

**Review Article**

**EDIBLE SEEDS MEDICINAL VALUE, THERAPEUTIC APPLICATIONS AND FUNCTIONAL PROPERTIES-A REVIEW**

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**ABSTRACT**

India has a rich source of tropical fruits containing edible seeds such as chia, hemp, sesame, pumkin, sunflower, mustard, nigella, guava, papaya, mangosteen, honeydew, pomegranate, fennel, fenugreek, cumin, sweet orange, cucumber, jackfruit, mango, melons, avocado and many more. These products such as the seed kernel, which constitutes about 10–35% of the weight, offer high nutritional value and therapeutic applications. This article explores the nutritional, medicinal, therapeutic applications, functional properties and bioactive constituents of the seeds of some fruits, which are analyzed for their functions and applications as sources of food value and bioactive phytochemical constituents. The seeds contain essential bioactive components such as alkaloids, carotenoids, flavonoids, glycosides, saponins, terpenoids, tannins, steroids and polyphenolic compounds and that exhibit excellent anti-inflammatory, antioxidant properties, anticancer, anti-diabetic, anti-hyperlipidemic, anti-obesity, neurological disorders, cardiovascular, skin diseases and chronic diseases. They have remarkable physicochemical properties and a high content of carbohydrates, fats, proteins, vitamins, and minerals. However extensive research activities can be carried out to determine the efficacy of the nutritional and bioactive components in different seed types, the bioavailability and potency. Extensive research with the seed parts can be investigated to identify the medicinal and functional potentials of these fruit seeds. This review gives an overview on the therapeutic applications and functional properties of seeds present in fruits, vegetables and medicinal plants. The medicinal and nutritional value, phytochemical composition, bioactive phytoconstituents, therapeutic activity, therapeutic applications and uses, proximate analysis, functional properties, analytical methods, spectroscopic methods and human clinical trials of some edible seeds are discussed in this review.

**Keywords:** Edible seeds, Bioactive phytoconstituents, Nutritional value, Therapeutic applications, Phytochemical composition

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**INTRODUCTION**

India is one of the largest producers and exporter of fruits in the world. India is well-known for its cultivation of rich fruit varieties with over many different species distributed throughout the country. Different varieties of major and minor fruits species and tropical fruits are cultivated and grown in the country. However, there are seeds present in fruits which include chia, hemp, sesame, pumkin, sunflower, mustard, nigella, guava, papaya, mangosteen, honeydew, pomegranate, fennel, fenugreek, cumin, sweet orange, cucumber, jackfruit, mango, melons, avocado and many more which are better known for large scale commercial cultivation. Fruit seeds are usually consumed by humans and thrown out as waste for processing. Processing of fruit usually generates a large amount of seeds as wastes. They are generally well-known for their nutritional and medicinal values, which include vitamins, proteins and carbohydrates. These fruits seeds are also processed into different by-products which has food value and food flavors. Studies were undertaken to explore their potential uses due to their high nutritional value and food applications. Many fruit seeds have been evaluated for their use in food industries and newer seed resources for the production of oils. [1]

The oil present in seeds is one of the most important components necessary for maintaining human health and diet since they are obtained in the form of renewable energy resource. Seed oils can be obtained by different extraction techniques such as hydraulic press, cold press, solvent extraction and refining. There is a high demand for seed oils and much interest is being focused on the possibilities of exploring newer seed resources for the production of oils. The quality characteristics of oils from different sources depend mainly on their fatty acid and triglyceride compositions. Apart from their nutritional status in human health, seed oils have food value, used as flavoring agents, excipients, additives in dosage forms and formulations in the preparation of topical formulations. Since there

has been an increasing demand and nutritional value for healthier oils with higher proportion of saturated and unsaturated fatty acids. [2] The article aims to present useful information on the utilization of various fruit seeds as raw materials for the preparation of food processing industries. The review article was compiled using various search criteria which include Pubmed, Scopus, Science Direct, Google scholar, etc. The articles related to the review were compiled from the last 10 y from 2010 to 2020.

**Pharmaceutical importance of few important seeds are presented in this article**

Chia seeds are the edible seeds of a flowering plant from the mint family. The seeds are used as anti-diabetic, antihypertensive, heart disease and skin diseases. Hemp seeds are a rich source of proteins. Hemp is related to cannabis plant, hemp seeds have a compound called as Tetrahydrocannabinol. The seeds have been used for topical formulations to treat certain skin diseases. They contain essential fatty acids and other nutritional requirements. Hemp seeds are used for treating rheumatoid arthritis, constipation, atherosclerosis, eczema and other chronic diseases. Sesame seed is used to treat hypertension, diabetes, high cholesterol, heart disease and many other chronic conditions. Pumkin seeds are rich in unsaturated fatty acids, protein, vitamins and minerals that reduce risk factors of chronic diseases and cancer. Pumpkin seeds are rich in antioxidants, anti-inflammatory effects. Pumpkin seeds lower the risk of diabetes, anti-cancer properties, and can stop the growth of cancer cells. Sunflower seeds are obtained from the flower heads of the sunflower plant. The seeds are covered with a black and white shell they are white in color and have a soft and smooth texture. They are known for their flavoring and high nutritional value, and the seeds can be consumed raw, roasted, or incorporated into other food items. Sunflower seeds have anti-inflammatory properties. Sunflower seeds contain flavonoids, vitamins and other plant compounds that

