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REVIEW ARTICLE

ORIGIN, DISTRIBUTION, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS, GENETIC DIVERSITY, AND BREEDING OF PUMPKINS AND SQUASHES (*Cucurbita* spp.)

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ABSTRACT

Pumpkins and squash are the edible fruits of four of the five cultivated species of the genus *Cucurbita*. Although the terms 'pumpkin' and 'squash' are often used interchangeably, the former is derived from the Latin word *pepo* and implies a large, round fruit, whereas the latter is derived from the native North American word *asq*, plural *asquash*, for a fruit eaten raw or immature. References to pumpkins date back many centuries. The name pumpkin originated from the Greek word for "large melon" which is "pepon." "Pepon" was nasalized by the French into "pompon." The English changed "pompon" to "Pumpion." Shakespeare referred to the "pumpion" in his Merry Wives of Windsor**.** American colonists changed "pumpion" into "pumpkin." The "pumpkin" is referred to in The Legend of Sleepy Hollow**,** Peter, Peter, Pumpkin Eater and Cinderella**.** Pumpkin and squash (*Cucurbita* L. spp.), collectively, are a major vegetable crop and are grown in almost all regions, from cool temperate to tropical. Generally, the edible *Cucurbita* fruit that are round or nearly round are referred to as pumpkins and those that are nonround are referred to as squash. Although *Cucurbita* plants and fruit are grown for various reasons, most often they are grown for human consumption of their entire young fruit or mature fruit flesh. The genus *Cucurbita* incorporating pumpkin, squashes or vegetable marrows is the most economically valuable genus of this family with 27 species, five of which (*C. moschata*, *C. pepo*, *C. maxima*, *C. mixta*, *C. ficifolia*) are cultivated all over the tropical and sub-tropical world. The edible portion of the fruit, botanically called 'pepo', is a pericarp with a very little portion of the mesocarp. Both mature and immature stages of the fruits are used as vegetable. The flesh is delicious when stewed, boiled or baked. The average nutritive value of pumpkin (2.68) is higher than brinjal (2.41), tomato (2.09) and cucumber (1.69) mainly because of high stored carbohydrate (mainly glucose) and carotenoids (74% β - carotene) along with a moderate quantity of ascorbic, nicotinic, pantothenic and folic acids and different minerals. Fully matured fruits, apart from utilization as a cooked vegetable can be used in preparing sweets, candy or fermented into beverages. Delicate sweet items like "halwa", other sweets and jams are prepared from the meshed flesh of fully matured fruit. Pulp is also mixed with tomato in the preparation of sauce and ketchup. In this review article origin, distribution, taxonomy, botanical description, genetics, genetic diversity, and breeding of pumpkins (*Cucurbita* spp.) are discussed.

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INTRODUCTION

Cucurbita (Latin for gourd) is a genus of herbaceous fruits in the gourd family, *Cucurbita*ceae (also known as cucurbits or cucurbi), native to the Andes and Mesoamerica. Five edible species are grown and consumed for their flesh and seeds. They are variously known as squash, pumpkin, or gourd, depending on species, variety, and local parlance (WIKI, 2022). The name pumpkin is derived from the Greek word pepon, which means large melon. The word was adapted by the French as pompon, and later changed to pumpion by the English. By the late 17_{th} century, English-speaking immigrants in the New World started pronouncing it as pumpkin, which remains the standard pronunciation to this day (Herbazest, 2021). References to pumpkins date back many centuries.

The name pumpkin originated from the Greek word for "large melon" which is "pepon." "Pepon" was nasalized by the French into "pompon." The English changed "pompon" to "Pumpion." Shakespeare referred to the "pumpion" in his Merry Wives of Windsor. American colonists changed "pumpion" into "pumpkin." The "pumpkin" is referred to in The Legend of Sleepy Hollow, Peter, Peter, Pumpkin Eater and Cinderella (UI, 2022). Pumpkins and squash are the edible fruits of four of the five cultivated species of the genus *Cucurbita*. Although the terms 'pumpkin' and 'squash' are often used interchangeably, the former is derived from the Latin word pepo and implies a large, round fruit, whereas the latter is derived from the native North American word asq, plural asquash, for a fruit eaten raw or immature. Generally, the term pumpkin applies to round or nearly round (oblate, globose, ovate, obovate, etc.) fruits and the term squash applies to non-round fruits of edible *Cucurbita*.

The great majority of pumpkins are harvested and consumed when the fruit is mature. Many squash are harvested and consumed when immature; these are known as summer squash. Squash which are harvested and consumed when mature are known as winter squash. Pumpkins and winter squash can be stored for several months after harvest in the fall, for consumption during the winter (Paris, 1994). Native Americans dried strips of pumpkin and wove them into mats. They also roasted long strips of pumpkin on the open fire and ate them. The origin of pumpkin pie occurred when the colonists sliced off the pumpkin top, removed the seeds, and filled the insides with milk, spices and honey. The pumpkin was then baked in hot ashes (UI, 2022). Pumpkin and squash (*Cucurbita* L. spp.), collectively, are a major vegetable crop and are grown in almost all regions, from cool temperate to tropical. The words pumpkin and squash are often used interchangeably, but the origin and root meaning of these two terms are different. Generally, the edible *Cucurbita* fruit that are round or nearly round are referred to as pumpkins and those that are non-round are referred to as squash. Although *Cucurbita* plants and fruit are grown for various reasons, most often they are grown for human consumption of their entire young fruit or mature fruit flesh (Paris and Brown, 2005). The genus *Cucurbita* incorporating pumpkin, squashes or vegetable marrows is the most economically valuable genus of this family with 27 species, five of which (*C. moschata*, *C. pepo*, *C. maxima*, *C. mixta*, *C. ficifolia*) are cultivated all over the tropical and sub-tropical world. The term "squash" is generally employed to designate the forms of *C. pepo*, that are used immature, all baking cultivars of *C. maxima* and the cushaw-type cultivars of *C. mixta*, used mature and the term "pumpkin" is normally applied to the edible fruit of any species of *Cucurbita* utilized when ripe as a table vegetable or in pie (Whitaker and Robinson 1986). However, pumpkin is mostly associated with *Cucurbita moschata* Duch. ex Poir. It is extensively cultivated in India, Africa, Latin America, Southern Asia and United States. However, the English name for the species, "tropical pumpkin" is an appropriate one because the greatest diversity lies in the neotropics where the vines are grown under a wide range of ecological conditions, including under hotter conditions than are tolerated by the other cultivated *Cucurbita* species (Andres, 2004).

"Butternut squash" is also popularly called pumpkin in Western countries. Pumpkin, like the majority of the domesticated *Cucurbita* species is monoecious and exhibits a succession of flower development, with a decreasing ratio of staminate to pistillate flowers as the plants mature. Flowers are axillary, solitary, unisexual, large and showy. The edible portion of the fruit, botanically called 'pepo', is a pericarp with a very little portion of the mesocarp. Both mature and immature stages of the fruits are used as vegetable. The flesh is delicious when stewed, boiled or baked (Gupta and Rai, 1990). The average nutritive value of pumpkin (2.68) is higher than brinjal (2.41), tomato (2.09) and cucumber (1.69) mainly because of high stored carbohydrate (mainly glucose) and carotenoids (74% β - carotene) along with a moderate quantity of ascorbic, nicotinic, pantothenic and folic acids and different minerals (Gupta and Rai, 1990). It is particularly important for the supply of antioxidants and especially carotenoids in foods. Matured fruits are also used as industrial raw material for carotene production (Vucetic et al., 1989). Fully matured fruits, apart from utilization as a cooked vegetable can be used in preparing sweets, candy or fermented into beverages. Delicate sweet items like "halwa", other sweets and jams are prepared from the meshed flesh of fully matured fruit. Pulp is also mixed with tomato in the preparation of sauce and ketchup (Sharma and Kumar 1995). The fermented product "Yerusseri" prepared from immature fruit is very popular in Kerala, India (Rajan and Markose, 2001). Its young leaves, tender twigs and flowers are also used as a cooked vegetable in different forms. In this review article origin, distribution, taxonomy, botanical description, genetics, genetic diversity, breeding, uses, nutritional value and health benefits of pumpkins and squashes (*Cucurbita* spp.) are discussd.

ORIGIN AND DISTRIBUTION

Archaeological remains trace the association of pumpkins and squashes with man in America for at least 10,000 years (Whitaker and Cutler, 1971).

It was presumed that fruits of most wild species of *Cucurbita* were of a size and color to attract the attention of primitive men but they had hard, tough rinds and excessively bitter flesh but the seeds were non-bitter, tasty and nutritious and the early men, in sampling the fruits of wild *Cucurbita* species for seeds, probably found a lack of the bitter principle which resulted in the modern domesticated species (Whitaker and Bemis, 1976). Temporal and geographical relationships among bean, squash, gourds and humans in eastern North America suggested the possibility of a long-term genetic interaction between wild and domesticated species (Kirkpatrick and Wilson, 1988). The centre of diversity of *Cucurbita* is in the area south of Mexico City extending to the Mexico-Guatemala border (Whitaker and Bemis, 1976), and South Central Mexico is believed to be the centre of distribution (Whitaker and Knight (Jr.), 1980). Not surprisingly, the wild species, *C. lundelliana* and *C. martinezii*, which are evidently closely related to the cultivated species, occur in this area (Whitaker and Robinson, 1986). Native areas of the cultivated species of *Cucurbita* appear to be North Mexico of Mexico City for *C. pepo*, South America for *C. maxima*, South America, Central America and Mexico for *C. moschata*, Mexico and South Mexico City for *C. mixata* and Central America and Mexico for *C. ficifolia* (Hurd et al. 1971). Most *Cucurbita* species grow wild in widely scattered regions of Mexico (Nee, 1990; Whitaker, 1947). Five species were cultivated by the inhabitants of the Americas for several thousand years before the arrival of Europeans. The domestication of a North American species, *C. pepo* L., is ancient, perhaps having begun 10,000 years ago (Smith, 1997). Wild forms of *C. moschata* have not been described, but primitive appearing landraces are known from Central America to Northern Peru which, coupled with archaeological evidence, suggests that the center of origin of pumpkin is in Northwestern South America (Andres, 2004).

Though commonly believed to have originated in Asia, pumpkin is now known to be native to the Americas - particularly regions of Latin America. The earliest known record of human consumption of cucurbits comes from Mexico**,** where remnants of seeds and squashes have been found in dwellings dating back to the year 5,000 BCE**.** Other archeological remains can be found in Belize**,** Peru, and Guatemala (Herbazest, 2021). Though information about where pumpkins originated remains largely unclear, they have been observed growing wild in parts of Northeastern Mexico. The earliest known record of human domestication and consumption of pumpkins comes from Mexico, where remnants of seeds and squashes have been found in the Oaxaca valley and Tamaulipas dwellings - perhaps dating as far back as 8750 BCE and 7000 BCE, respectively. Additional findings in Missouri (4000 BCE) and Mississippi (1400 BCE) are also relevant (Herbazest, 2021). After domestication, pumpkins were transported to other parts of the world by boat during the colonial era. The earliest evidence of pumpkins in Europe, for example, can be found in a prayer book made for Anne de Bretagne, the duchess of Brittany, between 1503 and 1508. Once domesticated, the crop produced larger fruit, developing more colors and sizes, compared with the wild plant. Throughout history, a large variety of different culinary, medicinal, and decorative uses for pumpkin have been applied (Herbazest, 2021).

Archaeological investigations have found evidence of domestication of *Cucurbita* going back over 8,000 years from the very Southern parts of Canada down to Argentina and Chile. Centers of domestication stretch from the Mississippi River watershed and Texas down through Mexico and Central America to Northern and Western South America. Of the 27 species that Nee delineates, five are domesticated Four of them, *C. argyrosperma/mixta*, *C. ficifolia*, *C. moschata*, and *C. pepo*, originated and were domesticated in Mesoamerica; for the fifth, *C. maxima*, these events occurred in South America. The domesticated forms of *C. pepo* have larger fruits than non-domesticated forms and seeds that are bigger but fewer in number. In a 1989 study on the origins and development of *C. pepo*, botanist Harry Paris suggested that the original wild specimen had a small round fruit and that the modern pumpkin is its direct descendant. He suggested that the crookneck, ornamental gourd, and scallop are early variants and that the acorn is a cross between the

scallop and the pumpkin. *C. argyrosperma* is not as widespread as the other species. *C. ficifolia* and *C. moschata* were originally thought to be Asiatic in origin, but this has been disproven. The origin of *C. ficifolia* is Latin America, most likely southern Mexico, Central America, or the Andes. It grows at elevations ranging from 1,000 to 3,000 meters (3,300 to 9,800 ft) in areas with heavy rainfall. *C. maxima* originated in South America over 4,000 years ago, probably in Argentina and Uruguay. The plants are sensitive to frost. *C. maxima* did not start to spread into North America until after the arrival of Columbus. Varieties were in use by native peoples of the United States by the 16th century. *C. moschata* is native to Latin America, but the precise location of origin is uncertain.[57] It has been present in Mexico, Belize, Guatemala, and Peru for 4,000–6,000 years and has spread to Bolivia, Ecuador, Panama, Puerto Rico, and Venezuela. *C. pepo* is one of the oldest, if not the oldest, domesticated species with the oldest known locations being Oaxaca, Mexico, 8,000–10,000 years ago, and Ocampo, Tamaulipas, Mexico, about 7,000 years ago. It is known to have appeared in Missouri, United States, at least 4,000 years ago (WIKI, 2022).

