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REVIEW ARTICLE

Antioxidant potential and health benefits of bitter gourd (*Momordica charantia* L.)

Preeti Kumari[1], R.B. Verma[1], Gulzar Ahmad Nayik[2], S.S.Solankey[1]

[1]Department of Horticulture (Vegetables & Floriculture), Bihar Agricultural University, Sabour, Bhagalpur 813210, Bihar, India.
[2]Department of Food Science and Technology, Govt. Degree College, Shopian, J&K, India-192303

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ABSTRACT

In recent years, there has been a great deal of attention toward the field of free radical chemistry. Free radicals reactive oxygen species and reactive nitrogen species are generated by our body by various endogenous systems, exposure to different physiochemical conditions or pathological states. A balance between free radicals and antioxidants is necessary for proper physiological function. Public awareness of the purported health benefits of dietary antioxidants has increased the demand for fruit and vegetable products with recognized and improved antioxidant quality and has created new opportunities for the horticulture industry to improve fruit and vegetable quality by enhancing antioxidant content. This review describes the vegetables specially bitter gourd's antioxidants, namely vitamin C, carotenoids, phenolics, Flavonoid, vitamin A, B, and E. Bitter gourd is a powerful nutrient-dense plant composed of a complex array of beneficial compounds. These include bioactive chemicals, vitamins, minerals and antioxidants which all contribute to its remarkable versatility in treating a wide range of illnesses. The fruits contain high amounts of vitamin C, vitamin A, vitamin E, vitamins B 1,B2 and B3, as well as vitamin B9 (folate). Medicinal value of bitter melon has been attributed to its high antioxidant properties due in part to phenols, flvonoids, isoflavones, terpens, anthroquinones, and glucosinolates, all of which confer a bitter taste. Bitter gourd fruit have anti-oxidant, anti-microbial, anti –viral activities and also used as a very popular traditional medicine in India, China and Central America for diabetes, it has also other important health promoting substances such as vicin, charatine and polypeptide-p.In view of potential use of bitter gourd fruit in the traditional medicine, its therapeutic benefits and bioactive compounds warrant furtherinvestigation.

Keywords: Antioxidant, free radicals, oxidative stress, bitter gourd.

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INTRODUCTION

Bitter gourd (*Momordica charantia* L.) has long been regarded as a food and medicinal plant. It is a powerful nutrient-dense plant composed of a complex array of beneficial compounds. These include phytochemicals, vitamins, minerals and antioxidants, which all contribute to its remarkable versatility in treating a wide range of illnesses. The fruits contain high amounts of vitamin C, vitamin A, vitamin E, vitamins B1, B2 and B3, as well as vitamin B9 (folate). Medicinal value of bitter melon has been attributed to its high antioxidant properties due in part to phenols, flavonoids, isoflavones, terpens, anthroquinones, and glucosinolates, all of which confer a bitter taste (Snee et al., 2011). Antioxidant in plants also includes vitamin C, vitamin E, phenolic acid and flavonide. Phytochemicals, particularly antioxidant from natural sources such as fruit, vegetable and herbs have gained popularity now a day due to their protective properties against several chronic and cardiovascular diseases (Temple, 2002). Natural antioxidants in bitter gourd are primarily plant phenols and polyphenolic compounds, which is a diverse class of chemical compounds that share the ability to act as chain breaking antioxidants and proposed to protect against the damage caused by free radicals to DNA, cell membrane and cell components (Dziri et al.,

* *For correspondence:* P. Kumari (Email: prityjaimatadi@gmail.com)
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2012). These polyphenols have received much attention among the natural compounds extracted from plants, due to their powerful antioxidant, antimicrobial and antiviral activities as well as their capacity to inhibit the proliferation of cancer cells, protect neuron against oxidative stress, simulative vasodilation, reduce vascularisation and improve insulin secretion (Rio et al., 2010).

Oxidative stress

Oxidative stress is an imbalance state between the generation of reactive oxygen species and antioxidant defence capacity of the body. This imbalance leads to oxidative damage to protein, molecules, and genes within the body. Since the body is incapable of keeping up with the detoxification of the free radical the damage continue to spread. It is induced by a wide range of factors, including UV, pathogen invasion, or oxygen shortage. In oxidative stress, innate antioxidant deference system becomes circumscribed and thus this state becomes the sole culprit for induction of highly prevalent diseases such as cancer, diabetes, hypertension, atherosclerosis, acute renal failure, and Alzheimer's and Parkinson's diseases. Oxidative stress occurs when the production of reactive oxygen in greater than the body's ability to detoxify the reactive intermediates.