can fight many diseases. Sunflower seeds are rich in fatty acids, including polyunsaturated fatty acids and monounsaturated fatty acids. Consumption of sunflower seeds lowered the rates of cardiovascular disease, lowers bad cholesterol and hypertension. Sunflower seeds are rich in vitamins and minerals that can boost our immune system to fight against viruses.

#### Hepatic and intestinal function of Chia seeds

Chia seeds *Salvia hispanica* belonging to Lamiaceae family contains linoleic acid and  $\alpha$ -linolenic acid which increased bone mineral content and improved hepatic and intestinal morphology in sprague-dawley rats [3].

#### Estimation of hemp seed oil by GC-MS and LC-MS methods

Hemp seed *Canabis sativa* belonging to Cannabaceae family contains linoleic acid (la) and-linolenic acid (lna), caryophyllene, myrcene, sitosterol and trace amounts of methyl salicylate and cannabidiol (cbd) were detected. Hemp seed oil was analyzed by GC-MS and LC-MS and Bioassays were performed with the oil to determine its effectiveness as an antimicrobial agent [4].

#### Estimation of hemp seeds by LC-MS method

Canabis sativa seeds contain tetrahydrocannabinol and cannabidiol, and other 30 cannabinoids were identified for the first time in hemp seed oil. Cannabinoid profile was estimated by a liquid chromatography method coupled to high-resolution mass spectrometry LC-MS [5].

#### Antioxidant and antiproliferative activity of sesame seeds

Sesame seeds *Sesamum indicum* belonging to pedaliaceae family contains phenolics and lignans. The antioxidant and antiproliferative activities were determined against HepG2 cells. The nonlignan components in bound phenolics contributed to the antioxidant and antiproliferative activities [6].

#### Antioxidant activity of Sesame seeds

*Sesamum indicum* seeds were extracted with methanol, ethanol or acetone and the extracts contain phenolics and flavonoids. The antioxidant, phytochemical and physicochemical properties were determined. Sesame seeds possess significant antioxidant activity [7].

#### Antioxidant and antibacterial activity of sesame seeds

Antioxidant, free radical scavenging and antibacterial properties were determined in sesame seeds *Sesamum indicum* seed oil sesamin, sesamol and lignans were present in sesame seed oil. Sesamol is the best antioxidant and free radical scavenger amongst the molecules studied. Antibacterial assays against food-borne pathogens revealed sesamol to be an antimicrobial agent [8].

#### Antioxidant activity of sesame seeds

*Sesamum indicum* contains phenolic acids (hydroxybenzoic acids and hydroxycinnamic acids), flavonoids, and lignans. The antioxidant activity was estimated by reversed-phase high-performance liquid chromatography coupled to diode array detector and quadrupole-time-of-flight-mass spectrometry RP-HPLC (DAD) Q-TOF MS. Organic acids and some nitrogenous compounds also were characterized. The total phenol content and the antioxidant activity of the extract were determined [9].

The antioxidant activities of two varieties of sesame seeds were determined in *Sesamum indicum* seeds contains phenolics as well as flavonoids. The antioxidant potential was determined using DPPH, ABTS, and FRAP assays, total phenolic content (TPC) and total flavonoid content (TFC) were determined by ultraviolet (UV)-Vis spectrophotometry and analyzed by Pearson's method. Phenolic compounds in black sesame seeds were found to be the major contributors to antioxidant activities by using ABTS and FRAP methods [10].

*Sesamum indicum* seeds containing amino acids, total phenolics, sesamine, sesamol, catechin, epicatechin and sinapic acids were identified and antioxidant potential was determined. Amino acids

also remarkably increased in sprouted white and black seeds, arginine and tryptophan exhibited the greatest variations [11].

#### Comparative study of two varieties of pumpkin seeds

Pumpkin seeds *Cucurbita maxima* belonging to Cucurbitaceae family containing fatty acids and amino acids were identified by GC/MS and amino acid analyzer. Comparative study of nutrient contents was determined in different parts of two varieties of pumpkin. The saturated fatty acid such as capric acid, myristic acid, and stearic acid, unsaturated fatty acids oleic, linoleic and linolenic acid were present. A significant amount of threonine, serine, methionine, isoleucine and tyrosine were present in the seed but only alanine in the seed of hybrid variety [12].