Cucurbita pepo is an economically important crop, which consists of cultivated *C. pepo* ssp. *pepo*, and two wild taxa (*C. pepo* ssp. *fraterna* and *C. pepo* ssp. *ovifera*). We used two chloroplast regions and nine nuclear microsatellite loci to assess the levels of genetic variation and structure for *C. pepo* ssp. *pepo's* landraces sampled in 13 locations in Mexico, five improved varieties, one *C. pepo* ssp. *fraterna* population and ornamental *C. pepo* ssp. *ovifera*. We tested four hypotheses regarding the origin of *C. pepo* ssp. *pepo's* ancestor through approximate Bayesian computation*: C. pepo* ssp. *ovifera* as the ancestor; *C. pepo* ssp. *fraterna* as the ancestor; an unknown extinct lineage as the ancestor; and *C. pepo* ssp. *pepo* as hybrid from *C. pepo* ssp. *ovifera* and *C. pepo* ssp. *fraterna* ancestors. *Cucurbita pepo* ssp. *pepo* showed high genetic variation and low genetic differentiation. *Cucurbita pepo* ssp. *fraterna* and *C. pepo* ssp. *pepo* shared two chloroplast haplotypes. The three subspecies were well differentiated for microsatellite loci. *Cucurbita pepo* ssp. *fraterna* was probably *C. pepo* ssp. *pepo's* wild ancestor, but subsequent hybridization between taxa complicate defining *C. pepo* ssp. *pepo's* ancestor (Castellanos-Morales et al., 2019). *Cucurbita pepo* has evolved into three main subspecies (or lineages): subsp. *fraterna*, subsp. *pepo*, and subsp. *texana*. Within these subspecies, there exist a myriad of different varieties and cultivars; many are manmade, while some have developed naturally in the wild. The *pepo* subspecies is the most commonly cultivated. Subsp. *fraterna* and subsp. *texana* grow wild in Northeastern Mexico and in the Southeastern United States, respectively. No natural specimens of subsp. *pepo* have been identified, but it may be native to Southern North America. Additionally, early 16th century colonial expansion resulted in a wider dispersal of *Cucurbita pepo* in Europe and beyond; pumpkins are now cultivated wherever crops can be grown in the warm summer months. The use of pumpkin as an important crop for human consumption dates many thousands of years back to the time of the ancient civilizations of North and South America. Pumpkins, as well as other species in the *Cucurbita*ceae family, have evolved in many natural and manmade ways while simultaneously spreading out from the Americas to Europe and other continents (Herbazest, 2021).

The genus *Cucurbita* is native to the Americas. The centre of diversity is in the tropics near the Mexico-Guatemala border. The archaeological evidences indicate that these were widely cultivated in Southwestern United States, Mexico, and Northern South America in pre-Colombian times i.e. prior to 1492 AD. *Cucubita pepo* is native to North America. The cultivated species of *Cucurbita* are widely distributed throughout tropical, subtropical and temperate regions of both the New and Old World. In these areas squash and pumpkin are important in agriculture, but are considered as minor crops (Vidhi, 2022). Pumpkin and squash were dispersed to other continents by transoceanic voyagers at the turn of the 16th century and have become familiar and important in many countries outside of the Americas (Paris and Brown, 2005).

Molecular analysis using AFLP and SRAP markers showed a genetic diversity concordant with the morphological variability and with both the markers, the accessions clustered according to geographical origin: Central America, South America and Spain suggesting the existence of two independent domestications in both American areas and/or introgressions from related species (Ferriol et al. 2004).

TAXONOMY

The genus *Cucurbita belongs to the tribe* Cucurbiteae and the family *Cucurbita*ceae. The synonyms of *Cucurbita are Mellonia* Gasp., *Melopepo* Mill., *Ozodycus* Raf., *Pepo* Mill., *Pileocalyx* Gasp., *Sphenantha* Schrad. And *Tristemon* Scheele (Hai and Long An, 2015; CABI, 2021; CABI. 2022; WIKI, 2022). There are 26 species of *Cucurbita*, five of which are domesticated, but genetically isolated from each other. The wild species contain many ecospecies which are separated geographically but are genetically cross-compatible (Vidhi, 2022).

Taxonomy of the genus *Cucurbita:* Various taxonomic treatments have been proposed for the Genus *Cucurbita*, ranging from **13-30** species. In 1990, *Cucurbita* expert Michael Nee classified them into the following oft-cited **13** species groups (**27** species total), listed by group and alphabetically, with geographic origin (Hai and Long An, 2015; WIKI, 2022):

Species group 1: [4 species]

1- *Cucurbita argyrosperma* (synonym *Cucurbita mixta*) - cushaw pumpkin; origin: Panama, Mexico. 2- *Cucurbita kellyana*, origin: Pacific coast of western Mexico. 3- *Cucurbita palmeri*, origin: Pacific coast of northwestern Mexico. 4- *Cucurbita sororia*, origin: Pacific coast Mexico to Nicaragua, northeastern Mexico.

Species group 2: [5 species]

1- *Cucurbita digitata* - fingerleaf gourd; origin: southwestern United States (USA), northwestern Mexico. 2- *Cucurbita californica.* 3- *Cucurbita cordata.* 4- *Cucurbita cylindrata.* 5- *Cucurbita palmata.*

Species group 3: [1 species]

1-*Cucurbita ecuadorensis*, origin: Ecuador's Pacific coast.

Species group 4: [1 species]

1- *Cucurbita ficifolia* - figleaf gourd, chilacayote; origin: Mexico, Panama, northern Chile and Argentina.

Species group 5: [2 species]

1- *Cucurbita foetidissima* - stinking gourd, buffalo gourd; origin: Mexico 2- *Cucurbita scabridifolia*, likely a natural hybrid of *C. foetidissima* and *C. pedatifolia*

Species group 6: [1 species]

1- *Cucurbita galeottii* is little known; origin: Oaxaca, Mexico

Species group 7: [1 species]

1- *Cucurbita lundelliana*, origin: Mexico, Guatemala, Belize

Species group 8: [2 species]

1-*Cucurbita maxima* - winter squash, pumpkin; origin: Argentina, Bolivia, Ecuador 2-*Cucurbita andreana*, origin – Argentina

Species group 9: [1 species]

1- *Cucurbita moschata* - butternut squash, 'Dickinson' pumpkin, golden cushaw; origin: Bolivia, Colombia, Ecuador, Mexico, Panama, Puerto Rico, Venezuela

Species group 10: [2 species]

1- *Cucurbita okeechobeensis*, origin: Florida 2- *Cucurbita martinezii*, origin: Mexican Gulf Coast and foothills

Species group 11: [2 species]

1- *Cucurbita pedatifolia*, origin: Querétaro, Mexico 2- *Cucurbita moorei*

Species group 12: [3 species] *Cucurbita pepo* - field pumpkin, summer squash, zucchini, vegetable marrow, courgette, acorn squash; origin: Mexico, USA 2- *Cucurbita fraterna*, origin: Tamaulipas and Nuevo León, Mexico 3- *Cucurbita texana*, origin: Texas, USA

Species group 13: [2 species]

1- *Cucurbita radicans* - calabacilla, calabaza de coyote; origin: Central Mexico 2- *Cucurbita gracilior*

The taxonomy by Nee closely matches the species groupings reported in a pair of studies by a botanical team led by Rhodes and Bemis in 1968 and 1970 based on statistical groupings of several phenotypic traits of 21 species. Seeds for studying additional species members were not available. Sixteen of the 21 species were grouped into five clusters with the remaining five being classified separately.

- *C. digitata*, *C. palmata*, *C. californica*, *C. cylindrata*, *C. cordata*
- *C. martinezii*, *C. okeechobeensis*, *C. lundelliana*
- *C. sororia*, *C. gracilior*, *C. palmeri*; *C. argyrosperma* (reported as *C. mixta*) was considered close to the three previous species
- *C. maxima*, *C. andreana*
- *C. pepo*, *C. texana*
- *C. moschata*, *C. ficifolia*, *C. pedatifolia*, *C. foetidissima*, and *C. ecuadorensis* were placed in their own four separate species groups as they were not considered significantly close to any of the other species studied

Domesticated species of the Genus *Cucurbita:* The five cultivated species *C. pepo*, *C. moschata*, *C. mixta, C. maxima* and *C. ficifolia* were selected by American Indians long before the discovery of America (Whitaker and Bemis, 1976). *Cucurbita* is a genus with numerous cultivars whose names can be most confusing the commonly used names pumpkin, squash, gourd, summer squash, winter squash could belong to any of the commonly grown species. The five domesticated species are: 1- *Cucurbita argyrosperma (Synon.C. mixta)*, 2- *Cucurbita ficifolia*, 3- *Cucurbita maxima*, 4- *Cucurbita moschata*, and 5- *Cucurbita pepo*. All of these can be treated as winter squash because the full-grown fruits can be stored for months; however, *C. pepo* includes some cultivars that are better used only as summer squash (Hai and Long An, 2015; Herbazest, 2021) (Fig. 1):

Species *Cucurbita argyrosperma* - Cushaw pumpkin: *Cucurbita argyrosperma* (synonym *Cucurbita mixta*) - cushaw pumpkin; origin: Panama, Mexico. *Cucurbita argyrosperma* is not as widespread as the other species. The wild form *Cucurbita argyrosperma* subsp. *sororia* is found from Mexico to Nicaragua, and cultivated forms are used in a somewhat wider area stretching from Panama to the Southeastern United States. It was probably bred for its seeds, which are large and high in oil and protein, but its flesh is of poorer quality than that of *Cucurbita moschata* and *Cucurbita pepo*. It is grown in a wide altitudinal range: from sea level to as high as 1,800 meters in dry areas, usually with the use of irrigation, or in areas with a defined rainy season, where seeds are sown in May and June. Leaves shallowly lobed, cordate at base, surface with white patches; petiole not prickly; peduncle in fruit angled, corky, enlarged at tip; male flower with long staminal column

Species *Cucurbita ficifolia* - Figleaf gourd, Chilacayote: *Cucurbita ficifolia* - figleaf gourd, chilacayote; origin: Mexico, Panama, northern Chile and Argentina.

The origin of *Cucurbita ficifolia* is in Latin America, most likely southern Mexico, Central America, or the Andes. It grows at altitudes ranging from 1,000 meters to 3,000 meters in areas with heavy rainfall. It does not hybridize well with the other cultivated species as it has significantly different enzymes and chromosomes. Leaves orbicular-ovate to reniform, with shallow obtuses sinuses, corolla lobes large spreading, fruit green with white stripes, flesh white, seeds dark.

Species *Cucurbita maxima* - Giant pumpkin: *Cucurbita maxima*, one of at least five species of cultivated squash, is one of the most diverse domesticated species. This species originated in South America from the wild *Cucurbita andreana* over 4000 years ago. All giant pumpkins (45 kg)) are of this species, including the largest pumpkins ever documented, which have attained a size of over 910 kg. The large red-orange squashes often seen at Halloween in the United States are *Cucurbita maxima*, but not to be confused with the orange type used for jack-o-lanterns, which are *Cucurbita pepo*. The seed of *Cucurbita maxima* is used in treating parasites in animals. Leaves shallowly lobed, sinus narrow obtuse;petiole not prickly; calyx linear-lanceolate; fruiting peduncle not grooved, not expanded at tip below fruit; corolla soft spreading or drooping.

Species *Cucurbita moschata* - Butternut squash: *Cucurbita moschata* - butternut squash, 'Dickinson' pumpkin, golden cushaw; origin: Bolivia, Colombia, Ecuador, Mexico, Panama, Puerto Rico, Venezuela. *Cucurbita moschata* is native to Latin America, but the precise location of origin is uncertain. It has been present in Mexico, Belize, Guatemala, and Peru for 4,000-6,000 years and has spread to Bolivia, Ecuador, Panama, Puerto Rico, and Venezuela. This species is closely related to *Cucurbita argyrosperma*. A variety known as the Seminole Pumpkin has been cultivated in Florida since before the arrival of Columbus. Its leaves are 20 to 30 centimeters wide. It generally grows at low altitudes in hot climates with heavy rainfall, but some varieties have been found above 2,200 meters. Groups of *Cucurbita moschata* include Cheese, Crookneck (*Cucurbita moschata*), and Bell. Leaves scarcely lobed, ovate-orbicular with white patches; petiole not prickly; calyx lobes large leafy; peduncle angled expanded at tip; corolla lobes spreading, crinky, acute.

