc compared to a group consuming corn/soy therapy because the consumption of staple foods fell in the corn/soy group. Both therapies resulted in modest weight pain, but the effect lasted longer for the RUTF group.

Issues related to peanut consumption

Peanut allergies

Peanut proteins have been customarily classified as albumins (water soluble) or globulins (saline soluble). Most of the storage proteins are globulins, which make up 87 % of the total protein (Johns and Jones 1916). The globulins are made up of two major proteins, arachin and conarachin. Barnett et al. (1983) tested the allergenicity of different peanut kernel. They cotyledons (kernels) are probably the major source of allergen for most individuals, as the skins and hearts are often removed during processing. This is because the heart contains saponins that impart a bitter flavor, and skin contains catechol tannins and related compounds, which give finished products an undesirable color (Woodroof 1983).

The exact cause of the allergy is unknown. Since terms of peanuts allergy are related to the action of immunoglobulin E (IgE) and other anaphylatoxins, which act to release histamine and other mediator substances from mast cells (degranulation). In addition to other effects, histamine induces vasodilatation and construction of bronchioles in the lungs, also known as bronchispasm. Symptoms can include vomiting, diarrhea, urticaria, angioedema (swelling of the lips, face, throat and skin), exacerbation of atopic eczema, asthma, anaphylactic shock. (Anderson 1996).

Peanut being a nutrient dense product can be utilized for nutrition to all only if the allergy is dealt with some new

techniques. Recently many techniques have been emerging like oral desensitization, Anti IgE Therapy, use of probiotics, Chinese Medicines, Soy-Based Immunotherapy, Cellular Mediator, Engineered allergen Immunotherapy, Plasmid DNA Immunotherapy, Bacterial adjuvant, Immunostimulatory Sequence and Oligodeoxynucleotide- Based Immunotherapy (Nowak et al. 2011). All these are still at initial stages and have a long way to go for regular and approved practical application.

Greater focus is needed to develop better techniques for increase in overall efficiency of extraction of specific functional components for the preparation of nutraceuticals which can benefit to those who suffer from metabolic disorders and allergies and are not able to consume peanuts directly.

Peanuts and food poisoning

Peanuts are frequently contaminated by the fungal species *Aspergillus flavus*, which can produce the aflatoxin. This infection can occur during transportation or storage of peanut meals. Aflatoxins are highly toxic and carcinogenic secondary metabolites of concern in food safety (Achar et al. 2009). Infection and aflatoxin concentration in peanut can be related to the occurrence of soil moisture stress during pod-filling when soil temperatures are near optimal for *A. flavus*. These relations could form the basis of a decision-support system to predict the risk of aflatoxin contamination in peanuts in similar environments (Craufurd et al. 2006).

A survey was carried out to assess the mycotoxin (aflatoxins) contamination in locally grown peanuts. A total of 72 samples of raw, roasted and salty peanuts were collected randomly from the Pothohar Plateau of Pakistan. The results indicated that aflatoxins were present in almost 82 % of the samples tested, with levels ranging from 14.3 to 98.8 μg/kg. This reflects that optimal conditions for fungal growth and mycotoxin contamination are frequent in peanut crop fields as well as in storehouses (Abbas et al. 2013).

Preservation of peanut

Oxidation of the lipid fraction of peanut meals is a major cause of deterioration in fatty peanuts due to the high degree of fatty acid unstauration (Talcott et al. 2005). Polyunsaturated fatty acids, specially linoleic and linolenic acid, are very susceptible to oxidation even under mild ambient conditions and are easily incorporated into the chain mechanism of lipid peroxidation, to yield free and peroxy radicals (Talcott et al. 2005). Lipid oxidation is usually implicated as a primary cause of a decreased shelf life, adverse tastes loss of nutrients and generation of undesirable aromas during extended storage of peanut meals (Reed et al. 2002). Also peanuts tend to be contaminated with aflatoxin due to fungal growth. So, it is important to develop preservation methods for the peanut meal. Although recently a research successfully claimed for minimizing oil migration through coating with protein based isolate (Han et al. 2009) but its contribution to the overall long term preservation of peanut was found questionable also the effect of coating on further processing needs to be evaluated.

Conclusion

Peanuts are a great source of nutrition. They can be abundantly utilized especially in a country like India which is one of the leading producers of peanut but ironically also has largest counts of malnourished population. Peanut allergies are comparatively less prevalent in India. Peanut is used amongst many traditional dishes in the country through the schemes of Mid-day meal and on the lines of plumpy nut, the under nourished can be feed and the double burden of malnutrition and obesity can be reduced. Thus Organizational initiatives and greater commercialization of peanut products can be taken as a dual approach to build a healthy population.

It is clear that there is a huge scope for the commercialization of peanut products and the market trends look extremely positive owing to all the above mentioned factors. Also, there is a greater need of spreading awareness that peanut can prevent undesired supplementations through non dietary sources on regular consumption in Indians, particularly.

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