#### Wound healing Activity of pumpkin seeds

Wound healing property was studied in *Cucurbita pepo* L. seeds containing tocopherols, fatty acids, and phytosterols. The results obtained exhibited excellent wound healing activity [13].

#### Atherosclerotic activity of pumpkin seeds

Atherogenic diet-induced atherosclerosis was investigated in *Cucurbita pepo* L. seeds containing L-arginine, the total cholesterol TC, Low Density Lipoprotein-C, High-Density Lipoprotein-C, serum lipid concentrations in atherogenic rats was determined. Atherogenic rats supplemented with pumpkin seeds showed a significant decrease in their serum concentrations of total cholesterol and Low-Density Lipoprotein LDL-C. Pumpkin seeds supplementation has a protective effect against atherogenic rats [14].

#### Anthelmintic efficiency of pumpkin seeds

*In vitro* and *in vivo* anthelmintic efficiency of aqueous and ethanol extracts on *Cucurbita pepo* L. seeds was determined in containing cucurbitine, aminoacids, fatty acids, and-for the first time-berberine and palmatine were identified. Raman, IR and LC-MS spectroscopy analyses were performed. Pumpkin seed extracts may be used to control of Gastrointestinal (G. I.) nematode infections [15].

#### Anticancer activity of pumpkin seeds

The anticancer activity was determined in *Cucurbita pepo* L. belonging to Cucurbitaceae Pumpkin seed extract containing 1, 2-dimethylhydrazine (dmh) induced colon cancer in wistar rats. Pumpkin seed may prevent the risk of CC when consumed in dietary proportions [16].

#### Chemical and nutritional characterization of pumpkin seeds

In this study, the general chemical compositions and some bioactive components, such as tocopherols, carotenoids, and  $\beta$ -sitosterol, were analyzed in three major species of pumpkin *Cucurbita maxima* L. containing monounsaturated fatty acids and polyunsaturated fatty acids, triacylglycerol, palmitic, stearic, oleic and linoleic acids [17].

#### Anti-obesity activity of sunflower seeds

Anti-obesity activity was determined in sunflower seeds *Helianthus annuus* belonging to Asteraceae family containing chlorogenic acids. Consumption of sunflower extract has a beneficial effect on body weight, fat mass, and lipid profile [18].

#### Antioxidant activity of sunflower seeds

Antioxidant activity and phenolic profile were investigated in *Helianthus annuus* containing mono-and dicaffeoylquinic acid isomers and caffeic acid hexose, were identified using the LC-TOF-MS/MS technique [19].

Black mustard is used for common cold, rheumatoid arthritis, gout, respiratory disorders and other conditions. Black mustard seed has been used for asthma, arthritis, headache, nasal congestion, intestinal worms and toothache. Watermelon seeds *Citrullus lanatus* part of the plant family Cucurbitaceae, watermelon is largely cultivated in many parts of the world. There are currently more than 1,000 varieties available. Watermelon is rich in antioxidants and vitamins. It contains the compound lycopene, which is important for heart and

may protect the skin from UV rays. Watermelon contains citrulline a compound which has excellent source of amino acid. The citrulline found in watermelon increase immunity to protect the body against viruses. Citrulline deficiency may lead to decrease immune response and also improves cardiovascular risk factors. Musk Melon is a semi-sweet fruit that belongs to the watermelon and honeydew melon. It also belongs to the same plant family as cucumbers, pumpkins etc. The antioxidant present in musk melon has anti-inflammatory property. They have free radicals scavenging activity that cause oxidative stress and cell damage, reducing risk of developing serious health issues such as diabetes, heart disease, arthritis and more. Musk melon contains two vitamins A and C both of these vitamins play a major role in maintaining healthy skin. Vitamin A helps to protect the skin from UV radiations and vitamin C helps to support the production of natural collagen. Musk Melon has two carotenoid compounds lutein and zeaxanthin, two compounds that give fruits and vegetables their yellow and red colors. Combined with vitamin A, these antioxidants play an important role in protecting vision and eye health. Beta carotenes, found in Musk melon as vitamin A, may help prevent respiratory problems such as bronchial asthma. Choline, an antioxidant found in Musk melon, may also help to reduce inflammation in people with chronic bronchitis.

Pomegranate can help protect heart diseases and may even prevent cancer. Pomegranate seed is used for the treatment of hypertension, energy booster, heart disease, diabetes, and many other conditions. Fennel seed is a spice harvested from the herb fennel plant. They have a sweet flavor, fennel seeds have traditionally been used as a spice in cooking. However, they can be used in all types of food, uses of fennel seeds in recipes. Fennel seeds are taken orally in the form of spice for indigestion, constipation, lowers cholesterol, menstrual cramps and symptoms of menopause.

#### Anticancer activity of mustard seeds

Mustard seeds *Brassica nigra* belonging to Brassicaceae family in which sinigrin and myrosinase were present, the anticancer activity was determined by orthotopic rat bladder cancer model [20].

