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# RESEARCH ARTICLE

## ORIGIN, DISTRIBUTION, TAXONOMY, BOTANICAL DESCRIPTION, GENETIC DIVERSITY, AND BREEDING OF BOTTLE GOUD {*LAGENARIA SICERARIA* (MOLINA) STANDL.}

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**ABSTRACT**

Bottle gourd, (Lagenaria siceraria), also called white-flowered gourd or calabash gourd, running or climbing vine of the gourd family (Cucurbitaceae), native to tropical Africa but cultivated in warm climates around the world for its ornamental and useful hard-shelled fruits. Recent studies have revealed its origin and native home in Asia. It is a climbing perennial plant widely cultivated as a vegetable crop in tropical countries, such as India, Japan and Thailand. The bottle gourd belongs to the genus *Lagenaria* that is derived from lagena, meaning, "bottle". In the older literature it is often referred to as *Lagenaria vulgaris* (common) or *Lagenaria leucantha* (white flowered gourd) but it is now generally agreed that the correct name is *Lagenaria siceraria* (Mol.) Standl. Botle gourd or Calabash fruits have a variety of shapes: they can be huge and rounded, small and bottle-shaped, or slim and serpentine, and they can grow to be over a metre long. Rounder varieties are typically called calabash gourds. The plant has thick vines with large white flowers that open only at night. The fruit comes in a large variety of shapes, selected for by their human users. The bottle gourd is primarily grown for its fruit, which when dried forms a woody hollow vessel that is suitable for containing water and food, for fishing floats, for musical instruments and for clothing, among other things. In fact, the fruit itself floats, and bottle gourds with still-viable seeds have been discovered after floating in seawater for more than seven months. Tender fruits, young shoots and tendrils are also cooked, and oil is extracted from the seed. Its uses range from food and medicine, and as containers, artifacts, and musical instruments. Other uses of mature, dried hard shells of bottle gourd including musical instruments, cups, barrels, milk pails, ladles, fishing floats, penis sheaths, carvings, etc. Fruits are also used as herbal medicines in Asia. It has been in use as a vegetable in India since 2,000 BCE. It is part and parcel of the culture of the hill tribes *Karbi* and *Jhasi* in Assam (India), as it plays a key role of social ceremonies and rites of passage, as also in the offering of rice beer to gods and deities, and to serve guests. The offer and acceptance of a bottle gourd as a gift is sufficient to declare a couple's engagement among the *Karbis*. It is a symbol of longevity and good luck in China. The number of decorated bottle gourd containers denotes the social status of a *Hausa* tribes person in Nigeria, and form an essential or indispensable part of a bride's dowry. Bottle gourd is one of the excellent fruits gifted by nature to human beings having composition of all the essential constituents that are required for good health and quality human life. Bottle gourd has been used traditionally to help with many health conditions like fever, cough, pain, and asthma. It has been used since ancient times for its benefits. It is also considered a good source of vitamin B, C, and other nutrients. Fresh bottle gourd juice is used for its cooling, diuretic, antibilious, and pectoral properties. In this review article origin, distribution, taxonomy, botanical description, genetic diversity, breeding, uses, nutritional value and health benefits of bottle gourd ( *Lagenaria siceraria)* are discussed.



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# INTRODUCTION

Bottle gourd, (*Lagenaria siceraria*), also called white-flowered gourd or calabash gourd, running or climbing vine of the gourd family (Cucurbitaceae), native to tropical Africa but cultivated in warm climates around the world for its ornamental and useful hard-shelled fruits (Parle Milind and Satbir, 2011; Chimonyo and Modi, 2013; EEB, 2022; WIKI, 2022).

*Lagenaria siceraria* (Mol.) Stand. belongs to the Family Cucurbitaceae and may be the only cucurbit plant known in both new and old worlds in early prehistoric times (Kumar et al., 2017). Among all plants of the cucurbitaceae family, *Lagenaria* species is the most popular. The bottle gourd belongs to the genus Lagenaria that is derived from the word lagena, meaning the bottle. In the older literature, it is often referred to as *Lagenaria vulgaris* (common) or *Lagenaria leucantha* (white flowered gourd), but it is now generally agreed that the correct name is *Lagenaria siceraria* (Mol.) Standl. (Parle Milind and Satbir, 2011). *Lagenaria siceraria* (Mol.) Standl. (bottle gourd), of the family Cucurbitaceae, having chromosome

number 2n = 2x = 22. It is a climbing perennial plant widely cultivated as a vegetable crop in tropical countries, such as India, Japan and Thailand. The bottle gourd belongs to the genus *Lagenaria* that is derived from lagena, meaning, "bottle". In the older literature it is often referred to as *Lagenaria vulgaris* (common) or *Lagenaria leucantha* (white flowered gourd) but it is now generally agreed that the correct name is *Lagenaria siceraria* (Mol.) Standl. (Kumar et al., 2017; Vidhi, 2022). *Lagenaria siceraria* (Cucurbitaceae), popularly known as bottle gourd, lauki or ghiya, is a climbing plant, which bears hard-shelled and bottle-shaped gourds as fruits (Parle Milind and Satbir, 2011). The gourd was one of the world's first cultivated plants grown not primarily for food, but for use as containers. The bottle gourd may have been carried from Asia to Africa, Europe, and the Americas in the course of human migration, or by seeds floating across the oceans inside the gourd. (WIKI, 2022). It has been proven to have been globally domesticated (and existed in the New World) during the Pre-Columbian era. In Southern Italy and Sicily, a variety, *Lagenaria siceraria* var. *longissima*, called zucca da vino, zucca bottiglia, or cucuzza is grown and used in soup or along with pasta (WIKI, 2022) **(Fig. 1).**

**Fig. 1. *Lagenaria siceraria* var. *longissima*, called cucuzza**

The bottle gourd has been for a long time considered as originated and domesticated in Africa. Recent studies have revealed its origin and native home in Asia (Ahuja et al., 2011). The bottle gourd is a diploid, monoecious plant of the *Cucurbitacea*. The plant has thick vines with large white flowers that open only at night. The fruit comes in a large variety of shapes, selected for by their human users (Hirst, 2021). Bottle gourd is a cultivated annual monoecious species with five wild perennial dioecious species belongs to family Cucurbitaceae (Singh, 2005). Calabash ( *Lagenaria siceraria*), also known as bottle gourd, white-flowered gourd, long melon, birdhouse gourd, New Guinea bean, Tasmania bean, and opo squash, is a vine grown for its fruit. It can be either harvested young to be consumed as a vegetable, or harvested mature to be dried and used as a utensil, container, or a musical instrument. When it is fresh, the fruit has a light green smooth skin and white flesh (WIKI, 2022).

Bottle gourd or Calabash fruits have a variety of shapes: they can be huge and rounded, small and bottle-shaped, or slim and serpentine, and they can grow to be over a metre long. Rounder varieties are typically called calabash gourds (WIKI, 2022). It is grown for its tender fruits, basically used as vegetable. The tender edible fruits are also prepared into sweets, pickles, and other delicious preparations. It is known as poor man's vegetable in India, and is now attaining fast popularity among health conscious urban elite, which has encouraged round the year cultivation of this potentially important vegetable, except in very cool regions during winter (Singh, 2005).

The bottle gourd is primarily grown for its fruit, which when dried forms a woody hollow vessel that is suitable for containing water and food, for fishing floats, for musical instruments and for clothing, among other things. In fact, the fruit itself floats, and bottle gourds with still-viable seeds have been discovered after floating in seawater for more than seven months (Hirst, 2021). Human utilization of the gourd dates back to thousands of years, and it was long prized as a container before the advent of pottery. Its uses range from food and medicine, and as containers, artifacts, and musical instruments. It has been in use as a vegetable in India since 2,000 BCE. It is part and parcel of the culture of the hill tribes *Karbi* and *Jhasi* in Assam (India), as it plays a key role of social ceremonies and rites of passage, as also in the offering of rice beer to gods and deities, and to serve guests. The offer and acceptance of a bottle gourd as a gift is sufficient to declare a couple's engagement among the *Karbis*. It forms an integral part and essential evident through the local phrases around the plant. It is a symbol of longevity and good luck in China. The number of decorated bottle gourd containers denotes the social status of a *Hausa* tribes person in Nigeria, and form an essential or indispensable part of a bride's dowry (Agris. 2022). Bottle gourd has been used traditionally to help with many health conditions like fever, cough, pain, and asthma. It has been used since ancient times for its benefits. It is also considered a good source of vitamin B, C, and other nutrients (Singh, 2022). In many cases of ailments, it is a preferred vegetable because of its cooling effects and easy digestibility. Various plant parts have medicinal value too (Singh, 2005). The young tender peeled fruits are eaten. Fresh bottle gourd juice is used for its cooling, diuretic, antibilious, and pectoral properties. Young shoots and tendrils are also cooked, and oil is extracted from the seed. Other uses of mature, dried hard shells of bottle gourd including musical instruments, cups, barrels, milk pails, ladles, fishing floats, penis sheaths, carvings, etc. Fruits are also used as herbal medicines in Asia (Dhillon et al., 2016). Gourds have had numerous uses throughout history, including as tools, musical instruments, objects of art, film, and food (WIKI, 2022a). Human utilization of the gourd dates back to thousands of years, and it was long prized as a container before the advent of pottery. Its uses range from food and medicine, and as containers, artifacts, and musical instruments. It is a symbol of longevity and good luck in China. The number of decorated bottle gourd containers denotes the social status of a Hausa tribesperson in Nigeria, and form an essential or indispensable part of a bride's dowry (Ahuja et al., 2011). Bottle gourd is one of the excellent fruits gifted by nature to human beings having composition of all the essential constituents that are required for good health and quality human life (Parle Milind and Satbir, 2011).

Bottle gourd (*Lagenaria siceraria* (Molina) Standl.) is one of the most important crops in the Cucurbitaceae family, although it is considered as a poor man's crop due to the socio-economic restrictions governing its production and use. It has a pan-tropical distribution with regional economic importance and is used as a vegetable, container, musical instrument or float while its seeds are used for oil and protein. A lot of information is known on the medicinal aspects of bottle gourd; however its potential as a possible food security crop has been lowly documented. In nature, bottle gourd exhibits great morphological and genetic variability. This alone could indicate its wide environmental adaptation. The plant also demonstrates an indeterminate growth habit when there is enough supply of water. This allows farmers to have a constant supply of fresh green leaves for consumption and animal fodder. Young immature fruits are consumed in the same manner as pumpkin fruits, while the seeds are a rich source of essential amino and fatty acids. Practical considerations have shown that large seeds have better germination capacity and vigour, and will produce more competitive seedlings than smaller seeds, hence high seed quality. The possible effect of seed size on seed quality (germination and vigour) is associated with the longer duration and the rapid provision of energy by the large endosperm to the developing seedling. On the other hand, research has also demonstrated that there is an association between seed physical parameters such as seed coat thickness and endosperm size with seed quality. Of interest is the effect of seed coat thickness on seed electrical conductivity, which is another measure of seed quality **(**Chimonyo and Modi, 2013).

Bottle gourd is mainly grown as a vegetable for human consumption. However, hard dry shell is often used in utensil and instrument making, hence calabash gourd. Furthermore, in India different plant parts, especially the fruit juice, can be used as medicine to cure stomach elements. In many parts of the world the young green fruit is a popular cooked vegetable. In Southern Africa, the leaves are commonly consumed as a vegetable relish and at times mixed with other vegetable plants. They can also be added fresh to maize porridge. The leaves can also be dried and stored for later use in the off season. In Asia, bottle gourd is used as rootstock for watermelon (*Citrullus lanatus*) against soil-borne diseases and low soil temperature. In West Africa, mature seed of bottle gourd are roasted and ground to a paste, which is used to thicken sauces. In Botswana, Zimbabwe and South Africa, oil is extracted from the seed and used as an alternative to vegetable oil while the defatted cake can be used as a protein supplement (Chimonyo and Modi, 2013). Bottle gourd, like all cucurbits, produces trace quantities of complex substances known as cucurbitacins, which produce a distinctive aroma and help protect the plant from insects and animal predators. Cucurbitacins are bitter compounds and have a tetracyclic triterpenoid structure. Bitter bottle gourds have abnormally high levels of these cucurbitacins than the less bitter types (Chimonyo and Modi, 2013).