Species *Cucurbita pepo*-Field pumpkin, Summer squash, Zucchini: *Cucurbita pepo*- field pumpkin, summer squash, zucchini, vegetable marrow, courgette, acorn squash; origin: Mexico, USA. *Cucurbita pepo* is one of the oldest, if not the oldest, domesticated species with the oldest known locations being Oaxaca, Mexico, 8,000-10,000 years ago, and Ocampo, Tamaulipas, Mexico, about 7,000 years ago. It is known to have appeared in Missouri, United States, at least 4,000 years ago. Debates about the origin of *C. pepo* have been on-going since at least 1857. There have traditionally been two opposing theories about its origin: 1) that it is a direct descendant of *Cucurbita texana* and 2) that *Cucurbita texana* is merely feral *Cucurbita pepo*. A more recent theory by botanist Thomas Andres in 1987 is that descendants of *Cucurbita fraterna* hybridized with *Cucurbita texana*, resulting in two distinct domestication events in two different areas: one in Mexico and one in the eastern United States, with *Cucurbita fraterna* and *Cucurbita texana*, respectively, as the ancestral species. *Cucurbita pepo* may have appeared in the Old World before moving from Mexico into South America. It is found from sea level to slightly above 2,000 meters. Leaves have 3-5 lobes and are 20-35 centimeters wide. All the subspecies, varieties, and cultivars are interfertile. In 1986 Paris proposed a revised taxonomy of the edible cultivated *Cucurbita pepo* based primarily on the shape of the fruit, with eight groups . All but a few *Cucurbita pepo* cultivars can be included in these groups. There is one non-edible cultivated variety: *Cucurbita pepo* var. *ovifera*. Leaves ovate-triangular, deeply lobed, sinus broad, petiole prickly; prduncle 5-6 angled, grooved, expanded at tip; corolla erect sharp pointed. Phylogenetic analysis indicated that *C. moschata* and *C. mixata* are probably sister species and that *C. pepo* shares a common ancestor with these species that is not shared with *C. maxima* (Decker-Walters et al., 1990). The three economically important species, *C. pepo*, *C. maxima* Duchesne, and *C. moschata* Duchesne, differ in their climactic adaptation andtherefore

are distributed differently among the world's agricultural regions. Some *Cucurbita*, particularly the tropical pumpkins (*C. moschata*) are an important source of nutrition in less-developed countries having a tropical climate. Other *Cucurbita*, most notably zucchini squash (*C. pepo*), are of high monetary value in the economically developed countries having temperate climates. In addition to *C. pepo*, *C. maxima*, and *C. moschata*, two other species, *C. argyrosperma* Huber and *C. ficifolia* Bouché, are grown in some areas (Paris and Brown, 2005). Most of the domesticated *Cucurbita* species are associated with the closely related wild or weedy species revealing gene flow between domesticated and wild, weedy forms of *Cucurbita* species and indicating the possibility of introgressive hybridization (Wilson, 1990). *C. moschata* appears to be the possible common ancestor of the genus *Cucurbita* and the five cultivated species namely *C. pepo*, *C. moschata*, *C. maxima*, *C. mixata* and *C. ficifolia* came out independently as separate entities (Hurd et al., 1971; Nee, 1990). The *Cucurbita*ceae is a tropical or semitropical family to which the genus *Cucurbita* belongs. The *Cucurbita* genus, indigenous to the new world is a comparatively closed group or system of about 27 species. Cytogenetically, the species of *Cucurbita* show amazing uniformity in chromosome number and all the species have 20 pairs (2n = 40) of small, dot like chromosomes (Whitaker and Robinson, 1986). As far as is known, all *Cucurbita* have 20 pairs of chromosomes (2n = 2x = 40). Given this high basic chromosome number, relatively few cases of linkage of genes affecting the phenotype have been found (Paris and Brown, 2005). Squash and pumpkin (*Cucurbita* spp, 2n = 2x = 40) are the words quite often used interchangeably. However, the term 'squash' is more commonly used for *C. pepo* which is eaten as an immature fruit. The term 'pumpkin' is normally applied to the edible fruit of any species of *Cucurbita* utilized when ripe as a table vegetable or in pies (Vidhi, 2022).

Varietal Groups in *Cucurbita pepo*

Summer squash (*C. pepo*) exhibits perhaps highest level of polymorphism for fruit size, shape and colour. Mature fruits of *C. pepo* can range from several centi meters in diameter to over 20 kg in weight. Fruit shape can vary from round to disc to very long. The fruits can be smooth or warted, with or without longitudinal ribs (10 rounded protrusions), longitudinal grooves (shallow, narrow depressions, usually 20 in number), furrows (usually 10 deep, broad, angular depressions alternating with angular ridges of the same number) or wavy lobes (scalloping, usually 10 broad, rounded projections alternating with the same number of indentations). External colour may be green, orange or yellow but colour can range in shading and intensity from almost black to almost white and can appear in patterns of longitudinal striping which can be broad and contiguous, narrow and non-contiguous, irregular, and/or in longitudinal bi-colour patterns, all superimposed on barely discernible to obvious light colour speckling. The colour of mature fruit is most often light yellow-orange but can range from greenish white to intense orange. Paris (2006) has given 8 varietal groups in summer squash (**Fig. 2 & Table 1).**

BOTANICAL DESCRIPTION

Like most other members of the gourd family, *Cucurbita*ceae, pumpkin and squash are herbaceous and frost-sensitive, with large palmate leaves borne on usually trailing, tendril-bearing vines. The cultivated species are mesophytes having fibrous root systems. They are monoecious, bearing large, intensely orange-yellow, nectar-producing, unisexual flowers that are foraged by bees and that develop into prominent fruit. The greatest degree of polymorphism among genotypes is expressed in the fruit. The fast growth rate of pumpkin and squash, their large size, polymorphism, decorative value, and role as common table vegetables have fostered fascination and wonder in people of widely different cultures (Norrman and Haarberg, 1980). *Cucurbita* (Latin for gourd) is a genus of herbaceous vine in the gourd family *Cucurbita*ceae, also known as *Cucurbits*, native to the Andes and Mesoamerica. Five species are grown worldwide for their edible fruit, variously known as squash**,** pumpkin, or gourd depending on species, variety, and local parlance, and seeds. Most *Cucurbita* species are herbaceous vines that grow several meters in length and have tendrils, but non-vining "bush" cultivars of *Cucurbita pepo* and *Cucurbita maxima* have also been developed. The yellow or orange flowers on a *Cucurbita* plant are of two types: female and male. The female flowers produce the fruit and the male flowers produce pollen (Hai and Long An, 2015):

Plant: Most *Cucurbita* species are climbing annual vines; they are also mesophytes, plants which require a more or less continuous water supply. The less numerous perennial species grow in tropical zones and are xerophytes, plants which tolerate dry conditions. The stems in some species are angular. All of the above-ground parts may be hairy with various types of trichomes, which are often hardened and sharp. Growing 5 to 15 meters in height or length, the plant stem produces tendrils to help it climb adjacent plants and structures or extend along the ground. Most species do not readily root from the nodes; a notable exception is *Cucurbita ficifolia*, and the four other cultivated mesophytes do this to a lesser extent. The vine of the perennial *Cucurbita* can become semiwoody if left to grow. There is wide variation in size, shape, and color among *Cucurbita* fruits, and even within a single species. *Cucurbita ficifolia* is an exception, being highly uniform in appearance. The morphological variation in the species *Cucurbita pepo* and *Cucurbita maxima* is so vast that its various subspecies and cultivars have been misidentified as totally separate species.

Leaves**:** The typical cultivated *Cucurbita* species has five-lobed or palmately divided leaves with long petioles, with the leaves alternately arranged on the stem. Spring-like tendrils grow from each node and are branching in some species. *Cucurbita argyrosperma* has ovate-cordate (egg-shaped to heart-shaped) leaves. The shape of *Cucurbita pepo* leaves varies widely. *Cucurbita moschata* plants can have light or dense pubescence. *Cucurbita ficifolia* leaves are slightly angular and have light pubescence. The leaves of all four of these species may or may not have white spots.

Flowers: There are male (staminate) and female (pistillate) flowers (unisexual flowers) on a single plant (monoecious), and these grow singly, appearing from the leaf axils. Flowers have five fused yellow to orange petals (the corolla) and a green bell-shaped calyx. Male flowers in *Cucurbita*ceae generally have five stamens, but in *Cucurbita* there are only three, and their anthers are joined together so that there appears to be one. Female flowers have thick pedicels, and an inferior ovary with 3-5 stigmas that each have two lobes. The female flowers of *Cucurbita argyrosperma* and *Cucurbita ficifolia* have larger corollas than the male flowers. Female flowers of *Cucurbita pepo* have a small calyx, but the calyx of *Cucurbita moschata* male flowers is comparatively short.

Fruits**:** *Cucurbita* fruits are large and fleshy. Botanists classify the *Cucurbita* fruit as a pepo, which is a special type of berry derived from an inferior ovary, with a thick outer wall or rind with hypanthium tissue forming an exocarp around the ovary, and a fleshy interior composed of mesocarp and endocarp. The term **"**pepo**"** is used primarily for *Cucurbita*ceae fruits, where this fruit type is common, but the fruits of *Passiflora* and *Carica* are sometimes also considered pepos. Fruit size varies considerably: wild fruit specimens can be as small as 4 centimeters (1.6 in) and some domesticated specimens can weigh well over 300 kg.

Seeds**:** The seeds, which are attached to the ovary wall (parietal placentation) and not to the center, are large and fairly flat with a large embryo that consists almost entirely of two cotyledons.

Botanical description of pumpkins as described by Vidhi (2022) are as follows

Plant**:** Shape of cotyledon: elliptic, broad elliptic, or obovate. Growth habit: bush, semi-trailing or trailing

Branching: absent or present. Degree of branching: weak, medium or strong. Bush cultivars only: attitude of petiole (excluding lower external leaves) : erect, semi- erect or prostrate.

Cucurbita argyrosperma (synonym ***Cucurbita* mixta**)

C. ficifolia

C. maxima

C. moschata

C. pepo

Fig. 1.Cultivated species of *Cucurbita*

Acorn

Cocozzelle

Crookneck

Pumpkin

Scallop

Vegetable marrow

Zucchini/Courgette

Ornamental gourds

Fig. 2. Classification of cultivated *C. pepo* varieties in to 8 groups

Table I. A classification of cultivated *C pepo* varieties based on Paris' eight groups and the one non-edible varietv

Cultivar group	Botanical name	Descri1Ption
Acom	C. *pepo* var. *turbinata*	Winter squash, both a shrubby and creeping plant, obovoid or conical shape, pointed at the apex and with longitudinal grooves, thus resembling a spinning ton, ex: Acom squash
Cocozzelle	*C. pepo* var. *longa*	Summer squash, long round slender fruit that is slightly bulbous at the apex, similar *to.fastigata,* ex: Cocozelle von tripolis
Crookneck	C. *pepo* var. *tortico/lia* (also *torticollis)*	Summer squash, shrubby plant, with yellow, golden, or white fruit which is long and curved at the end and generally has a verrucose (wart-covered) rind, ex: Crook neck squash
Pumpkin	C. *pepo* var. *pepo*	Winter squash, creeping plant, round, oblate, or oval shape and round or flat on the ends, ex: Pumpkin; includes C. *pepo* subsp. *pepo* var. *styriaca,* used·for -Styrian pumpkin seed oil
Scallop	C. *pepo* var. *clypeata;*	Summer squash, prefers half-shrubby habitat, flattened or slightly discoidal shape, with undulations or equatorial edges, ex: Pattypan squash
Straight neck	C. *pepo* var. *recticollis*	Summer squash, shrubby plant, with yellow or golden fruit and verrucose rind, similar to var. *recticollis* but a stem end that narrows, ex: Straight neck squash
Vegetable marrow	C.*pepo var.jastigata*	Summer and winter squashes, creeper traits and a semi"shrub, cream to dark green color, s.hort round fruit with a slightly broad apex, ex: Spaghetti squash (a winter variety)
Zucchini/Courgette	C. *pepo* var. *cylindrica*	Summer squash, presently the most common group of cultivars, origin is recent (19th century), semi-shrubby, cylindrical fruit with a mostly consistent diameter, similar to *fasti.eata,* ex: Zucchini
Ornamental gourds	C. *pepo* var. *ovifera*	Non-edible, field squash closeiy related to *C. texana,* vine habitai, thin s1ems, small leaves, three sub-groups: *C. pepo* var. *ovifera* (egg-shaped, pear- shaped), *C. pepo* var. *aurantia* (orange color), and C. *pepo* var. *verrucosa* (round warty gourds), ornamental gourds.found in Texas and called var. *texana* and ornamental gourds found outside of Texas (Illinois, Missouri, Arkansas, Oklahoma, and Louisiana) are