#### Antioxidant activity of mustard seeds

Antioxidant activity of *Brassica Juncea* was determined containing ascorbate, riboflavin, and polyphenols, gallic acid, caffeic acid, quercetin and kaempferol dry seeds, and they were identified by HPLC analysis of the extract [21].

#### Antiproliferative, proapoptotic, antioxidant and antimicrobial effects of mustard seeds

The antiproliferative, proapoptotic, antioxidant and antimicrobial effects were determined in *Sinapis nigra* L. and *Sinapis alba* L. Glucosinolate, sinalbin and sinigrin were identified, Antiproliferative activity was correlated to Mitogen-Activated Protein Kinases modulation, which was cell and extract-dependent. Cell-cycle analysis evidenced a proapoptotic effect of *s. alba* on both tumor cell lines and of *s. nigra* only on HCT 116 cell lines [22].

#### Antioxidant capacity of mustard seed

Antioxidant capacity was investigated in *Brassica nigra* and *Brassica alba*. The fatty acids oleic, linoleic and linolenic were identified, whereas for yellow mustard seed the major fatty acid were erucic (6.87%), oleic (5.08%) and linoleic (1.87%) acids [23].

#### Anticancer effects of mustard seed

Anticancer effects of *Brassica nigra* ethanolic extract were determined on A549 and h1299 human non-small cell lung cancer cell lines. *B. nigra* extract showed a substantial growth-inhibitory effect as it reduced the viability and clonogenic survival of A549 and H1299 cells in a concentration-dependent manner. *B. nigra* seed extract may be an important anticancer potential against human lung cancer [24].

#### Antiasthmatic activity of mustard seed

A pilot study was performed on respiratory tract infections, *Brassica nigra* mustard seed footbaths were used for determining respiratory tract infections. 103 patients were included in the intervention

group and 36 patients were included in the control group. Participants of the intervention group who used mustard seed footbaths for six consecutive days showed an improvement in four of the five subscales of the Herdecke Warmth Perception Questionnaire HeWEF questionnaire [25].

#### Antihyperlipidemic activity of nigella seeds

Lipid-lowering effects were studied on Nigella seeds, *Nigella sativa* lowered total cholesterol triglyceride, low-density lipoprotein, increased high-density lipoprotein. The present study demonstrates that 8-week aerobic training plus *N. sativa* supplementation has a synergistic effect in improving lipid profile parameters [26].

#### Fatty acid profile of watermelon and muskmelon seeds

Watermelon and muskmelon *Citrullus lanatus* belonging to cucurbitaceae family containing saturated fatty acids and unsaturated fatty acids tetradecanoic acid, pentadecanoic acid, hexadecanoic acid, heptadecanoic acid and octadecanoic acid were determined by Gas chromatography-mass spectroscopy [27].

#### Antioxidant activity of watermelon seeds

*Citrullus lanatus* containing Linoleic, stearic, palmitic and oleic acid myristic, heptadecanoic, arachidic, 9-hexadecenoic and 14-eicosenoic acid. Total phenolics, antioxidant activity, peroxide value and oxidizability effects were determined [28].

#### Hypercholesterolemia-induced atherosclerosis of watermelon seeds

Hypercholesterolemia-induced atherosclerosis in mice was determined in *Citrullus lanatus* containing citrulline. *C. lanatus* 'sentinel' extract led to reduced body weight gain, decreased plasma cholesterol concentrations, improved homeostasis of pro-and anti-inflammatory cytokines, and attenuated development of atherosclerosis without affecting systolic blood pressure in hypercholesterolemic mice [29].

#### Tramadol-induced testicular damage of pomegranate seed

Tramadol-induced testicular damage in adult and adolescent rats was investigated on pomegranate seed extract. This effect may be due to the high amount of antioxidant compounds present in the pomegranate seeds [30].

#### Effects of pomegranate seed on human epidermal keratinocyte

Effects on human epidermal keratinocyte and human dermal fibroblast functions were determined in pomegranate seed oil *Punica granatum*. These results suggest heuristic potential of pomegranate fractions for facilitating skin repair in a polar manner, namely aqueous extracts promoting regeneration of dermis, and pomegranate seed oil promoting regeneration of epidermis [31].

#### A double-blind clinical trial of pomegranate seed

A randomized, double-blinded, placebo-controlled, balanced, cross-over trial was performed on pomegranate (*punica granatum*) extract. PE may be effective in improving performance outcomes at maximal effort and might help to restore force in the damaged muscles [32].

#### Ovarian-ischemia and reperfusion injury of pomegranate seed

Ovarian-ischemia and reperfusion injury in rats was studied in pomegranate seed oil *Punica granatum*. While NADPH oxidase activity, MDA and TNF- $\alpha$  levels were significantly increased, SOD activity and GSH levels were reduced in ischemia and I/R groups [33].