## ORIGIN AND DISTRIBUTION

Richardson (1972) stated that the bottle gourd is indigenous to Africa and may have been diffused either by transoceanic drift or by human transport. The evidence elaborated herein, however, supports the conclusions that (1) *Lagenaria* is not a monotypic genus and had an ancient pan-tropical distribution; (2) human utilization of *Lagenaria* is at least 15,000 years old in the New World and 12,000 years in the Old World; (3) the early dates for the use of *Lagenaria* are far too early convincingly to suggest transoceanic diffusion by man, although drifting of gourds from Africa or Asia may have occurred; (4) the earliest use of *Lagenaria* was probably as a wild plant in the context of a hunting and gathering society; and (5) *Lagenaria* was independently domesticated in the Old and New Worlds. It has been in use as a vegetable in India since 2,000 BCE. It is part and parcel of the culture of the hill tribes *Karbi* and *Khasi* in Assam (India), as it plays a key role during a number of social ceremonies and rites of passage, as also in the offering of rice beer to gods and deities, and to serve guests. The offer and acceptance of a bottle gourd as a gift is sufficient to declare a couple's engagement among the *Karbis*. It forms an integral part and essential item in a valid *Khasi* marriage (Ahuja et al., 2011).

It seems that bottle gourd was originated from India because its wild races are still found in Dehradun (high humid area) and Malabar costal area. Old Indian script reveals its cultivation around 2000 B.C. Archeological survey supports man's association with bottle gourd in Peru from 1100 to 13000 years B.C. The centre of origin has been located as the coastal areas of Malabar (North Kerala) and the humid forests of Dehradun (North India). The fossil records indicate its culture in India even before 2000 B.C. (Parle Milind and Satbir, 2011). Bottle gourd has a bi-hemisphere distribution with regional and sub-regional importance. Archeological findings have shown that the independent use and possible cultivation of the crop started from around 9 000 to 10 000 BP (before present) in the Americas (New world), 6 000 – 10 000 BP in East Asia and 4 000 – 5 000 BP in Africa. Based on this archeological evidence, bottle gourd is said to be one of the first species domesticated by humans. Bottle gourd has long attracted an interesting debate about its centre of origin. In that debate, there is strong evidence, that bottle gourd originated from Asia or, despite the lack of early remains but commonly thought, Africa south of the equator to be more precise. The centre of origin of a crop can be described as the area containing the highest number of the wild relatives of that crop and its subsequent domestication. Both continents contain wild species of bottle gourd; however, the discovery of an additional wild indigenous species (*Lagenaria breviflora*) in Zimbabwe in 2004 reinforced the latter hypothesis of Africa as the centre of origin. The origins and subsequent dispersal of bottle gourd still perplexes many scientists. The crop is said to have reached Asia and the Americas about 10 000 to 8 000 years ago, possibly as a wild species whose fruits and seed had floated across the seas and oceans with the aid of currents. It was demonstrated this hypothesis to be possible through experiments that showed that bottle gourd fruit still contained viable seeds even after floating in sea water for more than 7 months. Upon reaching Asia and the Americas, the wild bottle gourd is said to have evolved in to two subspecies, *L. siceraria* ssp. *siceraria* and *L. siceraria* ssp, *asiatica*, respectively. It has been hypothesized that multiple domestications of bottle gourd should have occurred. Through DNA analysis and comparison, it is now certain that two separate events of domestication occurred.The first in Asia around 10 000 BP, then in Africa at around 3 000 BP (Chimonyo and Modi, 2013). Bottle gourd (*Lagenaria siceraria*) was one of the first domesticated plants, and the only one with a global distribution during pre-Columbian times. Although native to Africa, bottle gourd was in use by humans in East Asia, possibly as early as 11,000 y ago (BP) and in the Americas by 10,000 BP. Despite its utilitarian importance to diverse human populations, it remains unresolved how the bottle gourd came to be so widely distributed, and in particular how and when it arrived in the New World. A previous study using ancient DNA concluded that Paleoindians transported already domesticated gourds to the Americas from Asia when colonizing the New World. However, this scenario requires the propagation of tropical-adapted bottle gourds across the Arctic. Here, we isolate 86,000 base pairs of plastid DNA from a geographically broad sample of archaeological and living bottle gourds. In contrast to the earlier results, we find that all pre-Columbian bottle gourds are most closely related to African gourds, not Asian gourds. Ocean-current drift modeling shows that wild African gourds could have simply floated across the Atlantic during the Late Pleistocene. Once they arrived in the New World, naturalized gourd populations likely became established in the Neotropics via dispersal by mega-faunal mammals. These wild populations were domesticated in several distinct New World locales, most likely near established centers of food crop domestication (Kistler et al., 2014). It seems that bottle gourd was originated from India because its wild races are still found in Dehradun (high humid area) and Malabar costal area. Old Indian script reveals its cultivation 2000 B.C. (Kumar et al., 2017). *Lagenaria siceraria* is probably native to tropical Africa but now has a pan-tropical distribution. Archaeological records show that *L. siceraria* has been cultivated since pre-Columbian times in both the Old and New World. This species is known almost exclusively in cultivation, and most records and collections are from cultivated plants or plants that escaped from cultivation, but in 1992 a wild population was discovered in a remote region of Southeastern Zimbabwe. Currently, *L. siceraria* can be found cultivated and naturalized across tropical and temperate Asia, Africa, the Americas, the West Indies, Australia and on many islands in the Pacific and Indian Oceans (Clarke et al., 2006; Sandoval, 2018)

The bottle gourd (*Lagenaria siceraria*) has had a complex domestication history written for it over the past twenty years. However, recent DNA research suggests that it was domesticated three times: in Asia, at least 10,000 years ago; in Central America, about 10,000 years ago; and in Africa, about 4,000 years ago. In addition, the bottle gourd's dispersal throughout Polynesia is a key part of evidence supporting the possible Polynesian discovery of the New World, circa 1000 AD (Hirst, 2021). The bottle gourd is native to Africa: wild populations of the plant have recently been discovered in Zimbabwe. Two subspecies, likely representing two separate domestication events, have been identified: *Lagenaria siceraria* spp. *siceraria* (in Africa, domesticated some 4,000 years ago) and *L. siceraria* spp. *asiatica* (Asia, domesticated at least 10,000 years ago. The likelihood of a third domestication event, in Central America about 10,000 years ago, has been implied from genetic analysis of American bottle gourds (Hirst, 2021). Bottle gourd appears to have been domesticated independently in Asia, Africa, and The New World. The evolution of the bottle gourd is not well understood. Two principal variants are recognized as subspecies, i.e. subsp. *siceraria* of Africa and the Americas and subsp. *Asiatica* of Asia. It is not known if the progenitor of the bottle gourd was a wild form of the species or one of the other extant species. It is not known whether domestication

occurred in Africa followed by dispersal to the Americas and Asia or the wild forms dispersed followed by independent domestication in the Americas, Africa and Asia. Was dispersal carried out by humans or by ocean currents? Bottle gourds can float on the oceans for many months without losing seed viability, hence the latter alternative is possible (Vidhi, 2022). *Lagenaria siceraria* or bottle gourd, are native to the Americas, being found in Peruvian archaeological sites dating from 13,000 to 11,000 BCE and Thailand sites from 11,000 to 6,000 BCE. A study of bottle gourd DNA published in 2005 suggests that there are two distinct subspecies of bottle gourds, domesticated independently in Africa and Asia, the latter approximately 4,000 years earlier. The gourds found in the Americas appear to have come from the Asian subspecies very early in history, although a new study now indicates Africa. The archaeological and DNA records show it is likely that the gourd was among the first domesticated species, in Asia between 12,000 and 13,000 years before present, and possibly the first domesticated plant species (WIKI, 2022a).

***History of Introduction and Spread****:* Healy (2014) reported that the bottle gourd, beloved since pre-Columbian times not only for its voluptuous shape but for its endless uses, very likely floated on ocean currents from its native Africa to South America inside the span of a year, with its seeds still intact and ready to propagate itself in the New World, says a new study. Sometimes called the calabash, opo squash or long melon, *Lagenaria siceraria* was one of the first domesticated plants, and as long as 11,000 years ago, archaeological evidence suggests it was being used by humans from East Asia to the Americas. But how the cultivated bottle gourd became such a ubiquitous human tool -- a drinking vessel, musical instrument, fishing bob, cricket cage and medicine bottle, as well as food -- remains a mystery. A 2005 study suggested that by the end of the Ice Age, the bottle gourd was already widely grown in Asia for use as a canteen and made its way to the Americas slung across the backs of Paleoindians as they migrated across the Bering land bridge with another domesticated species, the dog. But anthropologists have found little evidence of the bottle gourd's widespread use among Siberian or Alaskan inhabitants of the Late Pleistocene era, and the growing season was likely too short and too cold to grow this African native so far north. So the gourd's route to the Americas has remained a matter of debate. Enter a team of anthropologists, geneticists, engineers and oceanographers scattered across the United States, led by evolutionary molecular biologist Beth A. Shapiro of UC Santa Cruz. The team used genomic analysis and models of ancient ocean currents to explore the plausibility of the bottle gourd's having made a somewhat more direct route from its African home to the New World across the Atlantic Ocean. The team collected modern domestic gourds from across North, Central and South America, as well as nine archaeological samples of gourds estimated to have been cultivated and used by humans as long ago as 10,000 years. They ground the rinds of those gourds and compared their DNA with those of domestic gourds grown in Africa as well as of gourds harvested from two of the last remaining sites in Africa where *Lagenaria sicenaria* continues to grow wild. The genetic lineages of the African and Eurasian bottle gourds are quite distinct from each other, having diverged over thousands of years of cultivation. But the modern American gourds, as well as the gourds discovered in ancient human settlements stretching from Florida, Kentucky and Arizona to Mexico and Peru, all were found to bear the genetic imprint of their source: gourds from Africa. How, then, did they get from Africa to the Americas? The team used data sets on ocean currents that support a wide range of oceanographic and atmospheric research, and which permit estimates of the rate at which floating objects will drift. The seeds of domestic bottle gourds floating in ocean water will remain viable for as long as a year. So the researchers looked for evidence that a gourd dropped into the water along Africa's coast in the late Pleistocene era could make the crossing to the New World in less time than that. Those models suggested that a bobbing gourd could make its way from Africa's shores to American shores between Florida and Brazil in anywhere from 248 to 331 days. There, with the help of such megafauna as the mastodon, whose preserved dung has shown evidence of bottle gourd consumption, the plant may have made its way across the Americas.

It is generally accepted that *L. siceraria* is indigenous to Africa and that it reached temperate and tropical areas in Asia and the Americas about 10,000 years ago, with human help or probably as a wild species whose fruits were carried by ocean currents. Fruits are known to float in the sea for many months without the seeds losing their viability. Independent domestications from wild populations are believed to have occurred in both the Old and New World. From Africa, *L. siceraria* apparently travelled to India, where it evolved into numerous varieties and cultivars, and from India to China, Indonesia and as far as the Polynesian Islands and New Zealand. The Asian bottle gourd, *L. siceraria* subsp. *asiatica*, was used by humans in East Asia, possibly as early as 11000 years before present (BP) and it appears as a domesticated species in China and Japan from 8000-9000 years BP. Linguistic evidence and dated archaeological specimens suggest that this species has been present in Eastern Polynesia since before AD 1200. The dispersal of *L. siceraria* within Polynesia, where it is widely distributed, was certainly human-mediated. *Lagenaria siceraria* also reached the New World. Archaeological evidence shows that it was present in the Americas by at least 10000 years BP and became increasingly ubiquitous and widespread during the latter half of the Holocene (is the current geological epoch).