Table 2. Botanical characters of pumpkin, summer squash and winter squash

Characters	*C. moschata*	*C. maxima*	*C. pepo*
Growth habit	Annual vine	Annual vine	Annual vine or bush
Sex expression	Monoecious	Monoecious	Monoecious
Foliage texture	Soft, hairy	Foliage not harsh or prickly, bearing small setate interspersed with soft hairs	Stiff, upright, harsh and prickly to touch
Foliage shape	5-6 shallowly lobed, lobes acute or rarely obtuse, often with whitish blotches on the upper surface.	Leaves more or less reniform with 5 rounded, shallow lobes, margin minutely dented	Leaves broad, obtuse or acute, usually with 5 deep lobes, margin dentate, upper surface glabrous and lower with glandular club shaped hairs
Tendril	Tendril many fid	Tendril 2-6 fid	Tendril branched
Flowers	Solitary	Solitary	Solitary
Calyx	Calyx tube of staminate flower short or lacking, lobes 3, linear, very often leafy	Calyx tube club shaped, lobes 5, short, linear and hairy	Calyx tube obscurely 5 angled
Flower	Corolla campanulate, pale yellow, mostly reflexed, lobes 5, stamens 3, filaments swollen at the base, glanduliform	Corolla campanulate, light to deep yellow, lobes 5, reflexed, stamens 3, filaments thick, glanduliform	Corolla campanulate with erect or spreading lobes, stamens 3, filaments swollen below
Peduncle	Smooth, 5 angled expanded or flared at fruit attachment	Spongy, cylindrical, soft, corky	5 angled with little or no expansion at fruit attachment
Fruits	Usually large of variable shape and size, globular, cylindrical, flattened	Usually large, oblong- cylindrical or flattened-cylindrical	Usually of variable size, shape and colour
Seeds	Yellow with a thin or ragged margin, scalloped or shredded in appearance, the margin more deeply coloured than the body of the seed	Seed white or yellowish with margins of different colour	Seeds whitish yellow broadly or narrowing ovate usually with raised, smooth, well-differentiated margin

Table 3. Diversity in different characters of pumpkins and squashes

Stem characters	Soft hairy, harsh to somewhat prickly, polyangled or cylindrical
Leaf shape	Ovate, orbicular, reniform, retuse
Leaf size	Small, intermediate, large
Leaf margin	Smooth, dented
Leaf lobes	Absent, shallow, intermediate, deep
Leaf spots	White or silver, absent
Stalk length of staminate flower	(3-10 cm)
Sex ratio	5:1 to 20:1
Calyx of pistillate flower	Leaf shaped, pointed end, linear
Ovary shape	Globular, flattened, acorn, elongated, oval
Fruit shape crooked neck, elongate	Globular, round, flattened, dumbell, disc, oblong, cylindrical, oval, acorn or heart shaped, pyriform,
Fruit size index	Small, medium, large and very large
Flesh thickness	Thin, medium, thick, very thick
Flesh colour	Cream, yellowish green, yellow, orange, salmon
Fruit skin colour at immature stage	Dark green, green, dark green with whitish patches
Fruit skin colour at maturity	Green, blackish-green, cream, yellow, orange, orange-yellow, brown, mottled (dark green with orange spots, orange with dark green patches, light orange with dark green spots and patches, blackish with orange patches, dark green with creamy spots, dark green with irregular white stripe, dark green with yellow patches, blackish with irregular yellowish stripes, orange with blackish patches, orange with dark green spots
Fruit shape at stem end	Flattened, depressed, pointed
Fruit shape at blossom end	Flattened, depressed
Peduncle surface	Hard corky, soft corky
Peduncle shape	Deep-grooved, light-grooved, cylindrical
Peduncle base	Large flared, medium flared, low flared
Fruit ribs	Smooth or no ribs, superficial, intermediate deep
Flesh texture	Smooth, firm, soft spongy, fibrous, grainy
Peduncle separation from fruit	Easy, intermediate, difficult

Stem: Green colour: light alone, dark alone or light and dark. Tendrils: absent or rudimentary, or well developed.

***Leaf blade*:** Size: small, medium or large. Incisions: absent or very weak, weak, medium, strong or very strong.
Green colour of upper surface: light, medium or dark. Marbling: absent or present. Area covered by marbling: very small, small, medium, large, very large.

Petiole: Green colour: light, medium or dark. Length: short, medium or long. Thickness (at base): thin, medium or thick. Shape of cross-section: round or angular. Number of prickles: few, medium or many.

***Female flower*:** Ring at inner side of corolla: absent or present. Colour of ring at inner side of corolla: green, yellow or green and yellow. Intensity of ring colour inner side of corolla: weak, medium,


Plant with flowers and fruit


Male flower


Male flower


Female flower


Female flower


Female flowers of C. pepo


Pumpkin fruit


C. moschata 'Butternut'


C. pepo fruits

Fig. 3. Botanical description of genus *Cucurbits*

strong. Length of sepal: short, medium or long. Colour of pistil (before opening): yellow or orange.

***Male flower*:** Expression of coloured ring at inner side of corolla: absent or very weak, weak, medium, strong or very strong. Colour of ring at inner side of corolla base: green, yellow or green and yellow. Length of pedicel: short, medium or long. Diameter of pedicel: small, medium or large. Colour of pedicel: light green, medium green or dark green. Grooving of pedicel: weak, medium or strong. Hairiness of pedicel: weak, medium or strong. Length of sepal: short, medium or long

***Young fruit*:** Length: short, medium or long. Maximum diameter: small, medium or large. Ratio length/maximum diameter: small, medium or large. Neck: absent or present. Curving of neck (on normally set fruits): absent or present. Number of colours: one, two or three. Major colour: whitish, yellow, orange, green, whitish and yellow, whitish and green or green and yellow. Intensity of major colour: light, medium or dark. Shape of cross-section: round, ribbed, angular or lobed. Warts: absent or present Glossiness: weak, medium or strong. Colour of ribs compared to colour of rest of fruit: same or different. Colour of linear bands on ribs: whitish, yellow, orange or green. Mottling: absent or present.

Type of mottling: only diffuse; diffuse and in patches; diffuse and in linear bands; or diffuse, in patches and in linear bands. Colour of mottling of skin: whitish, yellow, orange or green. Conspicuousness of mottling of skin: weak, medium or strong. Size of flower scar: small, medium or large. Protrusion of flower scar: absent or present. Length of peduncle: short, medium or long. Main colour of peduncle: only green, only yellow, or green and yellow. Intensity of main colour of peduncle: light, medium or dark. Mottling of peduncle: absent or present. Conspicuousness of mottling of peduncle: weak, medium or strong.

Fruit: *General shape*: scallop-shaped, transverse elliptical, globular, top-shaped, ovoid, elliptical, cylindrical, club-shaped, pear-shaped or crook-neck. *Fully developed in size, major colour*: whitish, cream, yellow, orange or green. *Ripe, major colour*: whitish, cream, yellow, orange or green. *Fully developed in size, intensity of major colour*: light, medium or dark.

Ripe fruit: *intensity of major colour*: light, medium or dark. *Fruit fully developed in size*: whitish, yellow, orange or green.

***Ripe fruit*:** *colour of stripes on ribs*: whitish, yellow, orange or green *Fruit fully developed in size: colour of mottling of skin*: whitish, yellow, orange or green.

***Ripe fruit*:** *colour of mottling of skin*: whitish, yellow, orange or green.

***Fruit*:** *maximum length*: very short, short, medium, long or very long.

Fruit: *maximum diameter*: small, medium or large *Ratio length/maximum diameter*: very low, low, medium, high or very high

Seed: *Size:* small, medium or large. *Shape*: narrow elliptic, elliptic or broad elliptic. *Colour:* whitish or yellowish.

Cucurbita species fall into two main groups. The first group are annual or short-lived perennial vines and are mesophytic, i.e. they require a more or less continuous water supply.
The second group are perennials growing in arid zones and so are xerophytic, tolerating dry conditions. Cultivated *Cucurbita* species were derived from the first group. Growing 5 to 15 meters in height or length, the plant stem produces tendrils to help it climb adjacent plants and structures or extend along the ground. Most species do not readily root from the nodes; a notable exception is *C. ficifolia*, and the four other cultivated mesophytes do this to a lesser extent. The vine of the perennial *Cucurbita* can become semiwoody if left to grow. There is wide variation in size, shape, and color among *Cucurbita* fruits, and even within a single species. *C. ficifolia* is an exception, being highly uniform in appearance. The morphological variation in the species *C. pepo* and *C. maxima* is so vast that its various subspecies and cultivars have been misidentified as totally separate species (WIKI, 2022).

The leaves of *Cucurbita moschata* often have white spots near the veins. The typical cultivated *Cucurbita* species has five-lobed or palmately divided leaves with long petioles, with the leaves alternately arranged on the stem. The stems in some species are

angular. All of the above-ground parts may be hairy with various types of trichomes, which are often hardened and sharp. Spring-like tendrils grow from each node and are branching in some species. *C. argyrosperma* has ovate-cordate (egg-shaped to heart-shaped) leaves. The shape of *C. pepo* leaves varies widely. *C. moschata* plants can have light or dense pubescence. *C. ficifolia* leaves are slightly angular and have light pubescence. The leaves of all four of these species may or may not have white spots. The species are monoecious, with unisexual male (staminate) and female (pistillate) flowers on a single plant and these grow singly, appearing from the leaf axils. Flowers have five fused yellow to orange petals (the corolla) and a green bell-shaped calyx. Male flowers in *Cucurbita* have only three stamens, and their anthers are joined together so that there appears to be one. Female flowers have thick pedicels, and an inferior ovary with 3–5 stigmas that each have two lobes. The female flowers of *C. argyrosperma* and *C. ficifolia* have larger corollas than the male flowers.https://en.wikipedia.org/wiki/*Cucurbita*#cite_note-saade-10 Female flowers of *C. pepo* have a small calyx, but the calyx of *C. moschata* male flowers is comparatively short. *Cucurbita* fruits are large and fleshy. Botanists classify the *Cucurbita* fruit as a pepo, which is a special type of berry derived from an inferior ovary, with a thick outer wall or rind with hypanthium tissue forming an exocarp around the ovary, and a fleshy interior composed of mesocarp and endocarp. The term "pepo" is used primarily for *Cucurbita*ceae fruits, where this fruit type is common. The seeds, which are attached to the ovary wall (parietal placentation) and not to the center, are large and fairly flat with a large embryo that consists almost entirely of two cotyledons. Fruit size varies considerably: wild fruit specimens can be as small as 4 centimeters and some domesticated specimens can weigh well over 300 kg (WIKI, 2022).

Vidhi (2022) also stated that the four cultivated species of *Cucurbita* are herbaceous annuals with viny growth and several runners. However, *C. pepo* has short internodes and bush type appearance. The vine (stem/runner) may be prickly or spiny, rounded or angled. There are often roots at the nodes. The tendrils are long and branched. Leaves are large, alternate, shallow to deeply lobed and palmate. The flowers are large, showy with yellow or creamy corolla. The plant is monoecious. Flowers are unisexual and occur singly in the axils of the leaves. The staminate flowers are near the centre of the plant and have long, slender pedicels. The pistillate flowers have short, ridged pedicels and are distal to the staminate flowers. Tap root system is strong, efficient and goes substantially down in the soil. The morphology of the peduncle is distinct enough to be used in determining species limits. In *C. pepo*, the peduncle is deeply furrowed and five to eight-ridged. In *C. moschata*, the peduncle is five ridged and flared at the point of fruit attachment. In *C. maxima*, the peduncle is cylindrical or claviform but never prominently ridged. In *C. mixta,* the peduncle is basically five-angled, rounded, but not at all or only slightly, enlarged at the fruit attachment. In *C. ficifolia*, the peduncle is hard, smoothly angled, slightly flaring, but comparatively much smaller than in other species of *Cucurbita*. Calyx and corolla are campanulate. There are three anthers. Filaments are partly free. Pistil is oblong or discoid, unilocular with three to five placentae. Style is thick. The stigmas are three each two-lobed. Fruit is pepo. Botanical descriptions of pumpkin (*C. moschata*), summer squash (*C. pepo*) and winter squash (*C. maxima*) as described by Whitaker and Davis (1962) and Chakravarty (1982) are presented in Table 2. The globular, elongated and acorn-shaped ovary always give rise the respective fruit shape but an oval-shaped ovary may result in either an oval or flattened fruit shape (Mandal, 2006).

GENETICS

The three economically important species, *C. pepo*, *C. moschata*, and *C. maxima* are highly polymorphic in fruit characteristics, inspiring much research into their inheritance although most of such studies have been done in *C. pepo* and *C. maxima*. The new gene list for pumpkin and squash includes descriptions of gene interactions and the genetic background of the parents that had been used for crossing to allow easy confirmation of previous work and provide a sound foundation for further investigation. This gene list in- cludes 79 loci for phenotypic/morphological traits and 48 polymorphic allozyme loci along with linkage and gene mapping (Paris and Brown, 2005). Information on polygenic inheritance of quantitative characters in pumpkin is also meager. Non-additive gene ac- tion for vine length, number of laterals, nodes of first sta- minate and pistillate flowers and days to first staminate and pistillate flowers (Doijode and Sulladmath, 1988); for num- ber of seeds/fruit, 100-seed weight and seed size index (Doijode et al*.,* 1987); over-dominance (Galka, 1987) and dominance (Sirohi et al., 1986) for fruit weight; over-domi- nance for vine length, fruit number/plant, flesh thickness, fruit shape index and fruit yield/plant (Sirohi et al., 1986) and over-dominance gene action for all the nutritional traits, namely, total soluble solids, carotenoids, ascorbic acid, calcium, and iron content (Sirohi and Yayasani, 2001) clearly suggest the importance of exploiting heterosis commercially.