#### Anti-inflammatory effects of fennel seed

Anti-inflammatory effects of fennel in the model of lipopolysaccharide (lps)-induced acute lung injury was determined. Fennel effectively blocked the inflammatory processes induced by LPS, by regulating pro-inflammatory cytokine production, transcription factors, and NO [34].

#### Anti-obesity activity of fennel seed

Anti-obesity placebo-controlled, single-blinded, randomized, and 3-way crossover design was performed on *Foeniculum vulgare* Fennel tea (ft), fenugreek tea (fgt). Subjective appetite, hunger, fullness,

desire to eat, and prospective food consumption were measured at seven independent time point using a visual analog scale (VAS). Drinking the FT and FGT were significantly effective aid to suppress subjective appetite among overweight women [35].

#### **A double-blind clinical trial of fennel seed**

A double-blind, randomized, placebo-controlled trial was performed using *Foeniculum vulgare* fennel on body composition in menopausal women. Bodyweight, body mass index (BMI) as well as fat distribution was measured. Menopausal women in fennel group experienced a slight increase in body weight and fat distribution [36].

#### **Antioxidant and anticancer activity of fennel seed**

*Foeniculum vulgare* methanolic extract contains flavonoids, terpenoids, alkaloids, phenols, and sterols gallic acid, the phenolic compound l-limonene was the most prevalent monoterpene hydrocarbon. Antioxidant, cytotoxic, and antitumor activity in breast cancer cell line (mcf7) and liver cancer cell line (hepg-2) were determined [37].

#### **Polycystic ovary syndrome of fennel seed**

Polycystic ovary syndrome (PCOS) treatment and renoprotective effect in aqueous extract of *Foeniculum vulgare* were determined. The mean values of blood urea nitrogen in PCOS rats treated with low dose of aqueous extract of fennel and estradiol valerate (EV) and non-treated, was significantly increased compared with non-PCOS and PCOS rats treated with high dose of aqueous extract fennel (AEF) [38].

Fenugreek seed is taken orally for diabetes, menstrual problems, high cholesterol and many other conditions. Guava seed is a tropical fruit that grows in dry or humid conditions. Guava seeds are used for intestinal cramps, spasms, antispasmodic, pain, diabetes and wound healing. The fruit is used for high blood pressure. Papaya seed is taken by mouth for cancer, diabetes, a viral infection called human papilloma virus (HPV), dengue fever and other conditions. Honey dew contains Vitamin C, high fiber content and other nutrients. Honeydew seeds help in strengthening bones and treats osteoporosis. Honeydew contains many nutrients that are essential for bone health, including folate and Vitamin K. Folate helps to break down homocysteine a compound in the body, high levels of homocysteine which can weaken bone mineral density. Vitamin K helps the protein called osteocalcin found in bones to bond with calcium ions. Both the folate and Vitamin K found in honeydew can help strengthen bones while preventing them from losing bone density. Apart from Vitamin C, it also contains high water content it is an excellent source for maintaining healthy skin. Mangosteen seeds are used for obesity and gum infection such as periodontitis. It is also used for strengthening muscles, diarrhea and several skin diseases.

#### **Hyperlipidemic activity of fenugreek seeds**

Hyperlipidemia effects of high fat diet on gut microbiota in mice were studied in fenugreek seeds *Trigonella foenum-graecum*. Fenugreek attenuated HFD-induced hyperlipidemia and stabilized glucose tolerance without affecting body weight. Fenugreek specifically reversed the effects of HFD and metabolic function [39].

#### **Antidiabetic activity of fenugreek seeds**

Fasting blood glucose levels and glycosylated hemoglobin (hba1c) levels in patients of type 2 diabetes mellitus controlled with diet was determined in *Trigonella foenum-graecum*. Fenugreek seeds have a synergistic effect on diet control exercise and fasting blood glucose and HbA1c [40].

#### **Anti-inflammatory and anti-arthritis activity of fenugreek seeds**

Anti-inflammatory and anti-arthritis activities were performed on *Trigonella foenum-graecum* petroleum ether extract of fenugreek seeds containing linolenic and linoleic acids. Fenugreek seeds have significant anti-inflammatory and anti-arthritis activities which are due to the presence of linolenic and linoleic acids [41].

#### **Antioxidant activity of guava seeds**

Guava seeds *Psidium guajava* belonging to Myrtaceae family containing chlorogenic acid phytosterols stigmaterol,  $\beta$ -sitosterol and campesterol Lipid, phytosterol and phenolic compositions. The antioxidant activity, and the hepato-and neuroprotection of hydrogen peroxide-induced oxidative stress levels in the gso extract were determined [42].

#### **Antioxidant activities of papaya seeds**

Antioxidant activities of the *c. papaya* seeds water extract against hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) oxidative stress in human skin detroit 550 fibroblasts was determined in Papaya seeds *Carica papaya* belonging to *Caricaceae* family [43].

