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Cucurbita: A cavernous account of bioactive compounds and potential therapeutic agents

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Abstract
Pumpkin is primarily consumed in India, Mexico and various parts of USA, the plants have served medicinally worldwide by treating wounds, cardiovascular disease, several cancers, gastrointestinal diseases, anemia, urinary tract infections, and intestinal parasites. The medicinal properties of the pumpkin plant are associated with the nutritional and phytochemical configuration of its different parts. Among those constituents the carotenoids of fruits, gallic acid and quercetin of flowers, inorganic matter of stem, fibre of root, phytosterols of seeds and hematinic components of leaves are majorly studied for their bioactivity. In this aspect, the present review focuses on providing a detailed overview of its history, production scenario, phycological requirements and therapeutic uses of each part pumpkin plant. The evaluation of all these properties will help in understanding the production and processing requirements of pumpkin plant while its nutritional and physiological potential can further help in the development of the value-added products and supplements.

Keywords: Pumpkin, nutritional composition, physicochemical factors, therapeutic application, bioactive compounds, botanical description

Introduction
Pumpkin belongs to the family Cucurbitaceae and it consists of 118 genera with 825 species, the plant was oriented in Mexico around 5000 B.C and its name originated from the Greek word for "large melon" which is "Pepon" (Dhiman *et al*., 2009) [1]. It is creeping plant and is mainly famous for its fruit and seed but the peels, leaves and flower are also consumed in different parts of the world [Yadav *et al*., (2010)] [2, 47]. The pumpkin vine basically produces unisexual, radially symmetrical yellow to orange flowers with the common ratio of (male: female) ranging from (4:1) to (14:1) **[**Sotelo *et al*., (2007); Maynard and Elizabeth, (2008)] [3, 4].

Pumpkin plant is culturally very popular in China, Mexico, India and different parts of USA for their esculent, medicinal properties. Traditionally, flowers are used as a remedy for male infertility and minor injuries as they are rich in calcium, potassium and sodium [Ghosh and Rana, (2021)] [5].

Though plants have already been used in ancient Rome, Greece, India and China for victual and decorative nature but their role as functional foods, due to their bioactive components and nutritional composition have also been reported in history [Fernandes *et al*., (2017)] [6].

In addition to their biochemical composition, they are renewable, assemble and affordable source of bioactive compounds which makes edible plants a potential source of conventional foods which can help in developing the formulations of functional, fortified or modified foods [Gostin and Waisundara, (2019)] [7].

History and Botanical description of Pumpkin
Cucurbita is a western hemisphere fruit vegetable and is native to Latin America. It has been widely cultivated from over 10000 years in several different parts of the world like Continental Europe, New Zealand, Australia, India and other parts of Asia [Adhau *et al*., (2015) [8]; Andolfo *et al*., (2017)] [9].

The Pumpkin is a flowering plant of Cucurbitaceae family and Cucurbita genus which is known to be the most morphologically diverse genera in kingdom plantae and it encompasses the largest vegetable crops too [Rakcejeva *et al*., (2011); Lee *et al*., (2021)] [10, 11]. It has elongated, cylindrical, grooved stem that can grow up to 10m long, with tendrils, monoecious flowers, shallow rounded five lobed leaves that are arranged alternately along 10-20 cm hairy petioles [Ahmad and Khan, (2019)] [12].

The peduncle (part of stem that holds the fruit) is flared convex five-angled thick structure attached to the fruit. Fruits (pumpkin) depending upon its variety comes in various shapes size and color [Ahamed *et al*., (2012)] [13]. Seeds are obscurely marginate, ovate shaped, 16-20 mm long and the plants have fibrous root system.

The germination takes place in about one week and flowering starts in 35-60 days Pumpkin fruits are harvested when, nearly or fully matured in about (4-6 weeks) after flowering, and are picked until the crop ends, 90-180 days post planting [Kulkarni and Joshi, (2013)] [14]. Though these plants are cultivated generally for edible purpose but its fruit is also used for ornamental usage, popularly in the Halloween party [Patel, (2013)] [15]. Each part of pumpkin plant is consumable. For instance, in Indian cuisine, pumpkins and their leaves are traditionally cooked as curry, its flowers are eaten as pakora and raw squash is eaten in candied form [Mashitoa *et al*., (2021)] [16, 39]. In Italy and Japan number of local dishes and beers are prepared from pumpkin fruit. In African countries soups and soft alcoholic drinks are prepared from its fruit. Pumpkin is mainly used for production of bread, pie, puddings, biscuits, cake, desserts, donuts, granola, ice cream, butter, salads, soups etc [Andolfo *et al*., (2017)] [9]. The seeds are widely eaten raw as well as roasted and also used for oil. Blossom are used for culinary purposes and perfumes also [Seymen, (2020)] [17].