Pumpkin and squash (*Cucurbita* L. spp.) are important cucurbit crops and are grown in almost all arable regions of the world. The three economically important species, *Cucurbita pepo* L., *Cucurbita moschata* Duchesne, and *Cucurbita maxima* Duchesne are highly polymorphic in fruit characteristics, inspiring much research into their inheritance. A comprehensive list of genes for *Cucurbita* was last published more than a decade ago. This new gene list for pumpkin and squash includes descriptions of gene interactions and the genetic background of the parents that had been used for crossing to allow easy confirmation of previous work and provide a sound foundation for further investigation. This gene list includes 79 loci for phenotypic/morphological traits and 48 polymorphic allozyme loci (Paris and Brown, 2005).

GENETIC DIVERSITY

General character diversity recorded from the assemblage of different Indian materials (Sirohi, 1993; Mandal, 2006) is presented in Table 3. Of the three main cultivated *Cucurbita* species, *C. moschata* is the least studied although it is the most widely cultivated *Cucurbita* in the tropics and a highly polymorphic domesticate for which different intraspecific classifications based on fruit shape, geographic origin and other characterristics have been made and whose greatest diversity lies in the neotropics (American tropics) where the vines are grown under a wide range of ecological conditions (Andres, 2004). The southern region of Brazil has a great range of *Cucurbita* species especially in shape, weight, average length, skin firmness, presence of bulges and external color of fruits and based on leaf and pedicel characteristics, it was possible to classify the accessions into three species: *C. pepo*, *C. maxima* and *C. moschata* (Choer, 1999). However, peduncle characters which are important to classify accessions into these three species, did not conform to the characters of *C. moschata* strictly in some inbreds developed from indigenous open pollinated materials of India but rather to the peduncle character of *C. moschata*, *C. maxima* and *C. mixta* which was expressed conjointly in them (Mandal, 2006). Most of the peduncle surface was hard corky even though soft corky, which is regarded as a character of *C. maxima* (Whitaker and Davis, 1962) was also found in three inbreds.

The peduncle was mostly grooved but the intensity of grooving varied (angular grooved, smoothly grooved) and even a somewhat cylindrical peduncle was recorded in five inbreds (Hazra, 2006; Mandal, 2006). In all the inbreds peduncles flared at fruit attachment however, flaring was very low in eleven inbreds which somewhat resembles *C. mixta* (Mandal, 2006). These findings amply support the proposal of probable gene exchange among these three monophylatic species of *Cucurbita* (Wilson et al*.,* 1992) during the process of domestication and cultivar development, which is usually expected because *C. moschata* is a highly polymorphic domesticate for which different intra-specific classification based on fruit shape, geographic region and other characteristics have been made (Andres, 2004). Pumpkin, after its introduction from South America by foreign navigators and emissaries has well been accepted in India and its wide-spread cultivation has caused the development of huge genetic diversity in different areas. Diversity in the Indian gene centre is concentrated in Indo- Gangetic plains, the North-eastern region,

North-western Himalayas, the Western and Eastern Ghats and sporadically in the tribal dominant belt of Central India (Srivastava , 2006).

The specific hull-less form *Cucurbita pepo* var. *styriaca* (2n=2x=40) has facilitated easy seed-oil production since the beginning of this century Pumpkin seed oil enjoys a growing popularity. Testing inbreds for combining ability in the field is especially expensive for pumpkins, and therefore indirect selection methods would be of great advantage. Here we report the results of a preliminary study on the use of RAPD markers to estimate the extent of polymorphism and calculate genetic diversity in 20 inbred lines of pumpkin. The data obtained could air in the selection of parents for heterosis breeding (Stachel et al., 1998). The Southern region of Brazil has a great range of *Cucurbita* species especially in shape, weight, average length, skin firmness, presence of bulges and external color of fruits and based on leaf and pedicel characteristics, it was possible to classify the accessions into three species: *C. pepo*, *C. maxima* and *C. moschata* (Choer, 1999).

Knowledge of genetic relationships among genotypes is essential for the effective utilisation of germplasm, especially for poorly characterised species. Random amplified polymorphic DNA (RAPD) analysis provides a quick and reliable method for resolving genetic relationships. Although *Cucurbita moschata* Duch, also known as tropical pumpkin, is one of the most important vegetable crops in Africa, being adapted to a wide range of climatic and soil conditions, it is a scientifically neglected species. Cluster analysis, based on 39 polymorphic and 105 monomorphic DNA fragments amplified by 16 primers, was used to show relationships among 31 genotypes obtained from Zambia and Malawi. The analysis revealed four clusters, with genotypes from Malawi mainly clustering in three clusters while all genotypes from Zambia and three from Malawi clustered in one cluster. The pair-wise mean genetic distance was 0.32 ± 0.04 for samples from Malawi and 0.26 ± 0.04 for samples from Zambia. The possible application of the resulting classification in breeding of *C. moschata* is discussed (Gwanama et al., 2000). The aim of this research was the genetic characterization of 218 accessions of *Cucurbita moschata* Duchesne, a squash, and its relationship with morphological characteristics of agronomic interest, which are part of the international collection conserved at Tropical Agricultural Research and Higher Education Center (CATIE), Costa Rica. The majority of the accessions came from Mexico and Central America; single genotypes from Curaζao, Colombia, Peru and the Russian Federation were also included. The polymerase chain reaction (PCR) and single strand conformation polymorphism analysis (SSCP) were used for the analysis of the regions amplified with ITS1–ITS2 nuclear primers and t*RN*L–F chloroplast primers. Haplotypes were constructed according to band patterns in SSCP gels. Twenty-five haplotypes were found using the ITS1–ITS2 markers, and 24 haplotypes were found with the t*RN*L–F markers. Unique haplotypes were found with both markers. Two individuals of each t*RN*L–F haplotype were sequenced. The results indicated a high level of genetic diversity in CATIE squash collection. Using ITS1–ITS2 primers, it was found that the number of haplotypes was independent of the geographical source of the accession, and haplotypes were distributed randomly throughout the study area. Mexico had the highest values of total heterozygosity (HE), genetic diversity (*H*) and Shannon index (*I*) while Panama showed the lowest values. Sequences obtained from t*RN*L–F intergenic marker showed the highest diversity index values were present in the group of additional sequences and Mexico, and lower values were observed for Nicaragua, Guatemala and Panama. PCoA based on morphological data showed three groups and by ANOSIM (*R*) all group differences were significant. Results obtained in this study suggest that high diversity is a characteristic of *C. moschata* from Mesoamerica (Barboza et al., 2012). Plant identification, classification, and genotyping within a germplasm collection are essential elements for establishing a breeding program that enhances the probability of plants with desirable characteristics in the market place. In this study, random amplified polymorphic DNA (RAPD) was used as a molecular tool to assess the diversity and relationship among 20 summer squash (*Curcubita pepo* L.) landraces traditionally used to treat hypertension and prostate hyperplasia. A total of 10 RAPD primers produced 65 reproducible bands of which 46 (70.77 %) were polymorphic, indicating a large number of genotypes within the summer squash lines. Cluster analysis divided the summer squash germplasm into two groups, one including one landrace and a second containing 19 landraces that could be divided into five sub-groups. Results of this study indicate the potential of RAPD markers for the identification and assessment of genetic variations among squash landraces and provide a number of choices for developing a successful breeding program to improve summer squash (Mady et al., 2013).

Seed pumpkin is an important economic crop grown in Heilongjiang Province, China that comprises distinct cultivars of *Cucurbita maxima* and *C. pepo*. However, little is known about the genetic diversity of seed pumpkin. Morphological and molecular characterizations were used to investigate the genetic diversity and genetic relationships within a germplasm collection that included 38 Chinese and 28 Russian seed cultivars of *C. maxima*, and 10 Chinese seed genotypes of *C. pepo*. The most variable morphological characters were all usually associated with the fruit. Thirty-five SSR markers yielded a total of 85 amplified DNA fragments, of which 85.89% were polymorphic, indicating a high degree of genetic diversity. The information provided by the SSR markers was agreed with the morphological diversity. Principal components analysis (PCA), principal coordinates analysis (PCO), and UPGMA clustering clearly distinguished the accessions based on species and geographic regions for both morphological and molecular characterizations. This indicated that genetic divergence has occurred between germplasm from China and that from Russia. On the other hand, geographical location also appeared to have affected genetic diversity due to adaptation of the plants to the different environments. This finding suggested that molecular information on genetic relationships in combination with morphological characteristics would serve to (1) improve the classification system of seed pumpkin cultivars in cultivation for germplasm conservation, (2) enhance the economic value of seed pumpkin (Liu et al., 2013). In this study, SSR markers were used to detect genetic diversity among and within accessions of *Cucurbita pepo* L. 26 landraces, belonging to four groups, were studied using 14 primers SSR, to investigate the genetic structure between accessions for different part of regions in Iran. Percentage of polymorphic loci, estimated using Nei's genetic diversity index and Shannon's information index revealed moderate or high levels of genetic variations within each landraces. Biochemical characters, including seed oil, protein, sitosterol, β-sitosterol, potassium and zinc content were evaluated among accessions. Results showed a great genetic variation for biochemical traits. Seed oil and protein content were from 26.5 to 45.8% and 21.0 to 28.6% respectively. β-Sitosterol content had a high positive correlation ($r = 0.97$) with oil content.
It ranged from 15.1 to 26.5 mg/100 g oil. There was no significant difference for biochemical traits between naked seed pumpkin and vegetable marrow morphotypes (Barzegar et al., 2013). Little is known regarding the effect of fragmentation and human agricultural management on the genetic variation and gene flow of *Cucurbita pepo* L., 1753 in moderate fragmented areas in central Guatemala. We hypothesize that the genetic variation of *C. pepo* is affected by forest fragmentation and by traditional agricultural management. Therefore, we aim to determine: (1) the genetic diversity and genetic structure of *C. pepo* in the Cloud Forest Corridor (CFC) (2) the extent of genetic admixture between commercial variety (CV) and traditional landraces (TL) of *C. pepo*, (3) the effect of habitat fragmentation in the population genetics of *C. pepo* with a landscape approach, and (4) the potential relationship between traditional management practices and genetic diversity of *C. pepo* in the CFC. We detected the existence of high level of genetic diversity (*AR* = 3.43; *He* = 0.50), inbreeding (*Fis* = 0.25) and moderate population structure of *C. pepo* in the CFC (*Fst* = 0.16). No correlation between landscape and genetics was found. Also, we found high genetic admixture between CV and TL. It seems that human practices, mainly related with seed exchange patterns, could affect genetic diversity of *C. pepo* in the CFC. *C. pepo* populations in the CFC are structured, with inbreeding, and show

admixture with the CV, an aspect that could affect its genetic diversity. The agricultural management influenced the population genetics of *C. pepo* in the CFC, but the landscape did not. We suggest that special efforts should be made to preserve the diversity of this important indigenous food source for Guatemalan people as well as their management practices (Enríquez et al., 2018).

Pumpkins (*Cucurbita* spp.) are among most neglected and underutilized crops cultivated for food and medicine. The major constraint to pumpkin production is lack of genetically improved seeds. The current study was aimed at evaluating the genetic diversity of pumpkins from eight counties in Western Kenya using five SSR markers. Seeds were extracted from pumpkin fruits, dried and planted on plastic trays for 4 weeks. DNA was isolated from young leaves using CTAB method and amplified. The samples were genotyped using an ABI 3730 genetic analyzer and the allelic data analyzed using Power Marker V 3.25, DARwin V 6.0.12 and GenAIEx V 6.41software. The five SSR loci were polymorphic with a total of 33 alleles and a mean PIC value of 0.534. The gene diversity and observed heterozygosity was 0.796-0.329 and 0.967-0.164, respectively. Most of genetic variations were found within and among individual samples rather than among counties, with samples of some counties having private alleles. Based on the inbreeding coefficient (F), there was outbreeding in pumpkins from Kakamega county (F = -0.282) and inbreeding in pumpkins from Kisii, Bungoma and Nyamira counties (F = 0.500, 0.409 and 0.286 respectively). The findings of this study suggest that genetic variation and distribution of pumpkins in western Kenya was due to monocropping and intercropping farming systems, trading of pumpkins in markets and exchange of seeds among local farmers rather than geographical and climatic differences (Nyabera et al., 2021). Pumpkins (*Cucurbita moschata*) are one of the most important economic crops in genus *Cucurbita* worldwide. They are a popular food resource and an important rootstock resource for various *Cucurbita*ceae. Especially, *C. moschata* is widely used as a rootstock for the commercial production of bloomless cucumbers in East Asia. Since the genetic diversity of the commercial rootstock varieties is narrow, there has been an increasing demand for the trait development of abiotic and biotic stress tolerance breeding. In this study, 2071 high-quality SNPs that were distributed evenly across 20 chromosomes of pumpkins were discovered through the genotyping-by-sequencing (GBS) analysis of 610 accessions of *C. moschata* germplasm with a global origin. Using these SNPs, various analyses of the genetic diversity and the population structure were performed. Three subgroups were clustered from the germplasm collection, which included East Asia, Africa, and America, and these areas were included the most in each subgroup. Among those groups, accessions from Africa and South Asia showed the highest genetic diversity, which was followed by the Mexico accessions. This result reflected that large gene pools that consist of various native landraces have been conserved in those of countries. Based on the genetic diversity, we finally constructed the *C. moschata* core collection, which included 67 representative accessions from the 610 germplasms. Five morphological traits that are important in commercial grafting and rootstock seed production, which include the cotyledon length, the cotyledon width, the hypocotyl length, the internode length, and the number of female flowers, were investigated for three years and used to confirm the validity of the core collection selection. The results are expected to provide valuable information about the genetic structure of the worldwide *C. moschata* germplasm and help to create new gene pools to develop genetically diverse rootstock breeding materials (Lee et al., 2021). Genetic diversity in 30 genotypes of Pumpkins was collected from unexplored mountainous areas of Khyber Pakhtunkhwa, Pakistan was investigated through biochemical characterization. For biochemical characterization, Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis was carried out. The seed proteins were resolved on 7.5% and 15% polyacrylamide gel. A total of 35% genetic disagreement was observed in the collected lines with linkage distances ranging from 0.00 - 0.83 (percent disagreement). Similarly, cluster analysis sorted total germplasm on the basis of 12 bands (total bands) into eight clusters. Present study revealed a considerable amount of genetic diversity explored in pumpkin germplasm, Cluster analysis exhibited moderate level of genetic diversity; to broaden the gene pool. Further collection of the important germplasm is needed to be used in the development of improved cultivars with respect to quality and quantity (Ikram et al., 2021).