#### **Anthelmintic and anti-amoebic activity of papaya seeds**

Anthelmintic and anti-amoebic activities against human intestinal parasitosis were investigated in *Carica papaya* Elixir composed with air-dried *c. papaya* seeds and honey. Thus, air-dried *C. papaya* seeds are efficacious in treating human intestinal parasites and without significant side effects [44].

#### **Antioxidant activities of papaya seeds**

Antioxidant activities of ethanol, petroleum ether, ethyl acetate, *n*-butanol and water extract were determined in *Carica papaya* seed, containing *p*-hydroxybenzoic acid (1) and vanillic acid (2), total phenolics and total flavonoids [45].

#### **Antibacterial effect of papaya seeds**

Antibacterial effect was evaluated on methanol extract of *Carica papaya* papaya seed. The growth or inhibition of control strains of *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhi*, and *Pseudomonas aeruginosa* as well as the clinical isolates of these bacteria were determined in growth media [46].

#### **Antioxidant activity of honey dew seeds**

Honey dew *Cucumis melo* belonging to Cucurbitaceae family, five phenolic compounds in water extract namely gallic, hydroxybenzoic acid and catechin and caffeic acid, nine phenolic compounds identified in methanol-water extract two vanillic acid derivatives, ellagitannins, quercetin-3-rutinoside, derivatives of syringic acid and ellagic acid. Antioxidant activity was determined, phenolic compounds were identified using a reversed-phase high performance liquid chromatography with diode array detection (HPLC-DAD) method [47].

#### **Total phenolic content and antioxidative activity of honeydew seeds**

Total phenolic content and antioxidative activities were determined in *Cucumis melo* containing phenolic and flavonoid compounds 3-hydroxybenzoic acid, chlorogenic acid, neochlorogenic acid, isovanillic acid, apigenin-7- $\alpha$ -glucoside, luteolin-7-*o*-glucoside, and quercetin-3-galactoside were analyzed using HPLC [48].

#### **Antioxidant activity of honey dew seeds**

Antioxidant activity was determined in *Cucumis melo* evaluating total polyphenols, *ortho*-diphenols, flavonoids, and tannins content [49].

#### **Anticancer activity of honeydew seeds**

High-performance liquid chromatography (HPLC) was used to examine and assess the contents of phenolic acid (gallic acid) and flavonoid (rutin) compounds in *Cucumis melo*. GC-MS analysis 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide (mtt) was used to assess the cytotoxicity effect against pc3, hct116, hela, and jurkat cell lines [50].

#### **Human metabolic syndrome of mangosteen seeds**

Mangosteen seeds *Garcinia dulcis* belonging to Clusiaceae family containing garcinol, morelloflavone and citric acid were assessed for rat model of human metabolic syndrome [51].

#### **Antioxidant and anti-inflammatory effects of mangosteen seeds**



A randomized, double-blind, placebo-controlled clinical trial was performed on *Garcinia mangostana* and antioxidant and anti-inflammatory and immunity biomarkers in plasma of healthy adults were determined. The mangosteen significantly increased antioxidant capacity and possesses anti-inflammatory benefits with no side effects on immune, hepatic and renal functions [52].

#### GC-MS estimation of mangosteen seeds

*Garcinia mangostana* containing anthocyanins, saturated palmitic acid, stearic acid, unsaturated fatty acids, oleic acid, linoleic acid were analyzed using Gas chromatography-flame ionized detector [53].

Mango seed is used as anti-diabetic, anti-obesity, reduces high cholesterol, etc. The antioxidants, minerals and vitamins present in mango can provide important health benefits to human beings. Vitamin K helps prevent anemia and blood clot. It also plays an important role in the strengthening of bones. Mangos are also rich in vitamin C, which is important for forming healthy collagen. Mangos can also provide other health benefits like, anticancer activity lower risk of cancer, mangos contain beta-carotene, a pigment responsible for the color of the fruit. Mangos are also helpful for supporting cardiovascular system. They are a great source of magnesium and potassium, both of which are connected to lower blood pressure and maintaining a regular pulse rate. Mangos have a compound known as mangiferin, which has anti-inflammatory properties, they can improve digestion help maintain digestive system. They have both amylase and dietary fiber, which can help relieve constipation. Amylase can break down starches and dissolves other foods in the stomach. Meanwhile, the fiber in mangos can be more effective for relieving constipation than equivalent fiber supplements. Cumin seeds are used in many conditions, including abnormal levels of cholesterol or blood fats dyslipidemia, obesity and many other conditions. Jackfruit seed is taken by mouth as an aphrodisiac or for diabetes. Jackfruit paste is applied to the skin for poisonous bites. Avocado is used for high cholesterol, psoriasis, arthritis, obesity, and many other conditions. Cucumber seed is used for osteoarthritis, reducing high levels of cholesterol, hyperlipidemia, wound healing potentials and hypertension.