Remains found in North America date from 10000 to 7500 years BP, those in Mexico from 7000 to 5500 years BP and in Peru from about 6000 years BP. Currently, there are two theories to explain how this species reached the New World: the first theory suggests that the bottle gourd was moved from Asia (Asian origin theory) to the Americas by Paleo-Indian populations as they crossed the Bering Land Bridge and colonized the New World. The second theory suggests that the bottle gourd arrived in the Americas from Africa (African origin theory) via long-range dispersal on ocean currents. Experimental evidence suggests that the early spread from Africa to the New World could have occurred through oceanic drift as dried gourds with viable seeds have survived in seawater for at least 200 days. Regardless of how it reached the New World, *L. siceraria* is now extensively cultivated throughout the tropical and subtropical regions of the Americas for food and its useful gourds (Clarke et al., 2006; Sandoval, 2018). *Lagenaria siceraria* spreads by seeds. Fruits can be dispersed by ocean currents and by large mammals. Fruits are known to float in the sea for many months without the seeds losing their viability. It has been suggested that this species could have been dispersed by mega-faunal mammals (Sandoval, 2018). *Lagenaria siceraria* is an ancient crop that has been introduced and extensively cultivated by humans. It is the only crop known to have been cultivated in pre-Columbian times in both the Old and New World. Currently, it is one of the most widely distributed plant species in the world with a long history of domestication and cultivation (Sandoval, 2018).

*Lagenaria siceraria* is a vine species, probably originating from tropical Africa, that has been transported and cultivated by humans since ancient times mainly for its fruit. This species is considered one of the most widely distributed plants in the world due to its long history of domestication. Plants can grow up to 5 m long and are shallow-rooted with an extensive lateral root system. Even where this species is known almost exclusively in cultivation, it often escapes from cultivation and can be found naturalized along riversides, roadsides, dry thickets, savannahs and in areas near villages. *L. siceraria* is a species of environmental concern because it is a vigorous and fast-growing vine that often grows over other plant species, displacing and out-competing them for water, nutrients and sunlight (Sandoval, 2018).

***Bottle Gourd Dispersals:*** The archaeological evidences suggest that *Lagenaria* is not a monotypic genus and has an ancient pan tropical distribution. It is widely cultivated in tropical and pan-tropical regions of the world. It is cultivated in Delhi, U.P, Punjab, Haryana, Gujarat, Assam, Meghalaya, Maharashtra, Karnataka and Rajasthan in India (Parle Milind and Satbir, 2011). The earliest dispersal of the bottle gourd into the Americas was long believed by scholars to have occurred from the floating of domesticated fruits across the Atlantic.

In 2005, researchers David Erickson and colleagues (among others) argued that bottle gourds, like dogs, had been brought into the Americas with the arrival of Paleoindian hunter-gatherers, at least 10,000 years ago. If true, then the Asian form of the bottle gourd was domesticated at least a couple of thousand years before that. Evidence of that has not been discovered, although domestic bottle gourds from several Jomon period sites on Japan have early dates. In 2014, researchers Kistler et al. disputed that theory, in part because it would have required the tropical and subtropical bottle gourd to have been planted at the crossing place into the Americas in the Bering Land Bridge region, an area far too cold to support that; and evidence for its presence in the likely entryway into the Americas has yet to be found. Instead, Kistler's team looked at DNA from samples in several locales in the Americas between 8,000 BC and 1925 AD (included Guila Naquitz and Quebrada Jaguay) and concluded that Africa is the clear source region of the bottle gourd in the Americas. Kistler et al. suggest that the African bottle gourds were domesticated in the American Neotropics, derived from seeds out of gourds which had drifted across the Atlantic. Later dispersals throughout eastern Polynesia, Hawai'i, New Zealand and the western South American coastal region may have been driven by Polynesian seafaring. New Zealand bottle gourds exhibit features of both subspecies. The Kistler study identified the Polynesia bottle gourds as *L. siceria* ssp. *asiatica*, more closely related to Asian examples, but the puzzle was not addressed in that study (Hirst, 2021).

## TAXONOMY

Bottlegourd, *Lagenaria siceraria* (Molina) Standl., belongs to the genus *Lagenaria* and the family Cucurbitaceae (Sandoval, 2018). Within the species *siceraria*, two morphologically distinct sub-species of bottle gourd have been recognized *viz. L. siceraria* ssp. *siceraria* and *L. siceraria* ssp. *asiatica* (Chimonyo and Modi, 2013; Sandoval, 2018). The species *Lagenaria siceraria* is one of the most widely distributed plants in the world with a long history of domestication and use in both the Old and New World. *L. siceraria* is extremely variable with numerous forms and cultivars available after being in cultivation for such a long time (Sandoval, 2018).

**Synonyms of *Lagenaria siceraria* are as follows (Sandoval, 2018):**

- Cucumis bicirrha J.R.Forst. ex Guill.
- Cucumis lagenaria (L.) Dumort.
- Cucumis mairei H.Lév.
- Cucurbita ciceraria Molina
- Cucurbita idolatrica Willd.
- Cucurbita lagenaria L.
- Cucurbita lagenaria var. oblonga Blanco
- Cucurbita lagenaria var. villosa Blanco
- Cucurbita leucantha Duchesne
- Cucurbita pyriformis M.Roem.
- Cucurbita siceraria Molina
- Cucurbita vittata Blume
- Lagenaria bicornuta Chakrav.
- Lagenaria idolatrica (Willd.) Ser. ex Cogn.
- Lagenaria leucantha Rusby
- Lagenaria leucantha var. microcarpa (Naudin) Nakai
- Lagenaria microcarpa Naudin
- Lagenaria siceraria var. microcarpa (Naudin) H. Hara
- Lagenaria vulgaris Ser.
- Lagenaria vulgaris subsp. afrikana Kobjakova
- Lagenaria vulgaris var. microcarpa Hort. ex Matsum. & Nakai
- Pepo lagenarius Moench

**Five wild species of *Lagenaria* exist in Africa:** *Lagenaria breviflora* (Benth.), *L. abyssinica* (Hook f.), *L. rufa* (Gilg.) Jeffrey, *L. sphaerica* (Sonder) Naudin and *L. guineensis* (G. Don) Jeffrey. Wild species produce small round fruits with strong bitter taste. During domestication, selection for non-bitter fruits must have been practiced (Chimonyo and Modi, 2013; Dhillon et al., 2016),

## BOTANICAL DESCRIPTION

Monoecious, annual, climbing or trailing herb, with proximally bifid tendrils. (Clarke et al., 2006; Sandoval, 2018; Vidhi, 2022). Leaves alternate, simple; stipules absent; petiole 2.5–12.5 cm long, pubescent, with a pair of tiny glands at apex; blade broadly ovate to kidney-shaped in outline, 3–33 cm × 4.5–33 cm, undivided or shortly palmately 5–9-lobed, cordate at base, shallowly sinuate-dentate, palmately veined. (Clarke et al., 2006; Sandoval, 2018; Vidhi, 2022). Flowers unisexual (rarely bisexual), solitary in leaf axils, regular, 5-merous, up to 15 cm in diameter; receptacle tube obconic-cylindrical, 1–1.5 cm long, lobes remote; petals free, white; male flowers on long pedicels 7–31 cm long, with 3 free stamens inserted on the receptacle tube, connectives broad; female flowers on short pedicels 2–10 cm long, with inferior, densely hairy ovary, stigma 3-lobed, thick, each lobe 2-lobed. (Clarke et al., 2006; Sandoval, 2018; Vidhi, 2022). Dioecious and andromonoecious sex forms bearing hermaphrodite flowers also exist in wild, non–cultivated types. Like most cucurbits, the sex ratio (male: female) for bottle gourd is high. The proportion of male to female flowers has been shown to affect yield significantly (Chimonyo and Modi, 2013).

Flowers are monoecious (solitary male and female flowers are found on the same plant), and cross-pollination is highly favourable. Dioecious and andromonoecious sex forms bearing hermaphrodite flowers have been reported for wild, non–cultivated types. Flowers open in the late afternoon and are pollinated by insects. In Kenya, 22 species of insects including hawkmoths (*Hippotion celerio, Agrius convolvuli*), moths (*Noctuidae* spp.), butterflies and honeybees were observed visiting *L. siceraria* flowers. In the Americas, humming birds visit the flowers. Pollen is usually abundant, and the stigmas are receptive up to 36 hours after anthesis. Female flowers are short-stalked while male flowers have long stalks (Sandoval, 2018). Fruit a berry, very variable in size and shape, often globular, bottle- or club-shaped, up to 1 m long, white-yellow to dark green when young, sometimes whitish speckled, usually brown when mature and dried, with hard, durable rind, flesh white and soft, many-seeded. (Clarke et al., 2006; Sandoval, 2018; Vidhi, 2022). The forms of fruits are named for the shape of the fruit e.g., club, dipper, dolphin, kettle, and trough. The fruits of some cultivated varieties may be more than 1 metre (about 3 feet) long (EEB, 2022).

Fruit shapes include long and cylindrical, elongate, curved, pyriform, crooked necked, and globular (Dhillon et al., 2016), Bottle gourd fruit vary widely in shape and size, and this is within or among cultivars. Among the six known species, *L. siceraria* exhibits the widest variations in fruit shape; these are either long, cylindrical, necked, oblong flat or round, conical pyriform to club shaped, while skin texture varies from warted to smooth. Fruit size varies from 5 to 40 cm wide, and 20 to 90 cm long (Chimonyo and Modi, 2013). Seeds oblong, compressed, up to 2 cm long, emarginate at base, with 2 flat facial ridges, smooth, sometimes rugose, whitish to brownish (Clarke et al., 2006; Sandoval, 2018; Vidhi, 2022). Seed forms also differ according to shape, size, presence or absence of frills and seed lines, and seed coat surface texture. (Chimonyo and Modi, 2013) (Fig. 2). Chimonyo and Modi (2013) reported that the bottle gourd is an annual herbaceous plant with a prostrate or branching type growth habit. The leaves are alternate and variable, and tendrils (Fig. 3) are almost always present. Flowers of *L. siceraria* are monoecious in nature, where solitary male and female flowers are found on different plant axis of the same plant, thus cross pollination is highly favorable. Dioecious and andromonoecious sex forms bearing hermaphrodite flowers also exist in wild, non–cultivated types. Like most cucurbits, the sex ratio (male: female) for bottle gourd ishigh. The proportion of male to female flowers has been shown to affect yield significantly. Bottle gourd fruit vary widely in shape and size, and this is within or among cultivars (Fig. 3). Among the six known species, *L. siceraria* exhibits the widest variations in fruit shape; these are either long, cylindrical, necked, oblong flat or round, conical pyriform to club shaped, while skin texture varies from warted to smooth (Fig. 3).

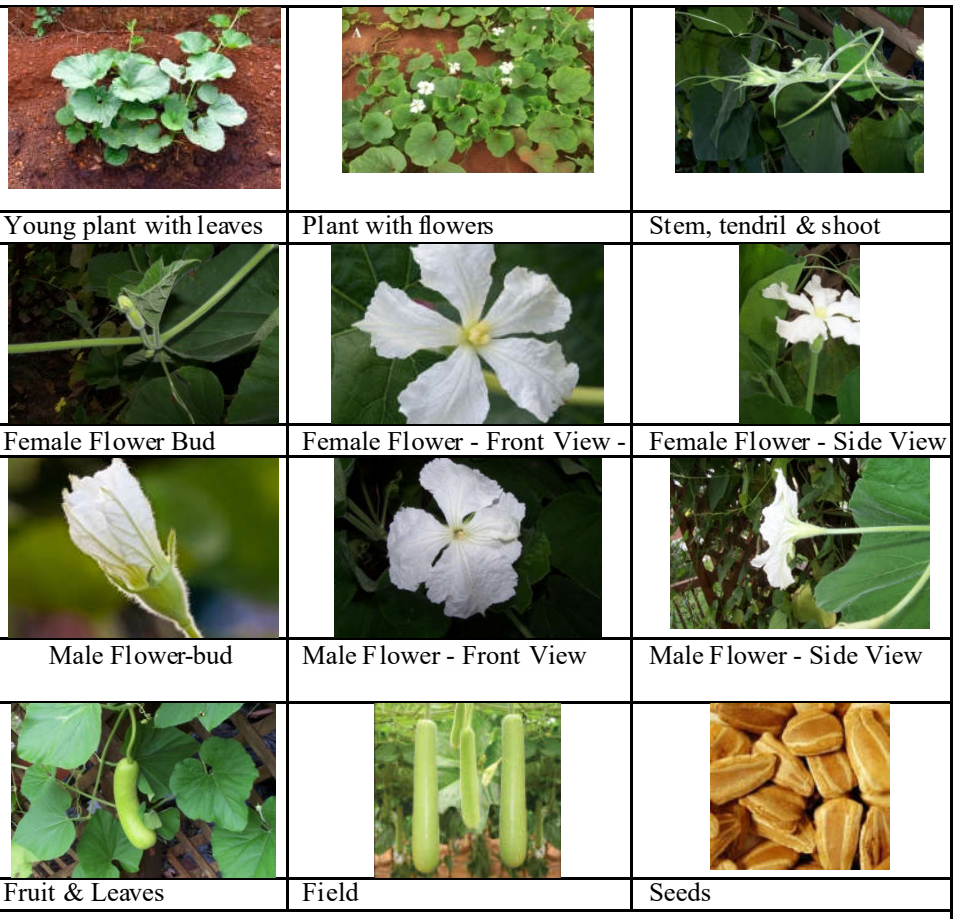



**Fig. 2. Botanical description of bottle gourd**


**Fig. 3. Bottle gourd exhibits the widest variations in fruit shape; these are either long, cylindrical, necked, oblong flat or round, conical pyriform to club shaped, while skin texture varies from warted to smooth**

Fruit size varies from 5 to 40 cm wide, and 20 to 90 cm long. Seed forms also differ according to shape, size, presence or absence of frills and seed lines, and seed coat surface texture. Dhillon et al. (2016) reported that the species presents the largest variation in fruit shape resulting, presumably, from thousands of years of selection in isolated areas of the world. Fruit shapes include long and cylindrical, elongate, curved, pyriform, crooked necked, and globular (Fig. 4 & 5)).