Plant genetic resources constitute the most valuable assets of countries. It is of great importance to determine the genetic variation among these resources and to use the data in breeding studies. To determine the genetic diversity among genotypes of *Cucurbita pepo* L. species of pumpkin, which is widely grown in Erzincan, 29 different pumpkin genotypes collected were examined based on the morphological parameters and molecular characteristics. SSR (Simple Sequence Repeat) markers were used to determine genetic diversity at the molecular level. The analysis of morphological characterization within genotypes showed a wide variability in morphological traits of plant, flower, fruit, and leaf. In the evaluation performed using SSR markers, all primers exhibited polymorphism rate of %100. Seven SSR markers yielded a total of 15 polymorphic bands, the number of alleles per marker ranged from 2 to 3, and the mean number of alleles was 2.14. Polymorphic information content (PIC) ranged from 0.06 (GMT-M61) to 0.247 (GMT-P41), and the mean PIC value per marker was 0.152. Cluster analysis using Nei's genetic distance determined that 29 genotypes were divided into 4 major groups. The present findings have revealed the genetic diversity among pumpkin genotypes collected from Erzincan province and may form the basis for further breeding studies in pumpkin (Öztürk et al., 2022).

Chemical characterization and genetic diversity among nine Egyptian landraces of pumpkin (*Cucurbita moschata* Duchesne) were estimated using Diode Array (DDA) Near Infra-Red (NIR) technology and the Inter simple Sequence Repeat markers (ISSR). Pumpkin seeds were collected from various geographical parts of Egypt. The spectroscopic properties of pumpkin seeds were used to quantify the fat, moisture, protein, ash, fiber, and total carbohydrate contents. The ten ISSR primers generated a total number of 46 genotype-specific bands, and the total polymorphism produced in the tested landraces was 63.58%. Based on the ISSR data, the polymorphism analysis divided the nine pumpkin landraces into two main groups, two subgroups, and four sub subgroups. The most diverse pumpkin landraces were Alexandria and Sohag, with a similarity percentage of 49.6%. However, the highest calculated similarity value was 88.3% between Matruh and Gharbia. The resultant genotype-specific bands can be used as markers for future genotypic characterization of pumpkins (Mady et al., 2022). *Cucurbita moschata* (Pumpkin) is a multipurpose species whose fruits and sometimes oil seeds are used for various purposes. It is low in calories and is a significant source of income. Despite the great potential of the pumpkin production and usage, there is no attention to establish the varieties grown in Benin for proper documentation. Therefore, the present study was carried out to (i) evaluate the agro-morphological variability of pumpkin accessions collected in Benin and (ii) investigate heritability, genetic gain, phenotypic and genotypic variances of the agronomic traits. Six landraces from one hundred and twenty accessions collected in Benin were sown and characterized. The agronomic experiment was laid out in a complete randomized block design with three replicates.

Out of the twenty-seven quantitative descriptors measured, fifteen were found to be significant. The 50% emergence time ($p = 0.03$), the number of female flowers ($p = 0.02$), the seed width ($p = 0.05$) and the ratio seed width and length ($p = 0.01$) were significant. A highly significant difference was observed with the days to 50% flowering and the length of male flower stalks ($p = 0.002$), the average weight of one hundred seeds ($p = 0.009$). Fruit set at 50%, length of female flower peduncle, number of male flowers, mean fruit weight, fruit length, fruit diameter, average number of seeds per fruit and seed length were very highly significant ($p < 0.001$). Fruit color and shape, seed color and leaf color showed phenotypic variability. A positive correlation ($r = 0.76$; $p < 0.05$) was observed between average fruit weight and average number of seeds per fruit. Principal component analysis and Hierarchical Ascending Classification revealed three classes. Estimates of the phenotypic coefficient of variation were higher than estimates of the genotypic coefficient of variation for

most characters. High heritability was observed for fruit diameter (96.73%), average fruit weight (96.46%) and fruit length (94.64%). High heritability associated with high genetic advance was observed for these traits. In sum, the genetic diversity observed within the landraces of pumpkin shows that there is possibility for further selection (Ezin et al., 2022).

Gene action, combining ability and heterosis

Gene action, combining ability and heterosis for quality and yield attributes in pumpkin (*Cucurbita moschata* Duch. ex Poir.) was studied involving 21 cross combinations obtained from seven diverse inbreds in half-diallel fashion for four characters. The analysis revealed that none of the parents was a good general combiner for all the characters consistently; however, the parent, pumpkin-172 was good combiner for flesh thickness, total carotenoids and yield. The parents, IVPK-226 and BP-18 appeared to be good general combiners for ascorbic acids content. The gca variances were higher than the sca variances for flesh thickness, total carotenoids and ascorbic acid, while yield per plant had gca variances lower than the sca variances indicating the predominance of non-additive gene effects for yield and additive gene action for flesh thickness, total carotenoids and ascorbic acid. The cross Pumpkin-172 × Pumpkin-105 exhibited highest sca estimates for flesh thickness, total carotenoids and yield, while the combination, IVPK-226 × Pumpkin- 172 exhibited significant sca estimate for ascorbic acid content. The maximum heterosis for yield and ascorbic acid was exhibited by BS-165 × VRPG-7, whereas, BP-18 × Pumpkin-105 showed the maximum heterosis for total carotenoids. The study revealed that for improvement of traits like flesh thickness, total carotenoids and ascorbic acid, selections could be made, while fruit yield may be improved through hybridization (Pandey et al., 2010).

A Field experiment was conducted in Research and Development farm of Lal Teer Seed Ltd. to estimate the genetic divergence among the 21 genotypes of pumpkin were estimated using D^2 and principal component analyses. The genotypes under study grouped in to six clusters. The inter-cluster distance was larger than the intra-cluster distance suggesting wider genetic diversity among the genotypes of different groups. The intra-cluster value was maximum in cluster VI and minimum in cluster III. The maximum inter cluster distance average D2 value was observed between cluster I and cluster III (25.75) indicating wide range of genetic diversity between these two clusters. Thus the genetically diverged genotypes could be used as parent in hybridization program for getting desirable segregants. The lowest inter cluster divergence was observed between cluster III and IV (7.14). Cluster I showed the lowest mean values for days to first male and female flowering and highest mean values for flesh thickness, number of seeds per fruit and brix (%), while cluster VI revealed the highest mean vales for fruit diameter, single fruit weight and yield per plant. Germplasms much in use of the above mentioned characters both in cluster I and VI would offer a good scope of improvement of the crop through rational selection for hybrid breeding program (Mohsin et al., 2016). Climate and planting system can affect crop responses and morphological and physiological characters. Evaluation of genetic variation in crops provides useful information about trait affinity and helps to conserve and protect germplasm. Genetic and phytochemical diversity of pumpkin accessions were evaluated to identify characters in the selection of parents for future breeding. Comparison was made to three accessions of naked seed and 11 accessions of true seed involved *C. pepo, C. moschata* and *C. maxima* Duch were planted in May 2012. At ripening stage fruit were harvested and analyzed for fruit and seed morphological characters. Cluster analysis divided accessions into six main groups mainly on fruit and seed characters. The seed oil contains the unsaturated fatty acids oleic acid and linoleic acid. The *maxima* accessions were placed in a separate group. For those with naked seed, the Khomein accession had higher seed weight than other naked seed types. The Chaloos *C. moschata* accession was best based on fruit and seed characters and amounts of saturated and unsaturated fatty acids, and an accession from Isfahan had the highest content of oleic acid, a valuable nutritional component of seed. Seed width, fruit width, seed cavity diameter, and fruit weight and length were appropriate for improvement through breeding to enhance seed quality (Soltani et al., 2017). Molecular marker examinations of genetic diversity are valuable for assessment of within-species diversity and relationships, genotype identification, to assist selection for crop improvement programs, and to handle coherently germplasm collections. *Cucurbita maxima* is a highly diverse cucurbit crop, but its genetic diversity at the molecular level is inadequately characterized. Presently, genomic simple sequence repeat (SSR) markers that were described and employed for *Cucurbita moschata* and *Cucurbita pepo* were screened on *C. maxima*. A set of 23 highly informative SSRs was selected to evaluate genetic diversity within a collection of 85 *C. maxima* accessions. This collection contained cultivars and breeding lines from Europe, North America, Asia, Australia, and New Zealand, of six horticultural groups. Based on the genotyping results and statistical analyses, a fundamental division was observed in *C. maxima* above the level of horticultural groups. One major cluster was comprised between accessions from the Banana, Buttercup, and Hubbard horticultural groups. The other major cluster was divided in two sub-clusters, the larger of which included all accessions of the Mammoth (Show) Pumpkin horticultural group and the smaller, more outlying cluster was comprised of accessions of the Australian Blue horticultural group, with the one representative of the Turban group most outlying. Generally, the horticultural groups formed sub-sub-clusters, as most accessions within these respective groups showed close affinity. The selected set of 23 *Cucurbita*-conserved SSR markers is expected to be of great value for further germplasm characterization in this species and for taxonomical identifications within the genus *Cucurbita* (Kaźmińska et al., 2017)

BREEDING

Breeding Objectives of Cucurbita The main objectives of pumpkin breeding include development of medium or short vines with high degree of female sex expression, high fruit yield, earliness as indicated by first pistillate flower at early node number, thick flesh quality of good with high β -carotene and sugar contents and resistance to important diseases and insect pests (Swarup 2006). Breeding objectives of *Cucurbita* are, 1) High fruit yield, 2) Early fruiting, 3) First pistillate flower at early node number, 4) High female to male flower ratio, 5) Yellow or mottled skin of fruit, 6) Non-ridged fruit surface, 7) High antioxidants specially carotenoids, 8) Thick fruit flesh and small seed cavity, 9) Round/oblong/flat round fruit shape, 10) Orange flesh colour, rich in β carotene, the precursor of vitamin A, 11) Resistance to powdery mildew, downy mildew, zucchini yellow mosaic virus, red pumpkin beetle, 12) Tolerance to low temperature and saline conditions (Vidhi, 2022).

Breeding Methods

Different breeding methods are discussed as follows:

Inbreeding and Individual plant selection; Pumpkin, as in other *Cucurbita* species, though cross-pollinated in nature, generally do not show significant loss in vigour due to inbreeding (Mandal, 2006), and the idea that inbreeding in *Cucurbita* does not decrease vigour came from some very early studies (Haber, 1928; Scott, 1934).In these crops, inbreeding and individual plant selection through pedigree breeding can be practiced as effectively as in self-pollinated crops. The three important uses of in- breeding are to attain uniformity in plant characters, to improve yield by individual plant selection and to recombine suitable inbred lines. Inbred selection was utilized to develop different improved varieties of pumpkin (Pexioto et al., 1990; Sirohi et al. , 1991; Hazra and Banerjee, 2005). A dwarf variety of pumpkin with short vines 'Non-vine I' has been identified which was considered to be a GA- related mutant, and the dwarf trait results from the failure of normal internode cell elongation (Cao et al., 2005). Numerous experiments have failed to demonstrate marked inbreeding depression in *Cucurbita*, even after prolonged selfing, therefore inbreeding along with selection could be adopted as one of the breeding methods as applicable to any other cucurbit (Vidhi, 2022).

***Combination breeding**:* Controlled hybridization between selected parental lines of pumpkin followed either by selfings and pedigree breeding or open pollination and selection is also effective in developing improved varieties because as a result of gene re-combination in the progeny following a cross, it is possible to possible to select desirable segregates. After crossing between the selected parents, several generations of individual plants are selected for the specific characteristics and when one of the parents is of much better horticultural type than the other, it may be desirable to backcross to the better pa- rent for one or more generations, followed by several gene- rations of selfing till uniformity is attained in the breeding lines and ultimately selfed or sibbed seeds from a number of selected plants are bulked (Whitaker and Robinson 1986). Huge requirement of space in the field for the evaluation of a reasonably large segregating population to identify the desirable one becomes the main practical difficulty of this breeding method.