#### UHPLC-HRMS of mango seeds

Mango seed *Irvingia gabonensis* mango seeds extract containing ellagic acid, mono, di, tri-*O* methyl-ellagic acids and their glycosides were analyzed by Ultra-High-Performance liquid chromatography with high-resolution mass spectrometry (UHPLC-HRMS) method [54].

#### Total phenolic content and antioxidant activities of mango seeds

Total phenolic content (TPC) antioxidant activities were determined in *Mangifera indica* belonging to Anacardiaceae family with the use of an HPLC-UV/Vis, gallic acid, caffeic acid, rutin and penta-*O*-galloyl- $\beta$ -D-glucose were identified to be present in the mango seed kernel [55].

#### Antioxidant activity of mango seeds

Antioxidant activity was determined in *Mangifera indica* containing gallic acid, polyphenols, flavonoids quercetin, gallic and chlorogenic acids. The extract inhibited the growth of *Escherichia coli*, *Salmonella Typhimurium*, *Staphylococcus aureus* and *Listeria monocytogenes*. Chromatographic analysis revealed the presence of gallic and chlorogenic acids [56].

#### Antioxidant, antidiabetic and anticancer properties of cumin seeds

Antioxidant, antidiabetic and anticancer properties were determined in Cumin seeds *Cuminum cyminum* belonging to Apiaceae family containing p-coumaric acid, ferulic acid, ellagic acid and cinnamic acid [57].

#### Antihyperlipidemic activity of cumin seeds and *Nigella sativa* seeds

*Cuminum cyminum* powdered *Nigella sativa* determined the low density lipoprotein cholesterol (LDL) and triglyceride (TG) high

density lipoprotein cholesterol (HDL) significantly increased Serum lipids, glucose homeostasis and anthropometric variables in patients with Hashimoto's thyroiditis [58].

#### A Randomized double-blind placebo-controlled clinical trial of cumin seeds

A Randomized double-blind placebo-controlled clinical trial was performed on *Cuminum cyminum*. The weight loss and metabolic profiles among subjects with overweight were studied. Results of the current study indicated that taking high-dose *C. cyminum* L. plus lime for eight weeks among subjects with overweight had beneficial effects on weight, BMI, FPG, QUICKI, triglycerides, total cholesterol and LDL-cholesterol levels. [59]

#### Anxiolytic activity of orange seed

Anxiolytic activity of sweet orange seed *Citrus sinensis* Rutaceae family containing essential oil aromatherapy for anxiety disorders was determined. Psychologic parameters and physiologic parameters were evaluated before the inhalation period and before, during, and after the Stroop Color-Word Test (SCWT) [60].

#### Anti-obesity activity of orange seed

Anti-obesity effects in *in vitro* and *in vivo* studies were determined in *Citrus sinensis* containing anthocyanins, hydroxycinnamic acids, flavone glycosides and ascorbic acid. The study was carried out in overweight healthy human volunteers for 12 w. There was a significant reduction in body mass index (BMI), body weight, waist and hip circumference. The results showed that they have a synergistic effect on fat accumulation in humans and the extract can be used in weight management and in the prevention of human obesity [61].

#### Antidepressant activity of orange seed

Antidepressant-like effects was studied on *Citrus sinensis* (L.) containing essential oil Limonene. The results indicated that Orange Essential Oil inhalation significantly ameliorated the depression-like behaviors of chronic unpredictable mild stress (CUMS) mice with decreased bodyweight, sucrose preference, curiosity, and mobility as well as shortened immobile time and attenuated dyslipidemia [62].

#### Antioxidant and anti-inflammatory activity of orange seed

Antioxidant and anti-inflammatory *in vitro* and *ex vivo* method were determined on *Citrus sinensis* polyphenolic extract, using the murine macrophages cell line J774A.1 and primary peritoneal macrophages. The *in vitro* bioavailability of *Citrus sinensis* polyphenolic extract was assessed using the human cell line Caco-2 grown as monolayers on a transwell membrane [63].

#### Anti-obesity activity of orange seed

Anti-Obesity in diet-induced obese zebrafish model was studied on *Citrus sinensis* containing flavonoid-rich extract of orange juice. In overfed zebrafish model, orange juice significantly decreased both body weight and Body Mass Index values and lowered the visceral adipose tissue, while it had little effect in the normal fed group [64].

#### Anticancer activity of orange seed and grape seed

*Citrus sinensis* and *Vitis vinifera* polyphenolic extracts in embryonic cardiomyocyte cells (H9c2), and human breast adenocarcinoma cell line (MCF-7) exposed to doxorubicin Possess bioactive polyphenols that protect cardiomyocytes against doxorubicin-induced oxidative stress. The polyphenolic extracts were characterized by Liquid Chromatography-Mass Spectrometry methods [65].