Seed morphology of the different landrace selections was indeed different. Seed and embryo size and seed coat thickness contributed most to seed diversity. The local landrace selections had either large or small seeds, and all had thin seed coats. On the other hand, seeds of landrace selections from Zimbabwe were medium in size and had thicker seed coats when compared to the local selections (Chimonyo and Modi, 2013) (Fig.6).

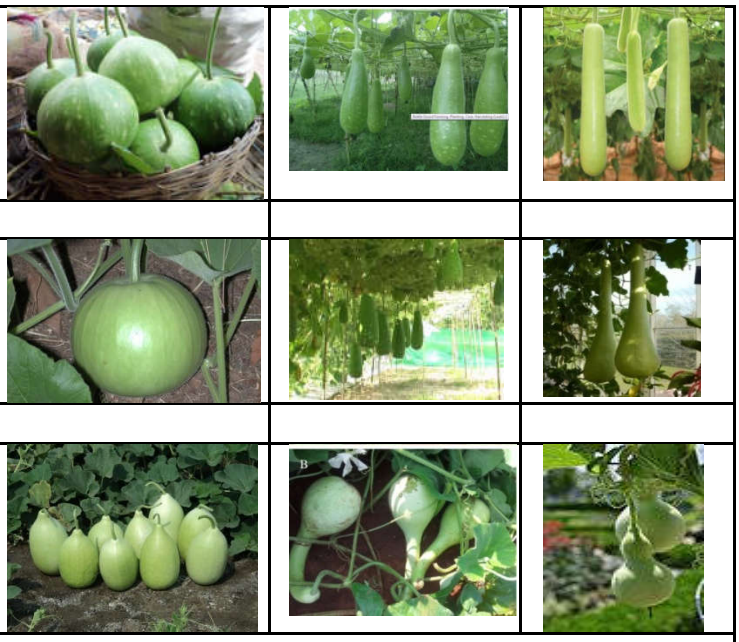


**Fig. 4. Variability for shape, size and color of bottle gourd**

**Fig. 5. Genetic variability for fruit shape and size among landraces, varieties and cultivars of bottle gourd**


**Fig. 6. Pictures of seeds for the different landrace selections (ZIM1, ZIM2, R, S, C andCal)**

**GENETIC DIVERSITY**: The chromosome number reported is $2n$=22. Populations of *L. siceraria* are heterozygous and highly variable. Hybridization is often common. Apparently, India is the region with the highest diversity of varieties and cultivars, followed by West Africa. Tropical Africa is considered the primary gene pool for this species (Sandoval, 2018). The landraces of *Lagenaria siceraria* in Turkey show great diversity for morphologic traits, particularly in fruit size and shape even though Turkey is not centre of genetic diversity for *L. siceraria*. In Turkey, *L. siceraria* is used as food, musical instruments and containers, according to the type and shape of their fruits. Its diversity has been gradually declining over the last 25 years. A total of 182 accessions (fruits and/or seeds) were collected. The morpho-agronomic characterization was carried out following the international standards for crop descriptors set by Bioversity International. The data were subject to both descriptive statistics and multivariate analysis by Principle Component Analysis. The descriptive statistics revealed that the whole collection exhibits a great deal of morphological diversity. Among the studied accessions, no apparently distinct patterns such as geographical origin were detected. This may suggest that the accessions have been introduced to Turkey from multiple locations and/or their diversity had been distributed almost evenly across the Mediterranean region of this country (Yetisir et al., 2008) (Fig. 7).

Levi et al. (2009) examined genetic diversity among 57 *L. siceraria* accessions that originated from 16 countries in Asia, Africa, and South America, using sequence- related amplified polymorphism (SRAP) markers; they found that collections of Indian origin were genetically distinct from the collections collected in Southern Africa and the Americas. Sarao et al. (2013) studied, 20 accessions of bottle gourd were fingerprinted using 20 simple sequence repeat (SSR) primers. Of these, ten primers exhibited polymorphic profiles, while nine exhibited monomorphic patterns and one revealed a null allele. The number of alleles ranged from 2 to 4 with an average of 2.6 alleles per locus. Unique DNA profiles of all the accessions could be created using a set of five polymorphic primers. Therefore, SSR markers used in the present study could precisely distinguish all the 20 accessions from each other, and these SSR markers can be further used to differentiate the future genotypes from the existing ones. The dendrogram depicting the genetic relationships as revealed by NTSYS-pc 2.02 and the tree diagram generated using the DARwin 5.0 program classified the accessions into two main clusters. There is no strong association between the clustering pattern and geographical origin of these accessions. This SSR marker-based diversity would facilitate the implementation of marker-assisted breeding schemes for efficient introduction of the desired traits into bottle gourd.

For the assessment of the molecular diversity, ten different genotypes of bottle gourd have been studied by RAPD marker and SDS-PAGE. A total of 10 genotypes were screened using 18 random oligonucleotiede decamer primers. Of the 8 selected screened primers, a total of 60 bands were observed, from which 60.29 % were polymorphic. Maximum similarities of 90.90 % were found between Narendra Jyoti and NDBG 132 followed by NDBG 132 and Andromon 6 with 75.75 % of similarity. Two major groups at 0.52 of similarity coefficient on similarity matrix were obtained. Polyacrylamide gel electrophoresis of total protein showed that highest no. of protein bands seen in the fruit and leaves of Narendra Shravasti whereas minimum no. of protein bands observed in Narendra Shishir and Narendra Shivani. Cluster analysis of combined banding pattern of leaves and fruit proteins on SDS-PAGE were separated from 0.68 of similarity coefficient on similarity matrix. Narendra Bow Wonder and NDBG 132 was most dissimilar (36.36 %) followed by Narendra Shishir and Narendra Bow Wonder with 36.40 % of similarity. The diverse bottle gourd genotypes may be further used in the development of improved cultivars with respect to quality and quantity (Srivastava et al. 2014).

Gürcan et al. (2015) reported molecular analysis of 60 Turkish bottle gourds along with 31 diverse exotic accessions. Eighth Simple Sequence Repeats and two chloroplast loci of 91 accessions were analyzed. Capillary electrophoresis was used for DNA size fragman separation. The number of alleles per locus ranged from 2 to 13, with a mean of 7. Mean values for expected heterozygosity, observed heterozgosity, and polymorphism information averaged 0.5, 0.13 and 0.50, respectively, thereby sugguesting very low (0.13) genetic diversity in a very diverse population. An unweighted pair group method with arithmetic mean dendrogram was constructed, Indian accessions clearly separated from the rest. Among the remaining samples, neither Turkish landraces grouped together based on their georgraphic origin, nor clear speration occurred according to origin continent. Interestingly, this co-dominant marker analysis shows close molecular allelic profile among bottle gourds originated from far different countries (Fig. 8).

Phenotypic and genotypic characterization of plant genetic resources is fundamental for breeding and strategic conservation. This study assessed the genetic diversity present in bottle gourd landraces using 10 fruit qualitative traits and 11 simple sequence repeat (SSR) markers. Thirty six South African bottle gourd landraces collected from various geographic locations were used for the study. Phenotypic diversity was estimated using Shannon-Weaver diversity indices, principal component and cluster analyses. Phenotypic diversity index was 0.98, showing high genetic diversity among bottle gourd landraces. Principal component analysis identified four PCs which contributed for 75.3% of the total phenotypic variation. Presence or absence of fruit neck, fruit shape, degree of neck bending and fruit neck length positively correlated with PC1, which accounted for 37.6% of the total variation. Primary fruit colour and fruit texture highly correlated with PC2 which accounted for 15.78% of the total variation. Number of alleles varied from 3 to 9 with a mean of 6 per SSR locus. Number of effective alleles ranged from 1.99 to 6.72 with a mean of 3.75. Expected heterozygosity values ranged from 0.5 to 0.87 with a mean of 0.71 with polymorphic information content varying from 0.5 to 0.85 and a mean of 0.7. Qualitative traits and SSR markers analyses had significant correlation ($r = 0.15$, $P = 0.02$) in clustering the landraces. The present study revealed that fruit qualitative traits are useful attributes in bottle gourd breeding and genetic analysis (Mashilo et al., 2017).

There is extensive genetic variation of bottle gourd in Africa for diverse qualitative and quantitative horticultural attributes for variety design, product development, and marketing. However, bottle gourd is under- researched and –utilized crop in sub-Saharan Africa. Improved varieties are yet to be developed and commercialized in the region to serve the diverse human needs and for the market place. There is need for collaborative research on bottle gourd involving plant breeders, agronomists, geneticists, and food scientists in the region and internationally for knowledge and germplasm sharing and innovative product development. The next generation of bottle gourd cultivars should encompass product profiles including quality and quantity leaves, fruit, fodder, seed, and nutritional compositions to serve varied value chains and the food and feed industry (Mkhize et al., 2021). Considerable genetic variability exists in bottle gourd genetic resources for fruit horticultural traits useful for strategic breeding and cultivar development. The crop show variation for fruit shape, size, length, colour, and texture (**Fig. 9**). Fruit shape is an important trait that determines usability of the crop either for food or decorative purposes. Bottle gourd fruits vary in shape such as club-shaped,globular, bottle shaped, flat, pear shaped, cylindrical, elongated straight, pyriform, round (oblate), elongated curved, and oval. Fruit shape can therefore serve as a selection marker in improvement programs. There is high genetic variability for fruit shape which may provide opportunities for improving this character. Further, fruit shape is a key market-preferred trait. Therefore, knowledge on the underlying gene action conditioning fruit shape is important for developing unique and attractive fruits to increase market opportunities. Oval and pear fruit shapes in bottle gourd are controlled by a combination of one dominant and one recessive genes.