***Hybrid Breeding/ Heterosis breeding**:* Absence of inbreeding depression does not signify that hybrid vigour in *Cucurbita* species is lacking. Advantages that F_1 hybrids may have over open-pollinated cultivars include increased vigour, enhanced fruit yield, earlier and more uni- form maturity. A number of investigators have found signi-ficant evidence for hybrid vigour in pumpkin. Pronounced positive heterosis for earliness, fruit number, fruit weight, fruit flesh thickness and fruit yield was reported by several researchers (Lozanov 1969; Doijode et al., 1982; Chattopadhyay, 1984; Sirohi et al., 1985; Mohanty and Mishra, 1999; Carle et al., 2000; Mahajan and Sirohi, 2000; Gwanama et al., 2001; Mohanty and Prusti, 2002; Sirohi et al., 2002; Pandit et al. , 2006). Variety effects and heterosis mean squares were significant for the days to anthesis of pistillate flower, the weight of the first mature fruit, the mean fruit weight and soluble solids, indicating the pre- sence of both additive and non-additive gene actions (Gwanama et al., 2001). Significant positive heterosis for total soluble solids, total sugar and carotene content of the pulp in few hybrids due predominantly to additive and additive × additive epistasic component of genetic variance (Pandit *et el*. 2006) is highly encouraging, while a report of marked negative heterosis for β - carotene content (Doijode, 1983) emphasized the importance of specific parental combinations for realizing the manifestation of positive heterosis for different fruit quality traits. Hazra (2006) however, advocated development of parental lines by inbred selection because no reduction in fruit, seed and fruit quality characters was evident even after four generations of successive selfings coupled with selection. Selection of divergent parents based on fruit weight, leaf area, seed weight, and fruit yield/plant per may be useful for heterosis breeding in pumpkin (Kale et al., 2002). Commercial hybrids were produced based on parental vine type: short × short vine and short × long vine. Marketable yield was highest in the short × long hybrids; flesh thickness however, was greatest in the open-pollinated control variety, intermediate in the short × short hybrids and lowest in the short × long hybrids (Maynard et al., 2001). Heterosis has been demonstrated in summer squash (*C. pepo*), hence hybrid breeding is also becoming popular in squash and pumpkin (Vidhi, 2022)

The common methods of commercial F_1 hybrid seed production in pumpkins are as follows (Vidhi, 2022):

***Manual Pollination/Use of Insects**:*In this system female and male parents are planted in a ratio of several rows of female alternated with 1 row of male parent. Since *Cucurbita* flowers are large, male buds are detected and removed several days before anlhesis from the female rows. The female flowers of the female rows are hand pollinated by the male flowers of the male parent row or the female flowers are left for pollination by insects in nature. Most *Cucurbita* types are monoecious. The blossoms open in the morning and are pollinated primarily by specially-adapted solitary bees. The large, connated corollas can be tied up both in male and female flowers to prevent pollinator entry the day before anthesis when the colour of the petals begins to turn to yellowish-orange. Male flowers produce big pollen grains which can be directly deposited on the fleshy stigmas the next morning. Petals of the female flowers can then be tied up again until fruits are developed. Usually, manual pollinations are carried out with fresh pollen, although pollen from pre-anthesis flowers that are kept for a few days at low temperatures and high humidity can also be used.

***Use of Chemicals**:* Robinson et al. (1970) carried out an experiment using 2-chloroethylphosphonic acid (ethephon) as a sex regulator in *Cucurbita* and this provided a basis for the economical production of hybrid seed. Production of male flowers on monoecious plants of *Cucurbita pepo* can be temporarily suppressed for 2-3 weeks by repeated sprays of ethephon at 250 ppm on young plants at the first true-leaf, third true leaf and fifth true leaf stage. The application of 250 ppm of ethephon prevents the development of staminate flowers for extended periods, but does not affect the development of pistillate flowers. By the time two-three fertile fruits have developed on each mother plant the ethrel effect has gone. Further sprays would not be effective and at this stage, development of lateral male flowers is stopped by cutting off the plants growing point with a knife. Thus, by arranging the seed field into alternate rows of treated and untreated plants, and harvesting only fruits from treated rows, hybrid seed can be produced in abundance with little hand labour. Shanon and Robinson (1979) used 2 applications of ethephon at 600 ppm at the 2 and 4 leaf stage and reported complete male suppression during the fruiting stage. Ethephon is being used for commercial production of hybrid seeds in squash. Conventional breeding alone can no longer sustain the global demand with the increasing population, declining resources (land, water) and the apparent plateauing of the yield curves. Thus the future of pumpkin and squashes breeding lies in integrating the established classical techniques with advancements in bioinformatics, biochemistry, molecular genetics, molecular biology and genetic engineering. The advancement in sequencing or high-throughput genetic technology has casted a path to develop a breeding approach, which can integrate gene function/information and regulatory networks to predict and estimate the genetic variations in phenotypes (Dhatt et al., 2020). The objective of this research is to improve summer and winter squash (*Cucurbita* spp) for traits of economic importance including disease resistance and fruit quality traits. During the past year, selected summer and winter squash cultivars, plant introductions (PIs), breeding lines, and wild species were evaluated and beneficial genes from this material were identified. From the winter squash (*C. moschata*) material, resistance to phytophthora blight, powdery mildew, and squash silver leaf disorder along with several fruit quality traits continued to be characterized for introgression into winter squash breeding lines. From the summer squash (*C. pepo*) material, resistance to phytophthora blight, squash silver leaf disorder and several fruit quality traits continue to be characterized for introgression into summer squash breeding lines. Genetic research of summer and winter squash continues with screening parental genotypes for polymorphic molecular markers. These polymorphisms will be used to identify molecular markers linked to traits of interest to facilitate breeding efforts and for the construction of linkage maps to increase our knowledge of *Cucurbita* genetics (UF, 2022.).

Varieties of Cucurbita Released in India (Vidhi, 2022)

Punjab Chappan Kaddu 1: It is an inbred selection from the segregating local material of Punjab and recommended for cultivation in 1982. Plants are bush type, foliage thick and erect, leaves non-lobed and green without white specks, petiole and leaves hairy, fruits green, disc shaped, mildly ribbed with flat stem-end and attractive, average fruit about 800 g and a plant bears about ten fruits, early maturing and is ready for first harvest in about 60 days from sowing. It has a predominant female tendency, field resistance to downy mildew and tolerance to CMV, powdery mildew and red pumpkin beetle. It has high yield (about 200-225 q/ha). It has been released by Punjab Agricultural University, Ludhiana. It belongs to *C. pepo*.

***Patty Pan*:** It is an introduction from United States and recommended for cultivation during 1972. Fruits disc shaped, chalky white, tender and very attractive at edible stage. It is a short duration variety with yield of 200 q/ha in 85 to 90 days. It is C. pepo.

***Early Yellow Prolific*:** It is an early variety with bush type plant and medium size fruits. Fruits are warted, tapering, orange-yellow on maturity. It was introduced by IARI regional station, Katrain. It is *C. pepo*.

Australian Green: An introduction, very early, bush type, fruits dark green with longitudinal stripes of white colour all over. Fruits are 25 to 30 cm long. There are 15 to 20 fruits/plant. Fruits are tender at edible stage. Yield is 150 to 165 q/ha. It is C. pepo and was introduced by IARI regional station, Katrain.

Pusa Alankar: It is an F_1 hybrid between EC 27050 and Sel-lPI-8 (a derivative from cross between Chappan Kaddu and Early Yellow Prolific), early maturing, uniform dark green fruits with light coloured stripes, slightly tapering towards the stem end, tender delicious and matures in 45 to 50 days. It has been bred at IARI regional station, Katrain.

Arka Chandan: It is an improvement of a collection from Rajasthan (IIHR-105) done at IIHR, Bangalore. It was identified in 1987 for zone VIII. Fruits are round with flat blossom end and medium sized (2-3 kg). Rind colour is light brown when mature. Flesh is thick, firm, sweet (TSS 8-10%), bright orange and rich in carotene (3331 IU/100 g). It has pleasant aroma. Cooking and keeping qualities are good. Yield is 300 q/ha, in 120 days. It belongs to *C. moschata*.

***Cm-14*:** It was developed from a local collection at KAU, Vellanikkara and identified in 1987 for zone VI where it gave 21% increased yield over control. It has spreading plant habit, fruits flat round in shape and weigh about 6 kg each, green in colour with shallow furrowed surface. Flesh thickness is about 4.30 cm. Average fruit yield/plant is 15 kg. It is C. moschata.

Pusa Biswas: It is a local selection of line SM-107 at IARI, New Delhi. It was identified in 1987 for zones V and VII. It has vigorous vegetative growth, dark green leaves with white spots including veins. Fruits are light brown with thick, golden yellow flesh and are spherical. Average weight is about 5.0 kg. It matures in 120 days. Average yield is 200 q/ha. It is C. moschata.

Arka Suryamukhi: It is an improvement done at IIHR Bangalore over a local collection (IIHR-79) from Mangalore. It was identified in 1987 for zone VIII. Fruits are small, round with flat ends, deep orange with creamy white streaks on the rind, each weighing 1-1.5 kg. Flesh is orange yellow. Keeping and transport qualities are good. It is tolerant to fruit fly. It yields 300 q/ha in about 100 days. It is *C. maxima*.

***Narendra Amrit*:** It is C. moschata developed and released at NDUAT, Kumarganj, Faizabad. Fruits are flat- round with uniform cream colour skin. It is rich in vit. A and has excellent flavour. Private seed companies in India have not gone for vigorous efforts in breeding and seed production of hybrids in pumpkin due to low market volume in total seed as such in pumpkin.

USES

Many culinary uses for pumpkin have developed over time. There is some evidence to suggest that the ancient Aztecs enjoyed pumpkin seeds as a quick but satiating snack. Native Americans roasted long strips of pumpkin to eat, while European colonists are responsible for the origin of pumpkin pie - they would cut off the pumpkin top, remove the pumpkin's seeds, and fill it with honey, milk, and seasonings before baking it in hot ashes. The sap and pulp of pumpkins has long been used throughout parts of Central and North America as treatment for burns. Seeds have also been used by the Menominee people as a diuretic. Dry strips of pumpkins were sometimes used by Native Americans, who wove them into household mats (Herbazest, 2021). The pumpkin is a valuable and versatile crop. Because it has been cultivated for several thousands of years, there is now a large variety of practical and unique uses of pumpkin. Pumpkins are commonly associated with the spooky jack-o-lanterns that children make with their families to light the night every Halloween. Because of their hard outer skin and soft, fleshy innards, pumpkins can be carved, then scooped out, and later preserved on front porches in the days leading up to the Halloween festivities. Since pumpkins may vary drastically in their color, size, shape, and general appearance, some will make good jack-o-lanterns, while others are good for decorative and ornamental use in center pieces**,** as well as on windowsills. The seeds and flesh of pumpkins are perhaps the most important - and certainly the most popular -parts of the pumpkin used for culinary purposes. Low in fat and high in protein, pumpkin seeds can be roasted for a quick and satiating snack, sprinkled over salad, or mixed into a number of different soups and stews. The flesh of a young pumpkin is good for savory vegetable dishes**,** while the mature fruit is used in certain breads and desserts**.** The pumpkin fruit is widely used in the food and drink industry to provide new flavors for beverages, especially craft beers and other autumn-themed drinks. While both are edible, the preparation of pumpkin leaves and flowers is a lesser-known culinary use of pumpkin. The leaves are dark green and high in iron; cooking them will help to bring out their flavors. The flowers may be sprinkled over salads, pastas, and grains for a lighter meal (Herbazest, 2021).

Traditional pumpkin uses will vary largely according to time period and other cultural factors. Here are some of the less common examples of what pumpkins are used for. Pumpkin has long been used to treat common ailments, such as bloating, dehydration, fatigue, infertility, and certain skin conditions. Consuming it and topically applying its flesh are among the most popular medicinal uses of pumpkin, while mixing the roasted or ground seeds with other ingredients is also common. Moreover, the oil extracted from the pumpkin seeds can be used to create capsules**.** Though less common in the U.S., pumpkin leaves have been used in traditional Ayurvedic medicine as a pain reliever. The pumpkin flower has found purpose in a number of fragrances and cosmetics due to its sweet and delicate aroma. Pumpkin seed oil is high in antioxidants like vitamin E, which aids in cell regeneration to help protect skin cells from damage. Pumpkin seed oil-based creams and moisturizers smooth the skin's appearance, and may be a positive addition to skincare regimens. Pumpkin pulp can also be mixed with honey, oils, and other natural ingredients for a rejuvenating homemade facial mask (Herbazest, 2021). Native Americans used pumpkins to meet a number of home décor needs. Dried strips of pumpkin were often used to weave mats during ancient times. They also used the thick shells as carrying containers. Historical knowledge and scientific research has generally determined the current depth of understanding about certain pumpkin uses. The gathering of new information has made it possible to further explore their heart-healthy, immune-boosting properties and all of their glorious complexity. What remains clear is that for thousands of years now, the use of pumpkin has proven a reliable food source and effective medicinal herb (Herbazest, 2021).