#### Antidiabetic activity of Jackfruit seed

Jackfruit seed *Artocarpus heterophyllus* belonging to Moraceae family, the ethanolic extract 70% of jackfruit seeds contains betacarotene, epoxide compounds. Jackfruit seeds in reducing blood glucose levels in gestational diabetic rats induced by streptozotocin and *in silico* study virtual screening through molecular docking were determined [66].

#### Starch from jackfruit seed powder as superdisintegrant

Starch from jackfruit seed *Artocarpus heterophyllus* powder superdisintegrant to design fast dissolving tablets of irbesartan. The tablets prepared from jackfruit seed starch as superdisintegrant were found to be suitable for the preparation of fast dissolving tablets [67].

#### Antioxidant and antimicrobial activity of Jackfruit seed

Antioxidant and antimicrobial activity were determined on *Artocarpus heterophyllus* containing minerals,  $\beta$  carotene and dietary fiber, alkaloids, saponins and tannins, phenolic and flavonoid content. GC/MS screening and quantitative analysis of polyphenols, catechin, ascorbic and chlorogenic acids were identified as major polyphenols analyzed by LC-MS/MS and GC/MS analysis [68].

#### Toxicological and Genotoxic evaluations of avocado seed

Toxicological and Genotoxic evaluations were determined on ethanolic seed extract of Avocado seed *Persea Americana* belonging to Lauraceae family [69].

#### Antioxidant activity of avocado seed

Antioxidant activity the radical scavenging assay methods ORAC and ABTS were performed on *Persea Americana*. Methanol and ethanol-water, avocado seed oil, peroxide value and thiobarbituric acid reactive compounds (TBARS) were determined [70].

#### Liver and kidney functions of avocado seed

*Persea americana* Avocado seed powder supplements on meat quality were determined Liver and kidney functions of culled female quails, serum glutamic oxaloacetic transaminase SGOT, and serum glutamic pyruvate transaminase SGPT were also determined. Avocado seed powder supplements improved meat quality as well as the liver and kidney functions of the culled female quail [71].

#### Antioxidant activity of avocado seed

Peroxide Value and TBARS (Thiobarbituric acid reactive substances), were analyzed Total polyphenols content (TPC) Oxygen Radical Antioxidant Capacity (ORAC) were determined on *Persea Americana* [72].

#### In vitro antioxidant and anticancer effects of avocado seed

*In vitro* Antioxidant and Anticancer Effects were determined on *Persea americana* CASE dose-dependently reduced the viability of human breast (MCF7), lung (H1299), colon (HT29), and prostate (LNCaP) cancer cells [73].

#### Polyphenolic compounds of Avocado seed were analyzed by UPLC-ESI-MS/MS

*Persea Americana* containing organic acids, hydroxycinnamic acids, catechins, free and glycosylated flavonoids, and dimeric and trimeric procyanidins. Catechin, epicatechin, six quercetin derivatives, four dimeric procyanidins and three trimeric procyanidins. The polyphenolic-rich extracts and their fractions were analyzed by ultra-performance liquid chromatography-electrospray ionization-mass spectrometry (UPLC-ESI-MS/MS) [74].

#### In vitro antioxidant and analgesic activities of cucumber seeds

*In vitro* antioxidant and analgesic activities were performed on Cucumber seeds *Cucumis sativus* belonging to Cucurbitaceae family containing flavonoids and tannins. The presence of flavonoids and tannins in the extract might be responsible for free radical scavenging and analgesic effects [75].

#### Atherosclerosis and hyperlipidemic activity of cucumber seeds

A Randomized double-blind placebo-controlled clinical trial was studied to determine Atherosclerosis and hyperlipidemic activity on *Cucumis sativus*. The Total cholesterol, triglycerides (TG), low-density lipoprotein (LDL-C), and high-density lipoprotein (HDL-C) were evaluated [76].

#### Antidiabetic activity of Cucumber seeds

Antidiabetic activity was determined on *Cucumis sativus* hydroalcoholic and buthanolic extract on Streptozotocin-Induced Diabetic Rats. *C. sativus* seeds extracts (hydroalcoholic and buthanolic) exhibited excellent antidiabetic activity [77].

#### CONCLUSION

This article reviews the functional properties, phytochemical composition of several seeds present in fruits and vegetables. The seeds discussed in this review are compiled from edible fruits, they have the nutritional value and therapeutic efficacy to be used directly as raw material for pharmaceutical formulations and have food value. As some of them contain considerable amounts of alkaloids, glycosides, saponins, flavonoids, terpenoids, tannins, steroids and polyphenolic compounds, as they can become the source for raw materials and lipids. As further investigation is needed in many areas like exploring bioactive phytoconstituents, therapeutic activity, analytical methods, spectroscopic methods and clinical trials, this article can be a future reference for research activities.

#### RESPONSE TO COMMENTS

Punctuation errors are rectified cautiously.

#### AUTHORS CONTRIBUTIONS

All the authors have equally contributed to the article.

#### CONFLICT OF INTERESTS

The authors have no conflict of interest.

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