World Scenario of Pumpkin Production

According to FAOSTAT (Food and Agriculture Organization Corporate Statistical Database), leading producer of pumpkin for the year (2019) was Guyana and Bahrain with production of 1139059 and 698605 Hectogram/ Hectare respectively, contributing to 37% of its global production followed by Indonesia, Spain, China Honkong SAR, Belgium, Kuwait, Poland, Republic of Korea and The United Arab Emirates [FAOSTAT Statistic Database. 2019, (2021)] [18]. The Indian production for the year 2019-2020 of pumpkin crop is 96010 hg/ha which is 0.160% of world's overall production [FAOSTAT Statistic Database. 2019, (2021)] [18].

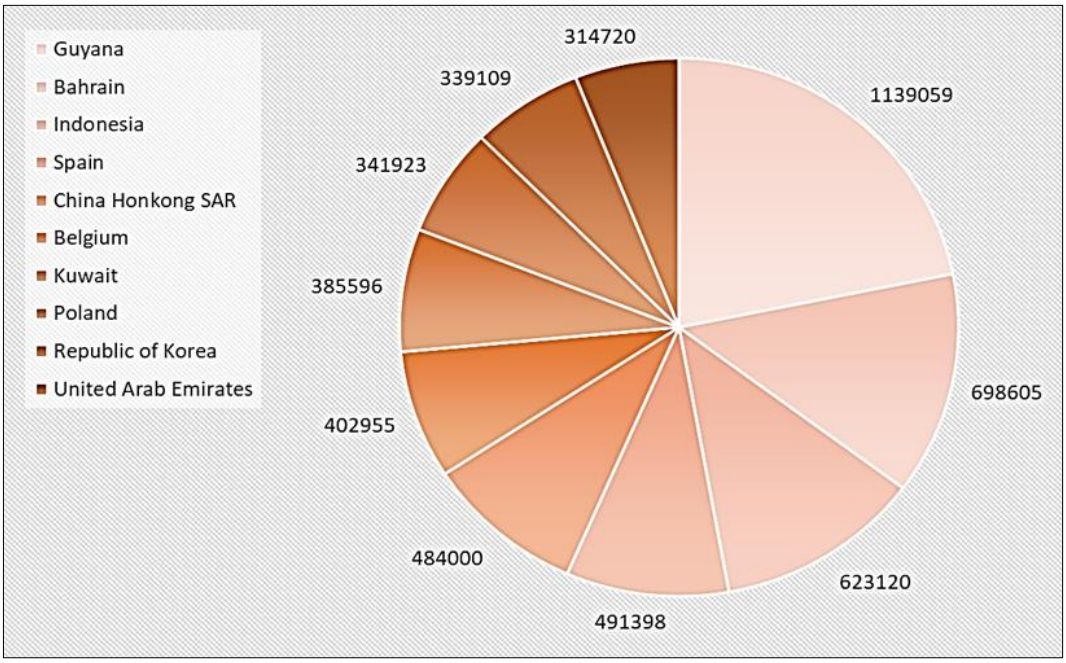

Fig 1: Bar graph showing top 10 pumpkin producing countries for the year 2019(Hg/Ha)

Physiological factors required for pumpkin crop

Physiological factors in agriculture are those elements which are pertaining to the functions of crop as well as to the chemical and physical processes involved in this functioning (Daniela *et al*., 2022) [19]. These factors can be classified into internal and external factors. Internal factors can be classified into genetic or hereditary elements which to which crop yields and other desirable characters are related, while external factors are classified into climatic, edaphic, biotic, phsiographic and socio-economic elements (Liliane and Charles, 2020) [20].

Climatic factors are attributed to the influence of climatic elements like precipitation, temperature, atmospheric humidity, solar radiation, wind velocity, atmospheric gases etc., which influences the crop production (Kingsley *et al*., 2022) [21]. Temperature is a measure of intensity of heat energy which is optimal for maximum growth of crop plant. Germination, chemical processes within the plant, growth and development are highly influenced by temperature as the diffusion rates of gases, liquids and solubility of different substances which are required in plant growth changes with temperature (Dragicevic and Sredojevic, 2011) [22]. The optimal temperature that is required for pumpkin plant is 18-27°C (Table. 2) (Bannayan, 2017) [23, 34].