Factors of oxidative stress

Free radicals occur naturally within the body and for the most part, the body's natural antioxidants can manage their detoxification. But there are some external that can trigger the production of these damaging free radicals. The factors includes

- Excessive exposure to UV rays.
- Pollution
- Smoking
- Eating an wealthy diet
- Excessive exercise
- Certain medicines and/ or treatment.

Reactive oxygen species (ROS)

It is generally accepted that reactive oxygen species (ROS) and / or free radicals play an important role in the development of tissue damage and pathological events in living organism (Kehrer, 1993; Halliwel and Gutteride, 1999). There are increase consumption of fruits and vegetables and intake of certain nutrients that are present in foods reduces the risk of various pathological events such as cancer (Goodwin and Brodwick, 1995; Steinmetz and potter, 1996) and cardio- and cerebro-vascular diseases (Rimm et al., 1996).This is often attributed to the antioxidants in the fruits and vegetable such as vitamin C, E, carotenoids, lycopenes and flavonoids that prevent free radical damages (Willett 1994). Thus, much attention has been focused on the investigation of antioxidants that can scavenge ROS, especially natural antioxidants, phenolic and flavonoids from plants which are mostly used as protective agents against free radical-mediated disease (Rice- Evans et al., 1996).

Antioxidant and its benefits

Antioxidants come up frequently in discussion about good health and preventing disease. Antioxidants are the substance that reduces damage due to oxygen, such as that caused by free radicals. Well-known antioxidants include enzymes and other substances, such as vitamin C, vitamin E and beta carotene, which are capable of counteracting the damaging effect of oxidation. Antioxidants may possibly reduce the risk of cancer and also slow the progression of age-related macular

degeneration. These powerful substances which mostly come from the fresh fruit and vegetables we eat, prohibit (and in some case even prevent), the oxidation of another molecule in the body. The benefits of antioxidants are very important to good health, because if free radical are left unchallenged. They can cause a wide range of illness and chronic disease.

Free Radicals and Antioxidant

Unbeknownst to most people, oxygen is both a blessing and a curse. Human needs oxygen in order to yet the simple act of breathing in oxygen result in the formation of highly reactive molecules called free radicals. As the free radicals interact with other molecules in the body, they cause oxidative damage that can result in the development of a wide range of illness and diseases. The human body naturally produced free radicals and the antioxidants to counteract their damaging effects. However, in most cases, free radicals for outnumber the naturally accruing antioxidants. In order to maintain the balance, a continual supply of external source of antioxidant is necessary in order to obtain the maximum benefits of antioxidants; Antioxidants benefit the body by neutralizing and removing the free radicals from the blood stream. In biomedical and scientific literature the term 'free radical' is used in a broad sense and also includes related reactive species such as 'excited states' that lead to free radical generation or those species that results from free radical generation or those species that results from free radical reaction. These free radicals are very short lived. Details about some of the biologically important reactive species are presented as Table 1. Antioxidants are added as Red-ox systems possessing higher oxidative potential than the drug that they are designed to protect or as chain inhibitors of radical inducted decomposition. In general, the effect of antioxidants is to break up the chains formed during the propagation process by providing a hydrogen atom or an electron to the free radical and receiving the excess energy possessed by the activated molecule. It has been suggested that fruits, vegetables, natural plants contain a large variety of substance called photochemical which are present in plants and are the main source of Antioxidant in the diet, which could decrease the potential stress caused by reactive oxygen species. The Natural antioxidants may have Free-radical scavengers, Reducing agents, Potential complexes of Pro-oxidant metals, Quenches of singlet oxygen etc. The antioxidants can interfere with the oxidation process by reacting with free radicals. Recently interest has increased considerably in finding natural occurring antioxidants for use in foods or medicinal materials.

Table 1: Reactive oxygen species of biological interest

Reactive species	Symbol	Reactivity/ Remarks
Superoxide	O_{2*}	Generated in mitrocondria and cardiovascular system
Hydroxyl radical	*OH	Very high reactive
Hydrogen peroxide	H_2O_2	Formed in our body due to large no of reaction
Peroxyl radical	ROO*	Formed from DNA, sugar and lipid during oxidative damage
Organic hydroperoxide	ROOH	Reacts with transient metal
Singlet oxygen	$^1O_2$	Highly reactive
Ozone	O_3	Present in atmospheric pollution

PROTECTIVE ACTION OF ANTIOXIDANTS

Increased consumption of fruits and vegetables has been associated with protection against various age-related diseases. What dietary constituents are responsible for this association is not known, but well-characterized antioxidants, including vitamins C and E, or β-carotene, are often assumed to contribute to the observed protection. However, the results from intervention trials have not been conclusive regarding the protection following supplementation with such antioxidants. Recent epidemiological evidence indicates that the putative beneficial effects of a high intake of fruits and vegetables on the risk of diseases of aging may not be exclusively due to these antioxidants but other antioxidant photochemical contained in fruits and

vegetables may be equally important. Table 2 represents same important antioxidant presents in vegetable, their function in body and source.