**Fig. 7: Variability in fruit colour, size and shape of bottle gourd germplasm in Turkey**

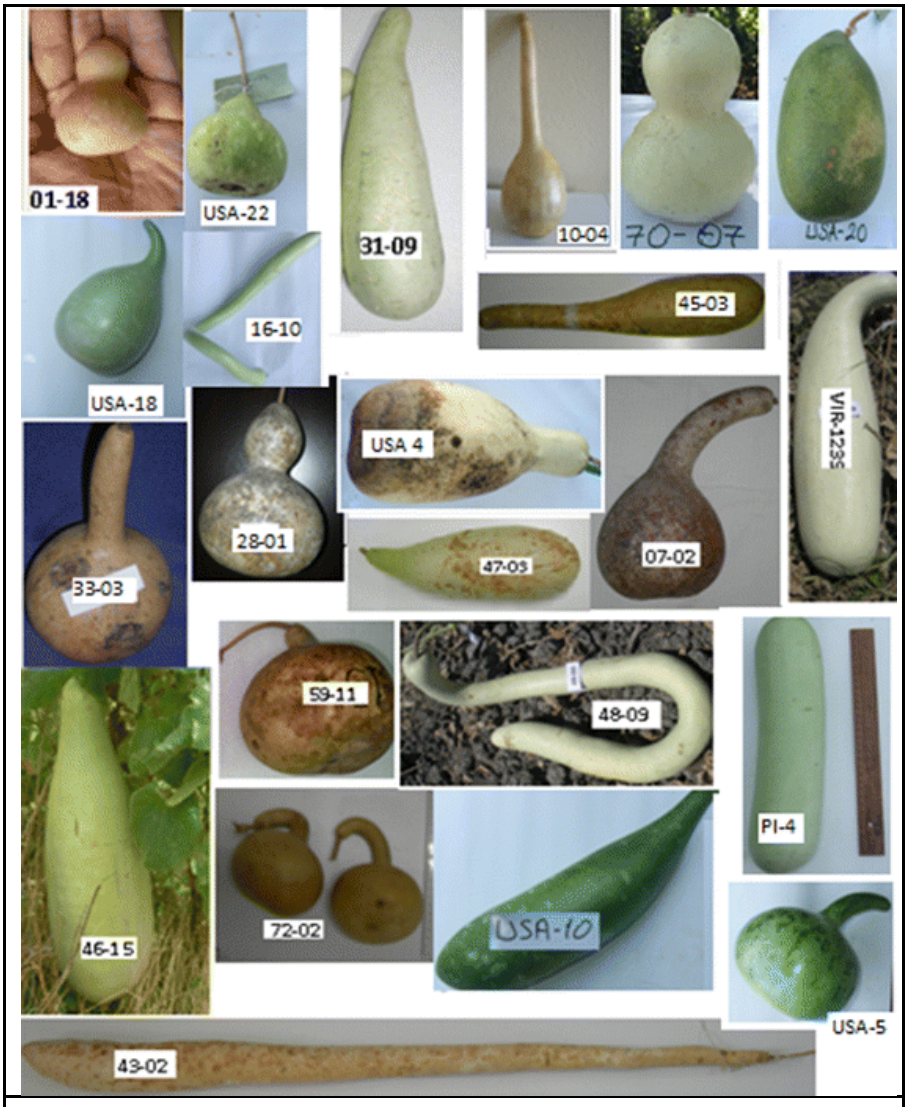



**Fig. 8: Fruits of some accessions showing the diversity in shape**

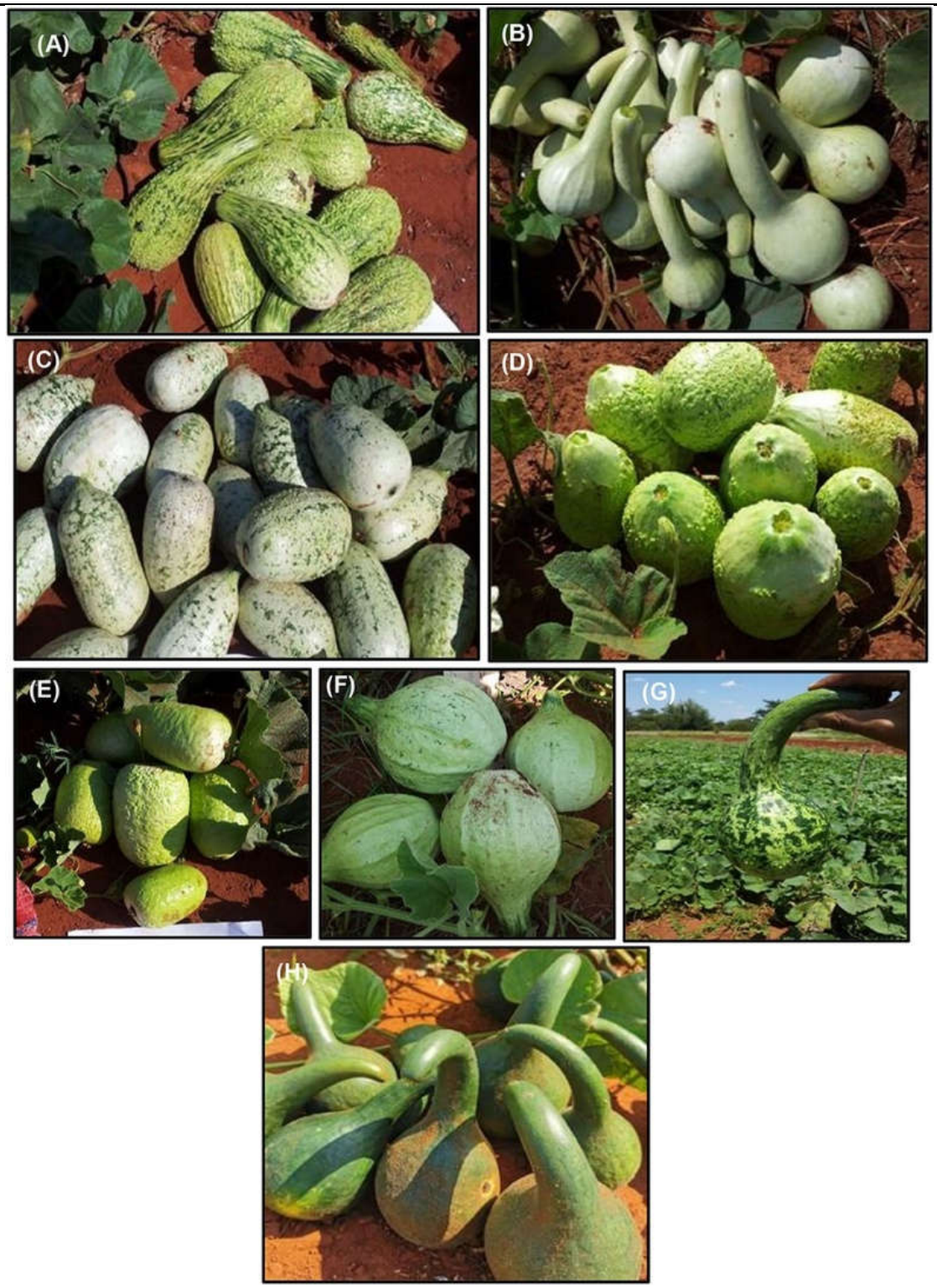



**Fig. 9 : Fruit morphotypes of bottle gourd accessions cultivated in the Limpopo Province of South Africa: (A) BG-67, verrucose fruit texture and club-shaped fruit used for food, (B) BG-78, light-green fruit color and long neck used for making containers and to serving traditional sorghum-brewed beer, (C) BG-70, white-green fruit color grown for food, (D) BG-79, cultivated for its edible fruit, (E) BG-100, commercially grown and sold in various retail outlets in KwaZulu-Natal and Gauteng provinces of South Africa, (F) BG-80, light-green fruit color, small-neck, and corrugated skin texture, (G) BG-27, dark and light green fruit color and slightly curved fruit neck, and (H) BG-31, dark green fruit color and curved fruit neck**

Round fruit shape is controlled by two recessive genes, whereas dominant genes control the expression of long fruit shape (Mkhize et al., 2021). Genetic diversity among 12 Egyptian bottle gourd genotypes was assessed using 11 ISSR molecular markers. The ISSR analysis generated 76 amplicons in a size range of 170–1600 bp with maximum (9) polymorphic amplicons by UBC 811.

The high degree of polymorphism and PIC values greater than 0.50 indicate that 844-B, HB 10, UBC 807 and UBC 825 markers could be useful for rapid fingerprinting of many bottle gourd genotypes. Parameters of genetic diversity and its partitioning were estimated among genotypes. Various parameters namely, observed heterozygosity, effective number of alleles per locus,

Shannon's index, expected heterozygosity, and represents percentage of polymorphic band were estimated. The genetic analysis demonstrated that Egyptian bottle gourd genotypes keep relatively high genetic diversity. Cluster analysis (UPGMA) clustered all genotypes into three main clusters based on the ISSR data. Overall, the results indicated that fingerprinting using ISSR markers might be an efficient tool in future breeding programs for varietal identification and assessing genetic diversity within the Egyptian bottle gourd genotypes. The high genetic variability among studied genotypes would be beneficial for breeding and conservation programs (Ibrahim, 2021).

**BREEDING:** For effective bottle gourd breeding, genetic diversity of this crop needs to be studied and documented. The monoecious and open-pollinated nature of bottle gourd supports conventional breeding by pure line selection, pedigree selection, recurrent selection and heterosis breeding. Besides traditional breeding, transgenic breeding, gene editing and marker-assisted selection are also needed to fully exploit the genetic resources of this crop to achieve desirable yield and quality (Islam et al., 2021). Total numbers of accessions of bottle gourd listed by the U.S. Germplasm Resources Information Network (GRIN) (500).and the World Vegetable Center (World Veg) (329) in 2016. A significant number of bottle gourd accessions collected in different regions of the world are held by the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India (739 accessions) (Dhillon et al., 2016).

***Breeding Goals of Bottle gourd:*** Breeding goals of bottle gourd are as follows: 1) High yield, 2) Greater fruit number, 3) Fruit weight as per market demand, 4) Earliness (appearance of pistillate flowers at early node number), 5) High female: male flower ratio, 6) Round, long, club shaped, pear shaped fruit, 7) Sparse hairs persisting on skin, 8) Non-fibrous flesh at edible stage, 9) Non-bitter fruit, 10) Attractive green fruit with long colour retention, 11) Resistance to powdery mildew, downy mildew and cummber mosaic virus and red pumpkin beetle (Vidhi, 2022).

**Breeding Methods (Vidhi, 2022):**

**Inbreeding:** Inbreeding in land races. followed by individual plant selection has been found effective method of breeding to develop pure-line cultivars of cucurbits including bottle gourd. Similarly two parental cultivars can be crossed and the typical pedigree/bulk/back cross method of breeding can be used. However, in view of reported heterosis by some authors and the fact that cylindrical fruit shape could be easily obtained by crossing long fruited varieties of varying shapes, heterosis breeding has also been followed. Some hybrid bottle gourd varieties were released as long back as 1971 by Indian Agricultural Research Institute, New Delhi. Pusa Meghdoot (long) gave an increase in total yield of 75 % while in Pusa Manjari (round) increase in total yield was 106%. Once a good, heterotic parental combination has been identified, the hybrid seed can be easily produced by planting 3-4 rows of female parent alternated with 1 row of male parent. The male buds of female rows are removed daily before anthesis and the fruit set on the female line is as a consequence of cross-pollination from male parent. This natural cross-pollination is carried out by the insects and can be further facilitated by keeping a few honey-bee hives in the seed production block which has to be at an isolation distance of about 1000 m from other bottle gourd fields (Vidhi, 2022). While breeding bottle gourd, it should be kept in mind that plant should be vigorous, well branched, high in pistillate to staminate flowers ratio and number of fruits. The lower node number of first pistillate flower is an indicator of earliness. The glossy, non-bitter and tender fruits are the preferred quality traits. The fruits should be uniform either of round, oval, cylindrical, dumble or club shape. The preference for fruit shape varies with the method of consumption and liking of consumers of a particular region. The persistence of sparse hairs on the surface of fruit, delay in development of fibrous flesh and softness of seed are the indicator of fruit tenderness.Resistance to *Fusarium wilt*, powdery mildew, viruses, red pumpkin beetle and fruit fly are the other points of consideration.

The breeding methods in bottle gourd are same as of other cucurbits and form a distinct group from other cross-pollinated crops. The cultivated bottle gourd is monoecious and entomophilous. Self-pollination also occurs, because insects do not distinguish flowers from the same plant or different plants at the time of involuntary pollination. This is one of the reasons for absence or even, if present, negligible degree of inbreeding depression than other cross-pollinated vegetable crops like onion, cabbage, cauliflower, carrot, radish etc. Though, cucurbits are cross-pollinated and monoecious, but the population structure is similar to the in- breeder than that of out-breeders. Therefore, inbred lines can be developed without loss of vigour in the bottle gourd. This does not mean that mass selection is not suitable, but does have value for breeding superior populations rather than individual plants.