Moisture present in the atmosphere in the form of water vapor, is normally known as humidity (Karl, 2019). Relative humidity refers to the moisture which is present in atmosphere and is expressed as the ratio of the amount of moisture present in the air to the saturation capacity of the air at a particular temperature (Kong and Singh, 2001). It influences the water requirement of crops and pumpkin crop requires temperate and humid climate for its optimal growth (Oluoch, 2012) [24].

The edaphic factors include whole range of soil conditions like soil structure and type, soil temperature, soil moisture, soil pH and acidity and mineral salt content (Onwuka, 2016; Gentili *et al*., 2018) [25, 26]. Crop plants growth completely depend upon the soil on which they grow and pumpkin crop

requires well drained sandy loam soil with soil pH in range of 6.0 - 6.5 for its optimum growth (Table. 2) (Oluoch, 2012) [24]. Soil moisture is a principal constituent in plant growth as it is essential chemical and biological processes of soil including mineralization and it also maintains the soil temperature from extremes (Lee *et al*., 2017; Haishui *et al*., 2019) [27, 28]. Nutrient availability and mobility increase with increase in soil moisture content.

The furrow, drip and overhead irrigation method are most suitable for pumpkin crop water management (Table. 2) (Maughan *et al*., 2015) [29, 33]. The mineral content of soil is also an important factor in growth of crop plant and as each type of crop is unique, so has a unique optimum nutrient range as well (Table. 2) (Fageria and Moreira, 2011) [30]. Though naturally the minerals are derived from withering of rocks but as this process is very slow, gradually to fulfill the requirement of fertilizers are used (Ribeiro *et al*., 2020) [31].

Table 1: Physiological factors required for pumpkin crop

Physiological factors	Requirements	Reference
Temperature	18-27°C	Bannayan, 2017 [23, 34]
Habitat	Temperate and humid climate	Oluoch, 2012 [24]
Soil	Well drained/sandy loam soil	Salehi *et al*., 2019
Soil pH	6.0 to 6.5	Oluoch, 2012 [24]
Plantation method	Seed propagation	Bahlgerdi, 2014 [32]
Irrigation	Furrow, drip and overhead irrigation	Maughan *et al*., 2015 [29, 33]
Fertilizers		Bannayan *et al*., 2017 [23, 34] and Chen *et al*., 2019 [35]
Nitrogen	150kg N/ha	
Phosphorus	95kg P/ha	
Potassium	80kg K/ha	

Table 2: Parts of pumpkin plant and their nutritional composition

Parts of pumpkin plant	Moisture (%)	Ash (%)	Crude Fat (%)	Protein (%)	Crude fiber (%)	Energy (Kcal)	Reference
Fruit	92.24	0.76	0.26	0.98	0.56	26	James *et al*., 2014, Judith *et al*., 2015 [36, 37]
Leave	65.40	6.02	1.35	4.24	4.36	19	Taiwo,2018, Mashitoa *et al*., 2021 [38, 16, 39]
Flower	85.03	1.78	0.11	1.63	4.33	15	Ghosh and Rana, 2021, USDA, 2010 [5]
Seed	4.06	3.8	36.57	34.56	22.79	559	Hong *et al*., 2009, Adaramoye *et al*., 2020, Syed *et al*., 2019 [41, 42, 43]

Different parts of pumpkin plant and their major bioactive compounds

Each part of pumpkin plant accounts medicinal properties due to the presence of wholesome amount of various bioactive compounds in its every single part [Lusiana *et al*., (2018)] [44].

The major therapeutic applications of pumpkin fruits (Figure.2) is due to carotenoids (alpha and beta carotene, beta-caryptoxanthin, lutein, and zeaxanthin) and phytosterols which depicts potent antioxidants, cholestrol lowering, antimicrobial and anti-inflammatoty properties [Kreck *et al*., (2006) [45]; Kulczyński and Gramza,(2019)] [46]. The amount of beta-carotene and alpha-carotene, in pumpkin fruit is 61.6ug/g DW and 29.3 µg/g DW, respectively [Bartosz and Anna, (2019)].