Antioxidant potential of other vegetables

Vegetables and fruit are rich in antioxidants which exhibit a wide range of biological, pharmacological and chemo protective properties that prevent cancer and reduce the risk of other diseases. The beneficial effects of vegetables are partially due to high amount of antioxidant including phenolic compounds.Vegetables prevents human from several sever and cronical disease. Consumption of vegetables prevents human from cancer, cardiovascular disease, diabetes, hyper tension, stoke, paralysis, urinary disorder etc since vegetables have antioxidant properties. More than 70% people in developing countries depend on vegetables and fruits further regular dietary needs. It is suggested to take about 400g of vegetables with including nuts and pulse for daily consumption. More than 50 vegetables and leafy vegetables are identified for their antioxidant activity in terms of DPPH, FRAR, IC50 and ORAC value. Table 3 represent the antioxidant potential in term of DPPH i.e. radical scavenging activity and compound responsible for antioxidant activity of some important vegetables.Vegetables contain several photochemical which possess strong antioxidant activity as scavenging or chelating action. The photochemical group of vegetable includes vitamin A, C, E and K, carotenoid, terpenoid, flavonoid, polyphenols, saponins, minerals and enzymes.

Table 2. Antioxidant present in different vegetable and their function.

Antioxidant Nutrient	Function in body	Vegetable sources
Lycopene	Reducing risk of cardiovascular disease and cancer	Tomato, red cabbage, and red chilli
Quercetin	Potential adjunct therapeutic in treatment of various cancers	Celery, Parsley, mushroom, spices
Lutein	Reducing the risk of brest cancer and help to prevent age related muscular degeneration	Turnip, Brussels sprout, kale, carrot
Tannin	It have anticarcinogenic and anti mutagenic properties	Beans
Anthocyanins	Act as potential source of antioxidant	Red cabbage, red onion, Kale,broccoli
Isoflavones	Influence women's health during menopause and it is necessary to reduce the risk of fibroids	Bitter gourd, legumes and bean
Phenoles	Reduces the risk of cancer	Bitter gourd, garlic, brinjal, cabbage
Vitamin A	Helps in maintain good vision, maintain integrity of white and red blood cell	Pumpkin, bitter gourd, spinach, turnip, carrots, Bitter gourd
Vitamin C	Potential source of antioxidant, essential in collagenformation and strengthen resistance to infection	Bitter gourd, chilli, brocalli, brussel sprouts and aspergus
Vitamin E	Protect vitamin A and fatty acids from oxidation	Beans, bitter gourd and dark leafy vegetables
Vitamin K	Helps make factors that promote blood clotting	Leafy vegetables, sweet potato

Bitter gourd as potential source of antioxidant

Bitter gourd (Momordica charantia L.) has been playing one of the most important dietary and medicinal roles in human beings for centuries. It has been cultivated since ancient times, it is mainly used as spice and as flavouring agent due to its potential benefits in preventive and curative medicine, it has been used in ancient and modern cultures (Bonzin et al., 2008). In the present days scenario also, the medicinal application of bitter gourd is widespread and grown rapidly. Epidemiological, clinical

and preclinical studies have demonstrated a close relation between dietary habits, including bitter gourd intake and the occurrence of diseased. Bitter gourd is considered as one of the best diseased preventive food based on its potential and diversified effects (Amagase, 2006).There are evidences that explain that increased uptake of fruits and vegetables reduce the risk of cancer. This is attributed by antioxidants presents in fruits and vegetables. The antioxidants present in bitter melon may help to seek out and destroy free radicals that can cause diseases (including numerous forms of cancer), but that is not the only benefit the fruit has in terms of cancer.

Table 3. Antioxidant activities of some vegetables

Botanical name/ Family	Active components responsible for antioxidant activity	Antioxidant values (DPPH)	Refrences
Daucus carota.	Protein, amino acids	33%	Chatarikun (2013)
Brassica oleracia Var. *capitata*	Isothiocyanate and Vitamin A,B,C	42.4%	Gacche et al. (2010)
Brassica oleracia Var. *botrytis*	Isothiocyanate and suphoraphane	67.2%	Gacche et al. (2010)
Raphonus sativus	Vitamin C	67.2%	Umamaheswari et al.(2012)
Abelmoschus esculentus	Carotene and vitamins	43.8%	Gacche et al. (2010)
Lycopersicon esculentum	Vitamin A, B and C	42%	Azeez at al. (2012)
Momordica charantia	Linolenic, momordicine, phenol, flavonoid and vitamin	82.05%	Hamissou et al.(2013)

Table 4. Antioxidant potential of bitter gourd in different assay.