Thus, taking advantage of both methods, suitable modifications can be made for improvement as per objectives and inheritance of the traits. Plant introduction, mass selection, recurrent selection, pedigree method, bulk population method, back cross method, hybridization and heterosis breeding are the common approaches followed for genetic improvement in bottle gourd. The immature fruits of bottle gourd are of economic importance and delayed pollination procedure can be adopted. Wherein, open pollination in a breeding line is allowed to set first fruit and based upon fruit characteristics at edible stage, desired plants are selected and selfed to advance the material than to self each and every plant for selection till fruit maturity as of muskmelon, watermelon and pumpkin etc. However, this approach would give less number of fruits due to end of the crop season, but large number of seeds per fruit compensate the delay along with saving of resources and time involved (Dhatt and Khosa, 2015)

***Heterosis Breeding:*** Heterosis breeding offers an opportunity in bottle gourd due to monoecious nature of flowers, high number of seeds per fruit or per pollination and requirement of less number of plants per unit area. This can be exploited not only for high yield, but for early maturity, uniform size, shape, colour, tenderness, longer harvesting span and resistance to biotic and abiotic stresses. In different reports heterotic effects for substantial increase in yield and earliness have been recorded. Heterosis breeding has been commercially exploited and a number of popular hybrids have been developed in both public and private sector (Dhatt and Khosa, 2015)

***Breeding for Resistance:*** Breeding for resistance is economical and environment friendly approach for controlling the insect-pest and diseases. It involves several steps, and breeding procedures vary with the nature of pathogen, source of resistance, inheritance of resistance, quality and horticultural traits required in a resistant variety. Screening of germplasm for resistance against diseases, insects and viruses needs collaboration with the experts of respective field. The initial screening of large collections can be carried out at the hot spots for particular diseases; however, confirmation of resistance should be done under artificial conditions for specific races. The stage of plant can be different for different diseases, as cotyledon leaves are inoculated for screening downy mildew and bacterial wilt, whereas, first or second true leaf stage are taken for powdery mildew and viruses. Successive or sequential screening for multiple diseases resistance is done at different stages of the plant growth. Availability of resistant source follows the transfer in commercial variety having superior horticultural traits. Backcross method is generally followed for transfer of resistance controlled by one or two genes and recurrent selection for polygenes. Every cross generation is screened artificially and resistant plants are selfed and grown till the development of stable lines/population for resistance along with superior horticultural traits. Horizontal resistance, with broad genetic base and general adaptability is more stable than the vertical resistance. Host and parasite relationship has to be studied, so that characteristics of pathogen and genetics of resistance can be suitably correlated (Dhatt and Khosa, 2015)

Container to store palm wine

A bottle gourd

Container for drinking *mate* with a metal *bombilla*.

*Mate* carved and decorated as a drinking container

*Mate burilado* in Peru

Drinking *mate*

Buffallo engraved

Handicrafts

Bowls and spoons

**Fig. 10 : Bottles, mates, bowls and spoons from dried bottle gourd**

***Insect Resistance Breeding:*** Nath (1971) has reviewed insect resistance breeding in cucurbits.

The three major insects of cucurbits including bottlegourd are red pumpkin beetle (*Aulacophora* spp.), fruit fly (*Dacus* spp.) and aphid (*Aphis* spp). Red pumpkin beetle causes damage on seedlings and continues further. For effective screening the adult beetles at the rate of one beetle per seedling at the cotyledonary stage are released inside the cage. In gourds, a final observation with regard to the damage by adult beetle on cotyledonary leaves is made 10 days after seed germination. The degree of fruit damage by fruit fly is recorded in terms of damaged fruits showing punctures on each vine twice a week and after record such fruits are harvested. The fruits with no damage are left on vine till maturity to confirm their resistance against the fly at every stage of fruit development. The percentage of total fruit damaged throughout the season is calculated for each line.

The rating system is as follows:
Immune – no damage
Highly resistant – 1-10% damage
Resistant – 11-25% damage
Medium resistant – 26-50% damage
Susceptible – 51-75% damage
Highly susceptible – 76-100% damage
For screening against aphids, artificial infestation in the seedling stage is required.

The review discussed on the value of both crops as a rootstock to improve fruit yield and quality of cultivated watermelon. This is followed by important summaries on phenotypic and genetic variation of bottle gourd and citron watermelon genetic resources and implications for new cultivar design. Finally, the review highlighted value-added non-food and food-based products developed based on indigenous knowledge systems in SSA and availability and access to genetic resources of bottle gourd and citron watermelon for breeding, product design and deployment (Shimelis and Ngwepe, 2022).

***Varieties of Bottlegourd released in India:*** Varieties developed in India by selection from local material are Pusa Summer Prolific Long, Pusa Summer Prolific Round, Pusa Naveen, Pusa Sandesh, Pusa Samridhi, Punjab Long, Kalyanpur Long Green,

Narendra Jyoti, Narendra Rashmi, Narendra Sankar Lauki-4, Kashi Bahar, Kashi Komal, Pant Lauki-3, CO-1, Samrat, Rajinder Chamtkar, Arka Bahar, Azad Nutan and BBOG-3-2.

Those through hybridization and selection are Punjab Round (LC-11 × LC-5), Punjab Komal (LC-11 × LC-5), Narendra Dharidar (NDBG-108 × NDBG-1), Kashi Ganga-1 (IC 92465 × DVBG 151) and Thar Samridhi (Banswara Local-1 × Gujarat Local-1)(Dhatt, and Khosa, 2015)

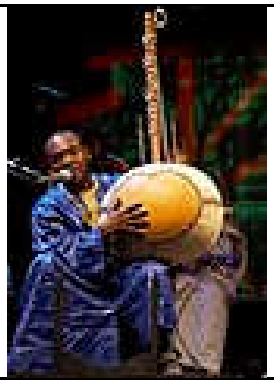
**Details of some of the varieties of bottlegourd released in India (Vidhi, 2022).**

***Pusa Summer Prolific Long:*** This was developed at IARI through selection from local germplasm. It is particularly suitable for growing as summer crop, although it can be grown in rainy season also. Fruits are 40-50 cm in length and 20-25 cm in girth and it has been released by IARI, New Delhi.

***Pusa Summer Prolific Round:*** This was developed through selection in local germplasm at IARI and has been released by the same institution. It has vigorous growth, round fruits of 15-18 cm girth. It is prolific bearer and heavy yielder.

***Pusa Meghdoot:*** This is an $F_1$ hybrid cultivar between Pusa Summer Prolific Long and Sel-2, developed and released by IARI, New Delhi in 1971. Fruits are long, light green and attractive. It is relatively early and suitable for cultivation in spring-summer season. It has shown considerable yield heterosis over Pusa Summer Prolific Long. No more in cultivation. Pusa Manjari. This is a round fruited $F_1$ hybrid cultivar developed and released at IARI in 1971 from a cross of Pusa Summer Prolific Round and Sel-11.


Bottle gourd flute


Musical instrument


Sitars and one rudra veena (down right)


Ektara (one string) resonator


The tambura or tanpura


Guitor


Sitar with resonator


Saraswati veena,


Rudra veena

**Fig. 11. Musical instruments from dried bottle gourds**

It has given 48% higher early yield and 106% total yield over Pusa Summer Prolific Round. Not commercially cultivated now.

***Pusa Naveen****:* This is a new variety developed and released by IARI. More than 75 collections were purified and evaluated under the renewed programme which was taken-up in 1984-85.

Sel-48 was released as Pusa Naveen by IARI variety release committee. It is high yielding (300 q/ha), and takes about 60 days for first harvesting. Fruits are perfectly cylindrical and straight without any crook neck or curve. Average fruit weight is 850 g.

***Punjab Komal****:* It is an early maturing, medium sized, oblong fruited variety developed and released by PAU, Ludhiana. Marketable fruits are available in about 70 days after sowing. The fruits are light green with pubescence. There are 10-12 fruits per vine. The fruits are tender and borne on medium long, thin pedicels on 4th or 5th node onwards. It is tolerant to cucumber mosaic virus. The yield potential is 400 q/ha.

***Arka Bahar:*** This was developed and released by IIHR, Bangalore. This is a selection in local cultivars of Karnataka. Fruits are straight, devoid of crook neck, medium in size, each weighing about 1 kg. The skin is light green. The flesh is shining, tender. The yield potential is about 400 q/ha in 120 days.

***Kalyanpur Long Green****:* This variety was developed at vegetable research station, Kalyanpur of CS Azad University of Agriculture and Technology, Kanpur. The vines are vigorous and long. Fruits are long with tapering and somewhat pointed blossom end. The yield potential is 300 q/ha in 120 days.

***Pant Sankar Lauki 1****:* A hybrid of PBOG 22 and PBOG 40 developed by GBPUAT, Pantnagar was released by CVRC in 1999. Fruits are 35 cm long. Yield is about 400 q/ha.

***Pant Sankar Lauki 2****:* A long fruited hybrid developed at Pantnagar. A few bottle gord hybrids from private seed companies in India are Warad, Shashi, Satya, etc. These are about 30-40 cm long, weighing 800-900 g at marketable stage.

## USES

- *Lagenaria siceraria* is a common sight everywhere in the tribal dominated pockets of Khammam district, where the ethnic groups mainly use the dry shells for carrying country liquor (mahua drink, toddy), honey and water.
- Domestic utensils like bottles, bowls, milk pots, spoons and containers of several types are made out of the dried shells.

- In some of the pockets, it is being used for making stringed and wind musical instruments and pipes.
- At few places, the natives use the dried shells as floats on water bodies as well.
- Though, it is nutritionally less calorific, tribals prefer bottle gourd as a vegetable for preparation of curries and pickles.
- The seed oil is used for both cooking purpose and as hair oil.

**Parle Milind and Satbir (2011) reported the following strange facts**

- The bottle gourd is so named because of one of its purposes: To serve as a bowl, cup, or bottle. In other parts of the world, it is known as calabash, lauki, doodhi, ghia, kaddu, tarkari.
- Bottle gourd is one of the excellent fruits gifted by the nature to human beings having composition of all the essential constituents that are required for good health and quality human life.
- It represents both earth and heaven in shape.
- It helps in losing weight quickly because it is low in fat and cholesterol, and provides high dietary fiber.
- Traditionally, lauki has been recommended for its anti-diabetic and aphrodisiac properties.
- The flesh of lauki has a cooling influence on the body.
- The ghiya juice is used in *Ayuvedic medicine* to treat high blood pressure and heart problems.
- Lauki has the highest content of choline (a lipotropic factor), a mental healer and also a precursor of acetylcholine, which is essential for memory than any other vegetable known to man till date.

The fruits of some cultivars of *L. siceraria* are used as a vegetable when young. These can be boiled, steamed, fried, used in curries or made into fritters. Cultivars differ markedly in sweetness or bitterness. Carefully selected cultivars are comparable to the popular summer squashes of temperate regions. Young shoots and flower buds of less bitter types are occasionally eaten as a green vegetable. Oil from the seeds has been used as cooking oil in Africa. Syrup made from the green fruit is used to treat bronchial disorders such as pectoral cough and asthma. Various medicinal uses of the leaves, fruit and seeds have been recorded from various countries, e.g. as a pectoral, an anthelmintic, a purgative and even as a headache remedy. The myriad of sizes and shapes of dried mature fruits accounts for the tremendous variation in the use of the dry shell (calabash) as containers and utensils in many parts of the world. Calabashes are used for storing and transporting drinking water, porridge, fresh or fermented milk, beer and wine, honey, ghee, animal fat, salt, tobacco, perfume, medicinal herbs, crop seeds or food grains. They are also used as beehives, as containers for brewing beer or for storing clothes (like a suitcase) as animal traps and decoys, animal feeders, air pumps, well buckets, vases, funnels, floats for fishing nets, beds for babies, washbasins, irrigation pots, cages for chicks, masks and containers for seedlings. Calabashes are also used to make decorative handicrafts, floats and musical instruments. In South America, the calabash gourds are dried and carved into "mates", the traditional container for mate, the popular caffeinated, tea-like drink brewed from the yerba mate plant. In the Polynesian islands, the calabash gourd is often dried when ripe and used as a traditional percussion instrument, the *ipu heke* in contemporary and ancient hula. Gourd containers are very common in Hawaii and on Easter Island, especially as water bottles. In Hawaii they are also used to make containers for a variety of uses, rattles, drums and head masks. On most Polynesian islands, calabash gourd containers are often elaborately decorated (Clarke et al., 2006; Sandoval, 2018). The young fruits are edible and are usually cooked as a vegetable. The mature gourds are made into water bottles, dippers, spoons, pipes, and many other utensils and containers; they can also be fashioned into birdhouses, fancy ornaments, lamps, and musical instruments (EEB, 2022).