The pumpkin seeds are good sources of antioxidants, antimicrobial and anti-inflammatoty agents such as tocopherol, polyphenols, flavonoids and beta-carotene. Besides this pumpkin seeds are also rich source of crude fiber, dietary lignans and curcurbitin [Yadav, (2010); Gutierrez, (2016); Dyshlyk *et al*., (2017); Habib *et al*., (2015)] [2, 47, 48, 49, 50] which helps in preventing diseases like Breast cancer, blood bile, blood vomiting, constipation, prostatitis (swelling of prostate gland which is predominantly caused by Escherichia coli) [Nickel, (2012)] [51], gonorrhea (sexually transmitted disease involving inflammatory discharge from the urethra or vagina, which is caused by Neisseria gonorrhoeae bacteria) [Hill *et al*., (2013)] [52], wounds healing and intestinal parasites/worms [Richter *et al*., (2013)]; Gilbert and Albjn, (2007); Kujawska and Pieroni, (2015); Vijayakumar *et al*., (2015); Motti and Motti, (2017); Balcha, (2014); Jaradat *et al*., (2016); Rude *et al*., (2009); Daysi *et al*., (2004)] [53, 54, 67, 68, 69, 70, 55, 56] (Figure.2).

Moreover, the pumpkin seed oil is a rich source of omega-3 fatty acid which limits and modulate the inflammatory response [Elhardallou *et al*., (2014)] [57] which ultimately helps in relieving arthritis (joint inflammation) pain [Gupta, (2017) [58]; Athanassiou *et al*., (2020)] [59].

The pumpkin stem extract is effective against Staphylococcus aureus, Escherichia coli, Proteus mirabilis, Klebsiella pneumoniae [Al-Ghazal, (2012)] [71] which makes it a great remedy for bacterial urinary tract infection which is usually caused by Escherichia coli [Flores *et al*., (2015)] [60] (Figure.2).

The pumpkin leaves (Figure.2) have lots of medicinal usage, due to their hematinic properties (substances that are crucial for the proper formation of the components of blood), high levels of protein, vitamin A, vitamin C, potassium, iron, magnesium and zinc [Ajayi *et al*., (2004)]. The protein of pumpkin leaves also helps in the maintenance of the connective tissues and muscles which can help in preventing arthritis [Ajayi *et al*., (2006)] [61]. The extract from the pumpkin leaves can be used to boost red blood cells for patient's suffering from malaria and anemia (condition in which enough healthy red blood cells are not avilable in blood) and malaria due to its high vitamin B6 (0.207mg/100g), vitamin B9 (36ug/100g) and iron (1040mg/Kg) content [Samson and Isaac, (2019); Ekpedeme *et al*., (2019)] [62, 63,]. The presence of polysaccharides helps in lowering the blood sugar level and maintain the levels of serum insulin [Ehiagbonare, (2008)] [64].

Seeds

Breast cancer, intestinal parasite, blood bile, blood vomiting, Intestinal worms, constipation, prostatitis, gonorrhea, wounds healing and arthritis [Menendez et al., (2014); Kujawska and Pieroni, (2015); Vijayakumar et al., (2015); Motti and Motti, (2017); Balcha, (2014); Jaradat et al., (2016)].

Stem

Bacterial urinary tract infections [Al-Ghazal, (2012)].

Leaves

Anemia, cancer (lung and head), arthritis, blood booster, dandruff and malaria [Peter et al., (2014); Agyare et al., (2018); Asowata-Ayodele et al., (2016); Odoh et al., (2018)].

Flower

Wound healing, blood pressure, osteosarcoma, cataract, acne, dermatitis, ecchymosis, fever, atherosclerosis and male infertility [Nayak et al., (2017); Rigat et al., (2015); USDA 2010].

Fruit

Blood pressure, constipation, Infection, gastritis, Stomachache and control of gastrointestinal nematode infections, male infertility [Ramzan et al., (2017); Meragiaw et al., (2016); Grzybek et al., (2016)].

Fig 2: Different parts of pumpkin plant and their medicinal properties.

Conclusion

The use of Cucurbita plant in various studies revealed that they are composed of multiple effective and useful compounds that provides an opportunity for further research and production of the formulations having anti-inflammatory, anti-microbial and antioxidant properties. The present review markedly highlights that each part of pumpkin plant has preventive and remedial abilities for treatment of different diseases. This consolidates the opportunity of their application as an upcoming anti-microbial, anti-cancerous, anti-cataract, cardio protective agents. Eventually, not the least foremost application of pumpkin flowers as functional food in public health affinity, is associated with great availability and safety profile.

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