Antioxidant assay	Value	Refrence
FRAP	2.29g Trolox equivalent/100g	Ee et al. (2015)
Metal chelating activity	10.6-89.3%	Choo et al. (2014)
Radical sacvenging (DPPH)	51.1%	Ee et al. (2015)
Radical sacvenging (DPPH)	63.4%-87.8%	Kim et al. (2013)
Radical sacvenging (DPPH)	41.57-85.65%	Anokwuru et al. (2011)
Radical sacvenging (DPPH)	79-87%.	Islam et al. (2011)
Radical sacvenging(DPPH)	37.1-46.1%	Kubola et al. (2008)

Bitter melon has been widely studied as an antitumor and anti-carcinogenic agent all by itself, along with its antioxidant properties. Primarily, studies have shown positive correlations between eating bitter melon and the prevention or reduction in tumour growth for cervical, prostate, and breast cancer patients. Some of this is due to the fruit's ability to induce apoptosis (cell death) in cancerous cells. A recent study also suggests that bitter melon supplementation ameliorates oxidative stress in liver of fructose fed offspring of rats by improving the antioxidant enzymes activity such as GPx, SOD, and catalyse (Ching et al., 2011). However, more studies are being done all the time to find out more about the powerful anti-cancer properties that this unassuming fruit seems to possess, and which other types of cancer patients it could benefit. Antioxidants and chemoprotective action of Momordica charantia fruit extracts in previous biological studies of Momordica charantia showed that the plant parts posses anti-oxidant properties (Hamissow et al., 2013 and Themozhi et al., 2010). Antioxidant activities of extract and juice could have contributed at least partly, to the therapeutic benefits of Momordica charantia fruit against worm infection. Fruit juice and fruit extract of Momordica charantia and whole fruit peels have potential antioxidant effect (Saikat et al., 2014).Table 4 represents the antioxidant potential of bitter gourd in several researches in different in-vitro assays. Previous work has established that the antioxidant properties of some plants are partly due to low molecular mass phenolic compounds,

particularly flavonoids, which are known to be potent antioxidants (Wang et al., 1999).Phenolic compounds from plant sources may act as antioxidants by scavenging lipid radicals. Bitter melon is a good source of phenolic compounds, flavonoid and ascorbic acid. Phenolic compound and flavonoid are the basic principal of antioxidant in bitter gourd.Phenolic compounds isolated from Momordica charantia are gallic acid, tannic acid, (+)-catechin, caffeic acid, p-coumaric, gentisic acid, chlorogenic acid, and epicatechin (Horax et al., 2010). Vitamin C (ascorbic acid) is a water- soluble free radical scavenger. The daily recommended dietary allowance is 60 mg. Flavonoids, which is mainly present as colouring pigments at levels (Cadenas and Packer, 1996; Kagan et al., 2002).

CASE STUDY

The antioxidant activity of the total aqueous extract and total phenolic extract of Momordica charantia fruits was assessed in rat cardiac fibroblasts (RCFs), NIH 3T3, and keratinocyte (A431). No significant cytoprotection was observed with both the extracts used in H2O2 and xanthine oxidase induced damages in cells (Kumaret al., 2010). However, the plant extracts showed significant protection against oxidative stress in several in-vivo models. Treatment with bitter melon extracts normalized the elevated concentrations of TBARS, hydroperoxides, and liver markers (ALP, AST, and ALT) in hyperammonemic rats induced by ammonium chloride while reversing the oxidant-antioxidant imbalance. This protective effect is mediated probably by increasing the activity and concentrations of GPx, SOD, and catalase and reduced glutathione in the liver and brain tissues (Thenmozhi et al., 2011). The plant extracts also prevented the lipid peroxidation in chronic sucrose fed rats and normalized the reduced glutathione level in liver (Chaturvedi et al., 2010).

CONCLUSION

Free radicals are implicated in etiology of large number of major disease. It can adversely alter many crucial biological molecules leading to loss of form and functions. These unwanted changes in body may create diseased conditions. Antioxidant produced with in body naturally as obtain from different herbs, vegetable and fruits can protect body from the damages caused by these free radicals at various at various levels. Different studies on Antioxidant potential of bitter gourd highlight that extract and juice of *M. Charantia* whole fruit, peel, seed have potential anti-oxidant activities. Since it contain good amount of biochemical compounds like ascorbic acid, phenolic compound and flavonoid. Flavonoid and phenolic compound are major source of antioxidant in bitter gourd. In view of potential use of bitter gourd fruit in the traditional medicine, its therapeutic benefits and bioactive compounds warrant further investigation.

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