**Cultural uses (WIKI, 2022)**

- Hollowed-out and dried calabashes are a very typical utensil in households across West Africa. They are used to clean rice, carry water, and as food containers. Smaller sizes are used as bowls to drink palm wine
- Calabashes are used in making the West African instruments like the Ṣẹ̀kẹ̀rẹ̀, a Yoruba instrument similar to a maraca, kora (a harp-lute), xalam/*ngoni* (a lute) and the goje (a traditional fiddle).
- They also serve as resonators underneath the balafon (West African marimba). The calabash is also used in making the *shegureh* (a Sierra Leonean women's rattle) and *balangi* (a Sierra Leonean type of *balafon*) musical instruments.
- Sometimes large calabashes are simply hollowed, dried and used as percussion instruments, especially by Fulani, Songhai, Gur-speaking and Hausa peoples.
- In Nigeria the calabash has been used to attempt circumventing a law requiring the wearing of a helmet on a motorcycle.
- In South Africa it is commonly used as a drinking vessel and a vessel for carrying food by communities, such as the Bapedi and AmaZulu.
- Erbore children of Ethiopia wear hats made from the calabash to protect them from the sun.
- South Africa's FNB Stadium, which hosted the 2010 FIFA World Cup, is known as The Calabash as its shape takes inspiration from the calabash.
- The calabash is also used in the manufacture of puppets.
- Calabash also has a large cultural significance. In many African legends, Calabash (commonly referred to as gourds) are presented as a vessel for knowledge and wisdom.
- The calabash is used as a resonator in many string instruments in India.
- Instruments that look like guitars are made of wood, but can have a calabash resonator at the end of the strings table, called *toomba*. The sitar, the surbahar, the tanpura (north of India, *tambura* south of India), may have a *toomba*. In some cases, the *toomba* may not be functional, but if the instrument is large, it is retained because of its balance function, which is the case of the Saraswati veena.
- Other instruments like rudra veena and vichitra veena have two large calabash resonators at both ends of the strings table. The instrument, Gopichand used by the Baul singers of Bengal is made out of calabash. The practice is also common among Buddhist and Jain sages.
- These *toombas* are made of dried calabash gourds, using special cultivars that were originally imported from Africa and Madagascar. They are mostly grown in Bengal and near Miraj, Maharashtra.
- These gourds are valuable items and they are carefully tended; for example, they are sometimes given injections to stop worms and insects from making holes in them while they are drying.
- Hindu ascetics (sadhu) traditionally use a dried gourd vessel called the kamandalu.
- In parts of India a dried, unpunctured gourd is used as a float (called *surai-kuduvai* in Tamil) to help people learn to swim in rural areas (Fig. : 10, 11, 12 )

**NUTRITIONAL VALUE**

It is generally grown for its tender fruits, which contains 96.1 g water, 2.5 g carbohydrates, 0.6 g fibers, 0.5 g minerals, 0.2 g proteins and 0.1 g fats in 100 g edible parts of the fruit (Gopalan *et al.*, 1982). The serving size of 116 grams of bottlegourd contains 16 calories and provides 13% of Vitamin C and 7.36% of zinc. The same amount of Bottle gourd provides 174 mg of Potassium, 13 mg of Magnesium, 15 mg of Phosphorus and 2 mg of Sodium. Bottle gourd possess various amounts of nutrients, minerals, vitamins, lipids and amino acids (EEB, 2022). Bottle gourd has many health benefits.

Artifacts

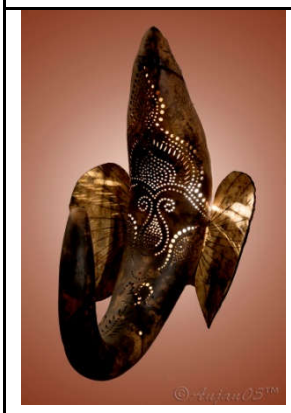
*Salakot* (the top one is made from calabash)

Artifacts

Puppet

A *fixed-key* balafon, showing gourd resonators with membrane holes

Birdhouse from Dried Fruit



Lord Ganesha shaped lamp shade

Snuff bottle

Gourd shaped Sake bottle (tokkuri)

**Fig. 12. Puppets, bird house, bust etc from dried bottle gourds**

These benefits are obtained as gourd bottle provides many nutrients and vitamins. Among them are zinc, calories and others. In 116 grams of Gourd contains 16% of calories, 13% vitamin C, zinc as much as 7.36%. In addition, the bottle gourd also provide many minerals such as potassium and others. While in 116 grams provides 174 mg potassium, 13 mg of magnesium, 2 mg sodium, as well as providing 15 mg of phosphorus (Syakira, 2022). Kobme (2022) reported that bottle gourd is extremely low in saturated fats and cholesterol and is rich in water and nutrients required to lose fat from the body. The vegetable contains essential nutrients like Vitamin C, Vitamin B, Vitamin K, Vitamin A, Vitamin E, Iron, Folate, Magnesium, and Potassium.

146g bottle gourd nutrition contain: Calories 22, Total Fat 0g, Saturated Fat 0g, Trans Fat 0g, Polyunsaturated Fat 0g, Monounsaturated Fat 0g, Cholesterol 0mg, Sodium 2.9mg, Potassium 248mg, Total Carbohydrates 5.4g, Dietary Fiber 1.8g and Protein 0.9g. Hassan et al. (2008) in a study on bottle gourd seeds showed a profile of seventeen amino acids (isoleucine, leucine, lysine, methionine, cysteine, phenylalanine, tyrosine, threonine, valine, alanine, arginine, aspartic acid, glutamic acid, glycine, histidine, proline and serine) with glutamic acid, leucine and aspartic acid being the predominant amino acid. The percentages (%) of essential and non-essential amino acids in dehulled seeds, whole seeds and seed coats were 44 vs 56, 41 vs 59 and 51 vs 49 respectively.

The dehulled seeds contained essential amino acids that were found to be higher than WHO/FAO/UNU requirement. In whole seeds, threonine, lysine and lysine were found to be the most limiting amino acids. Seed coats were deficient in all the essential amino acids except for valine. Generally, the mineral composition of the seed was found to be relatively high, indicating the seed to be a good source of dietary elements, except for Ca, Zn, Co and Cr where very low values were obtained. Finally, the results of the study indicate that, bottle gourd seed is a potential source of protein, lipid, micro and macronutrients, and if properly utilised, could contribute in solving the problem of malnutrition and also serve as raw material for agro-based industries.

**HEALTH BENEFITS:** Bottle gourd forms an excellent diet being rich in vitamins, iron and minerals. The fruit is reported to contain the triterepenoide cucurbitacins B, D, G, H, two sterols viz., fucosterol and campesterol, aerpene byonolic acid (an allergic compound), flavone-C glycosides (a ribosome inactivating protein) and lagenin. Extract of the ghiya seeds show antibiotic activity. The fruit juice is helpful in constipation, premature graying hair, urinary disorders and insomnia. Lauki has the highest content of choline among all the vegetables known to man till date, which serves as the precursor of neurotransmitter acetylcholine, which in turn is crucial for retaining and enhancing memory. Furthermore, *Lagenaria siceraria* is a vegetable useful in the management of many diseases like cardiac disorders, hepatic diseases and ulcer. Bottle gourd juice helps to regulate blood pressure of hypertensive patients, because of its high potassium content. It helps in losing weight quickly, because of its high dietary fiber and low fat and cholesterol content (Parle Milind and Satbir, 2011). Bottle gourd is traditionally used as cardio protective, general tonic, diuretic (stem bark), aphrodisiac, mild purgative, cooling agent, analgesic, anti-ulcer agent, antipyretic, broncho-dilator, antibilious, emetic (roots), alopecia, leucoderma, dropsy (seeds), worm infection (seeds), migraine (topical seed oil), toothache, gingivitis, diabetes mellitus, antidote to certain poisons such as scorpion stings (Parle Milind and Satbir, 2011). Bottle gourd may have nutritional properties, might have anti-inflammatory properties, and may have pain-killing properties. Fruits of bottlegourd are widely used in Ayurveda and other folk medicines traditionally used for its cardioprotective, cardiotonic, general tonic, diuretic, aphrodisiac, antidote to certain poisons and scorpion strings, alternative purgative, cooling effects. It cures pain, ulcers and fever and used for pectoral cough, asthma and other bronchial disorders-especially syrup prepared from the tender fruits. (Kumar et al., 2017).

**Major Health Benefits of Bottle Gourd (Sharma, 2018):** (1) Aids in weight loss: The low calorific value of bottle gourd makes it very beneficial for individuals who are on a weight loss regime and would like to get rid of some extra pounds. One can enjoy bottle gourd without the guilt of excessive calorie load as 100 grams of bottle gourd only provides 14 calories of energy. Dietary fibers in bottle gourd provide satiety to the stomach and thus controls overeating which is a major cause of obesity. Around 92 percent of bottle gourd is water that improves metabolism, aids digestion, and controls weight gain, and further helps the weight loss program.

**Keep our digestive system healthy**: Consuming bottle gourd improves our digestive health and is beneficial for our stomach. The laxative properties of the dietary fibers in bottle gourd improves bowel movement and ensures smooth elimination of stool from the system. This relieves constipation and other gastrointestinal problems like abdominal pain, gas, bloating and flatulence, etc. High water content (around 92 percent) in the bottle gourd also improves digestive health as it promotes digestion and smooth bowel movement. Vitamin C and other antioxidantal compounds like phytonutrients and polyphenols in the bottle gourd protect our digestive system from free radical damage and minimizes the risk of several cancers like abdominal cancer, pancreatic cancer, intestinal cancer, and stomach cancer, etc.

**Provides cooling effect**: Consuming bottle gourd keeps us well hydrated and also provides a cooling effect because of its high water content (around 92 percent). Water plays an important role in keeping us healthy as it is needed for various biological and cellular functions like providing moisturization to joints and tissues, improving metabolism, preventing dehydration, assisting digestion, maintaining the health of vital organs like liver and kidneys, etc. Our water is made up of around 60 percent water, and for organs like lungs and kidneys, it is even higher than 80 percent.

**Helps in treating urinary tract infection:** The diuretic properties of the bottle gourd help in the prevention and treatment of urinary tract infections. Because of its diuretic properties, it increases the frequency and flow of urine and thus helps in the removal of toxins, pollutants, excess fluids, excess salts, and other unwanted substances from the body. This improves our renal health and reduces the risk of urinary tract infection. Diuretic properties of bottle gourd are even more beneficial for individuals who find it difficult to pass urine efficiently. Vitamin C and other antioxidantal compounds like phytonutrients and polyphenols in the bottle gourd protect the vital organs like the liver and kidneys from free radical damage. Dietary fibers also help with detoxification and further improves our renal health.

**Reduces the risk of insomnia**: Sleep plays an important role in our well-being as our body and brain perform various functions even during the sleep stage. Quality of sleep is more important than quantity of sleep, and not getting enough sleep or quality sleep can give rise to various health problems like increased risk of cardiovascular problem, increased risk of hypertension, increased risk of diabetes and neurodegenerative diseases, etc. The rich nutritious profile of, bottle gourd helps in getting quality sleep and reduces the risk of insomnia and other sleep disorders. Vitamin B complex in the bottle gourd provides relief from stress and anxiety and allows us to enjoy quality sleep. Other nutrients like zinc, iron and magnesium, etc in the bottle gourd also improve sleep quality. Drinking a fresh bottle of gourd juice added with few drops of sesame oil is beneficial against insomnia.

**Keeps us hydrated**: Consuming bottle gourd keeps us hydrated because of its high water content ( around 92 percent). Water plays an important role in keeping us healthy as it is required for various biological and cellular functions. Bottle gourd helps control extreme thirst and replenish the lost water in the body. It also improves the functionality of vital organs like living and kidneys that contains more than 75 percent water.