When ripe, the pumpkin can be boiled, steamed, or roasted. In its native North America, pumpkins are an important part of the traditional autumn harvest, eaten mashed and making its way into soups and purées. Often, it is made into pumpkin pie, various kinds of which are a traditional staple of the Canadian and American Thanksgiving holidays. In Canada, Mexico, the United States, Europe and China, the seeds are often roasted and eaten as a snack. Pumpkins that are still small and green may be eaten in the same way as summer squash or zucchini. In the Middle East, pumpkin is used for sweet dishes; a well-known sweet delicacy is called *halawa yaqtin*. In the Indian subcontinent, pumpkin is cooked with butter, sugar, and spices in a dish called *kadu ka halwa*. Pumpkin is used to make *sambar* in Udupi cuisine. In Guangxi province, China, the leaves of the pumpkin plant are consumed as a cooked vegetable or in soups. In Australia and New Zealand, pumpkin is often roasted in conjunction with other vegetables. In Japan, small pumpkins are served in savory dishes, including tempura. In Myanmar, pumpkins are used in both cooking and desserts (candied). The seeds are a popular sunflower seed substitute. In Thailand, small pumpkins are steamed with custard inside and served as a dessert. In Vietnam, pumpkins are commonly cooked in soups with pork or shrimp. In Italy, it can be used with cheeses as a savory stuffing for ravioli. Also, pumpkin can be used to flavor both alcoholic and non-alcoholic beverages (WIKI, 2022).

In the Southwestern United States and Mexico, pumpkin and squash flowers are a popular and widely available food item. They may be used to garnish dishes, or dredged in a batter then fried in oil. Pumpkin leaves are a popular vegetable in the western and central regions of Kenya; they are called *seveve*, and are an ingredient of *mukimo*, respectively, whereas the pumpkin itself is usually boiled or steamed. The seeds are popular with children who roast them on a pan before eating them. Pumpkin leaves are also eaten in Zambia, where they are called *chibwabwa* and are boiled and cooked with groundnut paste as a side dish. Pumpkin seeds, also known as *pepitas*, are edible and nutrient-rich. They are about 1.5 cm (0.5 in) long, flat, asymmetrically oval, light green in color and usually covered by a white husk, although some pumpkin varieties produce seeds without them. Pumpkin seeds are a popular snack that can be found hulled or semi-hulled at many grocery stores (WIKI, 2022).

The fruits have many culinary uses including pumpkin pie, biscuits, bread, desserts, puddings, beverages, and soups. Although botanical fruits, *Cucurbita* gourds, such as squash or pumpkin, are typically cooked and eaten as vegetables. Pumpkins have been used as folk medicine by Native Americans to treat intestinal worms and urinary ailments, and this Native American remedy was adopted by American doctors in the early nineteenth century as an anthelmintic for the expulsion of worms. In Germany and southeastern Europe, seeds of *C. pepo* were also used as folk remedies to treat irritable bladder and benign prostatic hyperplasia. In China, *C. moschata* seeds were also used in traditional Chinese medicine for the treatment of the parasitic disease schistosomiasis and for the expulsion of tape worms. Pumpkin seed meal (*C. moschata*) represents a rich source of nutrients for poultry feeding with significant improvements in eggs for human consumption (WIKI, 2022).

NUTRITIONAL VALUE AND HEALTH BENFITS

Nutritional Value (Herbazest, 2021)

Vitamin A*:* Plant beta-carotenes play a key role in pumpkin nutrition since they are necessary for the production of vitamin A. Besides dairy products and fish oils, brightly-colored orange and yellow fruits and vegetables are among the best sources of vitamin A. Pumpkin is chock-full of this fat-soluble compound, which helps maintain healthy vision and skin. Vitamin A is also needed for cellular growth and bone health.

Vitamin E**:** Found primarily in vegetable oils, nuts, and dark green leafy vegetables, vitamin E is also present in high amounts in pumpkins. This powerful antioxidant works to thwart the harmful effects of free radicals found in the body. It not only supports the immune system so that the body can protect itself from foreign bacteria and illnesses, but also widens blood vessels to prevent clots.
Vitamin C**:** Pumpkins are also a source of vitamin C, which helps maintain healthy skin. Moreover, vitamin C is vital in the production of collagen, which is necessary for wound healing. A vitamin C deficiency is known to cause scurvy, which is associated with the loss of hair and teeth; sore, swollen gums; and fatigue**.**

Magnesium: Pumpkins also contain magnesium, a mineral responsible for the production of energy, protein synthesis, and blood pressure regulation. A lack of magnesium in the diet may cause nausea, vomiting, and fatigue in mild cases and muscle spasms and seizures in more severe cases. As an added benefit, pumpkins are a good source of protein, which is also used to create energy and to help the body build and repair tissues**.**

Potassium: To build protein and muscle, the body uses a mineral called potassium, which can be found in pumpkins. A diet that is low in sodium and high in potassium may lower high blood pressure levels over time.
Though the amount of potassium in pumpkins is only about 230 mg per 100-gram serving, it works together with other minerals to produce a hypotensive effect**.**

Zinc: Finally, zinc is a vital mineral responsible for acting as a catalyst for nearly 100 different enzymes. Pumpkin's nutritional content of zinc plays a crucial role in wound healing and protein synthesis, while supporting healthy growth and development, especially during the formative years of pregnancy and early childhood.

In addition to the aforementioned nutritional content of pumpkin, this fruit boasts phyto-constituents that exert anti-diabetic, antioxidant, and anti-inflammatory properties. Flavonoids, for example, are compounds whose consumption may help prevent certain cardiovascular diseases. Oleic acids are healing, anti-inflammatory compounds that are thought to be beneficial for inflammatory diseases, like prostate enlargement. Linoleic acids, on the other hand, may help the body maintain a healthy weight (Herbazest, 2021).

Numerous research studies on pumpkin have shed light on the benefits of its nutritional content. Pumpkins are wholesome foods full of essential vitamins and minerals that are beneficial for the overall health of the human body. To this end, pumpkins may be a wise addition to any healthy, well-balanced diet. The fruits of the genus *Cucurbita* are good sources of nutrients, such as vitamin A and vitamin C, among other nutrients according to species (WIKI, 2022). As an example of *Cucurbita*, raw summer squash is 94% water, 3% carbohydrates, and 1% protein, with negligible fat content (table). In a 100-gram reference serving, raw squash supplies 69 kilojoules (16 kcal) of food energy and is rich in vitamin C (20% of the Daily Value, DV), moderate in vitamin B6 and riboflavin (12–17% DV), but otherwise devoid of appreciable nutrient content (table), although the nutrient content of different *Curcubita* species may vary somewhat. Pumpkin seeds contain vitamin E, crude protein, B vitamins and several dietary minerals (see nutrition table at pepita). Also present in pumpkin seeds are unsaturated and saturated oils, palmitic, oleic and linoleic fatty acids, as well as carotenoids (WIKI, 2022). In a 100-gram (3.5 oz) amount, raw pumpkin provides 110 kilojoules (26 kilocalories) of food energy and is an excellent source (20% or more the Daily Value, DV) of provitamin A beta-carotene and vitamin A (53% DV) (table). Vitamin C is present in moderate content (11% DV), but no other nutrients are in significant amounts (less than 10% DV, table). Pumpkin is 92% water, 6.5% carbohydrate, 0.1% fat and 1% protein (WIKI, 2022).

Some of the following health benefits of pumpkin recognized in ancient healing rituals, have been substantiated in recent years through modern scientific studies and plant research (Herbazest, 2021):

Treating Common Skin Conditions: Pumpkins are believed to have originated in North or Central America. In that region, traditional healers have long used pumpkin as a treatment for common skin conditions. In the Yucatan Peninsula, for example, pumpkins are applied topically to burns, sores, and blisters. The effectiveness of this practice has been validated by modern science. Powerful antioxidants in pumpkin are beneficial for maintaining the health of the skin. Oil extracted from pumpkin seeds contains about **50%** vitamin **E**, which shields the skin from damage caused by free radicals and is used for the necessary cellular communication the skin needs to heal itself. A one-ounce serving of pumpkin seeds can provide about 28% of the recommended intake of zinc, which also plays a role in wound healing.

Treatment for Enlarged Prostate Gland: Traditional folk medicine touts pumpkin seeds as an effective treatment for prostate enlargement. Anti-inflammatory agents, known as phytosterols, combine with the healing properties of zinc to potentially reduce the size of the prostate.

Maintaining Healthy Vision: Pumpkins get their distinctive color from the presence of plant carotenes, which are easily converted into vitamin A in the body. Both vitamin A and beta-carotene help to

protect the eyes from damage, especially when adjusting to the dark after being in bright light.

Lowering High Blood Pressure: Among the various other important nutritional benefits of pumpkin is its well-documented hypotensive effect. Pumpkins contain an abundance of phytosterols and vitamin E, which protect the heart by widening the blood vessels, preventing blood clots, and lowering blood pressure. Secondary Nutritional Benefits. The many essential nutrients found in pumpkin help keep the body in working order. These secondary nutritional benefits include the following (Herbazest, 2021):

Maintaining proper hydration: Staying hydrated is of profound importance for the human body, which uses water to maintain healthy cellular growth and to perform just about every other major bodily function. Therefore, pumpkins - which are low in calories and composed of about 90% water - have been used as a cure for thirst and dehydration.

Promoting immune health: Vitamin E and zinc work together to help activate different cells in the immune system, which makes pumpkin beneficial for preventing common illnesses.

Improving energy levels*:* Pumpkins can provide a necessary energy boost as a treatment for general fatigue. A one-ounce serving of pumpkin seeds provides about 53% of the recommended daily intake of magnesium, a vital nutrient that is required for the production of energy.

Supporting reproductive health: Vitamin A and zinc play an important role in supporting healthy fetal growth and development during pregnancy while caring for the reproductive system overall. In some ancient traditions, pumpkins were used as a fertility boost and as a treatment to help new mothers produce milk for nursing.

CULTURAL SIGNIFICANCE

History of the Halloween pumpkin Or Jack O' Lantern Pumpkin: Halloween pumpkin/Jack-o'-lanterns, emerged from the Irish folkloric tradition of using small lanterns made within turnips and potatoes to ward off tortured, wandering spirits. In the New World, these immigrants used pumpkins instead, which are native to the Americas. Each fall, in anticipation of Halloween, thousands of visitors flock to pumpkin patches and festivals to enjoy the endless possibilities the pumpkin has to offer. Usually occurring at the end of September and during October, pumpkin events are more than just a fun way to spend a weekend (Herbazest, 2021).

The exact origins of the first pumpkin festival have been lost in time, but many scholars point to the Celtic celebration of Samhain as an important precursor to modern-day pumpkin events. Celebrated every year on the eve of November 1, the tradition began over 2,000 years ago as a way to commemorate the end of the harvest season and the beginning of a new year. Before pumpkins were introduced in Europe, one tradition included carving and scooping out gourds and fashioning lanterns out of them, which were believed to drive out darkness and malignant spirits. Upon their arrival in the New World, 19th century Irish and Scottish immigrants discovered that pumpkins, larger and more widely available, made better lanterns than the turnips and small gourds of Europe. Over time, Europeans began to associate pumpkin with the poor working class. Largely ignored in cookbooks, it became a minor crop (Herbazest, 2021). Pumpkins witnessed a resurgence in popularity after the Second World War, when the boomer generation placed higher demands on the market for jack-o'-lanterns. This period would also mark the emergence of small pumpkin festivals all over the U.S. and Canada. In many North American cities, pumpkin festivals began as strategically-orchestrated events put on by local farmers and merchants and supported by a community of enthusiastic volunteers. They bring prosperity to small towns, allowing communities to improve facilities and infrastructure for their residents. Pumpkin festivals are important events; in some towns, hundreds of fun family activities are spread out over several days or weeks. Here is a list of some of the exciting things to do at a pumpkin festival (Herbazest, 2021):

Pick a pumpkin: Festivals are excellent places for farmers and vendors to showcase their locally-grown pumpkins. A variety of sizes, colors, and shapes will be available for the choosing.

Buy pumpkin seeds: Pumpkin enthusiasts can become inspired to grow their very own pumpkin plants. In this case, a variety of seeds can be purchased.

Participate in a pie-eating contest: This is an unparalleled opportunity to savor as many pumpkin pies as possible, fusing Epicureanism with a deliciously competitive spirit.

Sample artisanal food and drink: Any local pumpkin festival offers a variety of foods and beverages, including stews, soups, fries, chips, donuts, pastries, and craft beer. Pumpkin festivals provide a diverse selection of wholesome activities the entire family can enjoy, such as face painting, crafts, live music, storytelling, games, parades, contests, and fireworks.

Folklore and fiction (WIKI, 2022)

There is a connection in folklore and popular culture between pumpkins and the supernatural, such as:

- The custom of carving jack-o-lanterns from pumpkins derives from folklore about a lost soul wandering the earth.
- In the fairy tale *Cinderella,* the fairy godmother turns a pumpkin into a carriage for the title character, but at midnight it reverts to a pumpkin.
- In some adaptations of Washington Irving's ghost story *The Legend of Sleepy Hollow*, the headless horseman is said to use a pumpkin as a substitute head.

In most folklore the carved pumpkin is meant to scare away evil spirits on All Hallows' Eve (that is, Halloween), when the dead were purported to walk the earth.

Chunking (WIKI, 2022): Pumpkin chunking is a competitive activity in which teams build various mechanical devices designed to throw a pumpkin as far as possible. Catapults, trebuchets (a type of catapult), ballistas (An ancient and medieval engine of warfare) and air cannons are the most common mechanisms

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