**Aids in controlling hypertension or high blood pressure**: Potassium, a vital mineral present in the bottle gourd is a natural vasodilator that relaxes our blood vessels, improves blood circulation, and thus provides relief from high blood pressure or hypertension. Hypertension is a state of elevated blood pressure that affects millions of people around the world and gives rise to various cardiovascular problems like heart attack, heart stroke, and coronary artery disease. It is a silent killer and doesn't have noticeable symptoms in the early stages. Low sodium content in the bottle gourd also plays a significant role in providing relief from hypertension. If you are already taking medication to regulate blood pressure then consult your doctor about the inclusion of bottle gourd in your diet to ensure that there won't be any food-drug intolerance.

**Manages cholesterol levels**: The dietary fibers in the bottle gourd reduce the level of bad LDL cholesterol in the body and thus helps in managing cholesterol levels. The reduction of LDL cholesterol reduces the risk of atherosclerosis, a condition that leads to hardening and narrowing of the arteries due to the accumulation of plaque and fat deposits within the arterial walls. Atherosclerosis is a leading cause of various cardiovascular problems.

**Improves cardiovascular health**: The abundance of essential nutrients in the bottle gourd keeps our heart healthy and improves our cardiovascular health. Vitamin C and other antioxidantal compounds like phytonutrients and polyphenols in the bottle gourd protect our cardiovascular system from free radical damage. Dietary fibers in bottle gourd reduce LDL cholesterol and thus reduces the risk of

atherosclerosis, a leading cause of various cardiovascular problems. Potassium, a natural vasodilator in the bottle gourd provides relief from hypertension or high blood pressure that give rise to various cardiovascular problems like heart attack, heart stroke, and coronary artery disease, and as well as other health problems. Iron, zinc, magnesium and vitamin B complex, etc in the bottle gourd also improves our cardiovascular health.

**Keeps our liver healthy**: The liver is a vital organ that removes toxins, pollutants, and other unwanted substances from the body, and also performs other functions like production of bile juice, production of cholesterol, hormones and bilirubin, enzyme activation, storage of glycogen, metabolism of fat, protein, and carbohydrates, etc. Regular consumption of bottle gourd or bottle gourd juice aids in maintaining our liver health. Vitamin C, an anti-inflammatory compound present in the bottle gourd reduces liver inflammation. Vitamin C and other antioxidantal compounds such as phytonutrients and polyphenols in bottle gourd also protect the liver from free radical damage and thus contribute to better liver health.

**Reduces the risk of several types of cancer(s):** The antioxidants present in the bottle gourd fight with the free radicals of our body, stabilize them, and thus prevents them from causing oxidative damage to our cells and reduces the risk of various cancers. Vitamin C, vitamin A and other antioxidnatal compounds like phytonutrients and polyphenols, etc in the bottle gourd protects our cells and tissues from the free radical damage and thus reduces the risk of several types of cancers like colon cancer, abdominal cancer, breast cancer, and lung cancer, etc. Free radicals are formed during the oxidation process. These are unstabilized ions that obtain stabilization by stealing electrons from neighboring molecules and while doing so, it causes oxidative damage to them.

**Good for diabetic patients**: With a low glycemic index of 15, bottle gourd slows down the rate at which sugar is released into the bloodstream, prevents a sudden spike in blood sugar level, and thus helps in managing diabetes. Additionally, dietary fibers in bottle gourd reduce sugar absorption into the bloodstream and thus regulates blood sugar level. Excessive intake of bottle gourd should be avoided as otherwise, it may drop blood sugar to an abnormally low level giving rise to hypoglycemia with symptoms like shakiness, dizziness, sweating, hunger, moodiness and fast heartbeat, etc. If you are already on diabetic medication, then consult your doctor before adding bottle gourd to your diet to ensure there's no food-drug intolerance.

**Provides relief from inflammation**: Vitamin C, an anti-inflammatory compound present in the bottle gourd provides relief from pain and inflammation caused by anti-inflammatory compounds like joint pain, arthritis, rheumatism, asthma, and bronchial asthma, etc.

**Aids in detoxification**: The detoxifying properties of the dietary fibers in bottle gourd eliminates toxins, pollutants, and other unwanted substances from the body. Removal of excess toxins reduces the burden of detoxification from the liver and kidneys to some extent, allowing them to focus on other functions they need to perform. Additionally, antioxidants like vitamin C and other relevant compounds like phytonutrients and polyphenols in bottle gourd protect vital organs like the liver and kidneys from free radical damage and further improves detoxification.

**Strengthens immune system**: Consuming bottle gourd strengthens our immune system, the sophisticated defense mechanism of the body that aids in the prevention and treatment of various microbial infections, injuries, and diseases, etc. Vitamin C and other antioxidantal compounds like phytonutrients and polyphenols etc in the bottle gourd protects our immune cells aka white blood cells from the free radical damage, and thus strengthens our immunity. Vitamin C also enhances the production of white blood cells and further strengthens immunity. When our immune system is stronger, we are less likely to be suffering from cough, cold, fever, and flu, etc. Zinc, iron, potassium, magnesium and vitamin B complex, etc also play a significant role in making our immune system stronger.

**Eating bottle gourd during pregnancy**: The rich nutritious profile of bottle gourd makes it very beneficial during pregnancy. During pregnancy, a woman needs to ensure that she is enjoying healthy meals loaded with essential nutrients like vitamins and minerals, etc. What she eats not only determines her health but also the health and wellness of the fetus developing in her womb. Vitamin C and other antioxidantal compounds like phytonutrients and polyphenols in bottle gourd protect the uterus and the fetus growing in the womb from free radical damage. The low glycemic index of bottle gourd reduces blood sugar level, and thus minimizes the risk of gestational diabetes. Dietary fibers in it manage cholesterol levels and also regulates blood sugar levels. Folic acid in the bottle gourd helps in the growth and development of the bones and minimizes the risk of neural tube defects like spina bifida etc. Iron, zinc, copper, and magnesium, etc in the bottle gourd also plays an important role in maintaining a healthy pregnancy.

**Make our bones stronger**: Consuming bottle gourd strengthens our bones and reduces the risk of osteoporosis due to the presence of bone-strengthening minerals like potassium, magnesium, phosphorus, and manganese, etc. Osteoporosis is a bone disorder in which our bones become weak and fragile, and are prone to damage and fracture.

**Beauty Benefits of Bottle Gourd for Skin (Sharma, 2018)**

**Reduces the risk of premature ageing**: Antioxidants and other relevant compounds like vitamin C, vitamin A, phytonutrients and polyphenols, etc in the bottle gourd protects our skin cells and tissues from free radical damage and thus reduces the risk of various signs of premature aging like fine lines, wrinkles, age spots, dark spots, and skin blemishes, etc. Other nutrients like zinc, selenium and vitamin B complex, etc also helps in maintaining healthy skin.

**Maintains skin health**: Vitamins, minerals, and other essential compounds present in the bottle gourd make our skin soft, supple, and radiant, and thus maintains our skin health. Antioxidantal compounds of bottle gourd protect the skin from free radical damage, and thus minimizes various signs of premature aging. Dietary fibers in the bottle gourd remove toxins and other impurities from the skin pores and thus contributes to better skin health. A high level of water (around 92 percent) in the bottle gourd keeps our skin well moisturized and hydrated, and thus makes it soft and supple. Antioxidants in bottle gourd enhance the production of collagen and maintain skin elasticity. Other nutrients like zinc, copper, selenium, etc in the bottle gourd helps in bringing out the natural glow of the skin and are thus beneficial for skin health.

**Aids in the treatment of acne**: Consuming bottle gourd or the bottle gourd juice and as well topical application of the same minimizes the risk of skin problems like acne and pimples. Acne is a common skin problem that affects millions of people around the world and is primarily caused by the accumulation of toxins, pollutants, dirt, impurities, and other unwanted substances from the skin pores. The detoxifying properties of the dietary fibers in bottle gourd eliminates toxins, pollutants, and other unwanted substances from our body. When there are fewer toxins in our system, they don't accumulate in our skin pores, and thus minimizes the risk of acne and pimples. Also, the dietary fibers in the bottle gourd control the secession of excess oil from skin glands, and thus prevents the acne from worsening.

**Increases collagen production**: Vitamin C, an antioxidantal compound present in the bottle gourd increases the production of collagen in our system. Collagen is an important amino acid that maintains our skin elasticity and is mainly found in the connective tissues like joints, tendons, bones, and cartilages, etc. Collagen provides shape and elasticity to the skin, tightens skin, and makes our skin wrinkle-free. Antioxidants like vitamin C and vitamin A also

protect our skin cells from free radical damage and keep various signs of premature aging at bay.

**Protects our skin from uv rays of sun:** Antioxidants like vitamin C, vitamin A and other relevant compounds like phytonutrients and polyphenols, etc present in the bottle gourd protects our skin cells from harmful UV rays of the sun, and also reduces the risk of skin cancer. Prolonged exposure to UV rays to the sun can give rise to problems like wrinkles, leathery skin, liver spots, actinic keratosis, solar elastosis, and eye problems.

**Good for skin detoxification**: The dietary fibers in the bottle gourd is a natural detoxifier that eliminates toxins, pollutants, and other unwanted substances from our skin pores, and improves our skin health. This reduces the risk of skin problems like acne and pimples. Additionally, antioxidants like vitamin C in the bottle gourd not only protect our skin cells from free radical damage but also helps in the elimination of toxins, pollutants, and other unwanted substances from the body. The abundance of water (around 92 percent) in the bottle gourd also helps with skin detoxification.

**Heals skin blemishes**: Vitamin C, vitamin E, and other relevant compounds in the bottle gourd protect the skin cells from free radical damage and diminishes skin blemishes like acne, scars, pimples, and other skin marks. It helps in bringing out the natural glow of the skin. Dietary fibers help with skin detoxification and contribute to skin health. Vitamin E, an essential nutrient for our skin provides nourishment to the skin and makes it healthy.

**Beauty Benefits of Bottle Gourd for Hair (Sharma, 2018)**

**Promotes hair growth**: Bottle gourd promotes hair growth due to the abundance of essential nutrients like vitamins, minerals, antioxidants, etc in them. Antioxidants like vitamin C and other relevant compounds like phytonutrients and polyphenols in the bottle gourd protect our hair follicles and scalp from free radical damage and minimizes signs of premature aging like greying of hair, splitting of hair, dry hair, split ends, etc. Potassium in the bottle gourd improves blood circulation in the scalp and thus provides nourishment to our hair follicles and scalp. By nourishing our hair follicles, they make them strong and lustrous, and a healthy scalp promotes the growth of new hairs. Other nutrients like zinc, copper, Iron, etc. also play a significant role in promoting hair growth.

**Make our hair strong and lustrous**: Consuming bottle gourd or bottle gourd juice and as well as topical application of the same improves our scalp health and make our hair strong and lustrous due to the abundance of nutrients like vitamins, minerals, and antioxidants in them. Antioxidants like vitamin C, vitamin E, phytonutrients and polyphenols, etc in the bottle gourd protects our hair follicles and scalp from the free radical damage. This improves scalp health, improves blood circulation in the scalp, and nourishes our hair follicles and scalp efficiently. Other nutrients like beta-carotene, vitamin E, zinc, iron, etc. also play a major role in making our hair strong and lustrous.

**Reduces the risk of scalp acne:** Acne is a common skin problem mainly caused by the accumulation of toxins, pollutants, and other unwanted substances within the skin pores. It can also breakout on the scalp, and is known as scalp acne. Dietary fibers in the bottle eliminate toxins, pollutants, and other unwanted substances from our body and thus prevents the accumulation of toxins in our skin and scalp pores. This minimizes the risk of acne and scalp acne. Antioxidants like vitamin C and vitamin E also contribute to detoxification. Dietary fibers also regulate the secretion of excess oil from skin glands and prevent scalp acne from worsening.

**Controls hair fall:** Nutrients like vitamins, minerals, antioxidants, and dietary fibers in the bottle gourd promote scalp health and strengthen our hair follicles. Antioxidants and other relevant compounds in the bottle gourd protect our hair follicles and scalp from free radical damage, strengthens them, and keep various signs of premature aging like greying of hair, hair fall, dry hair, and split ends, etc at bay. Potassium improves blood circulation in the scalp, provides nourishment to our hair follicles and scalp. This strengthens our hair follicles, and thus controls hair fall, dry hair, and split ends. Zinc, iron, and selenium, etc also contribute to better scalp health. These compounds make our hair strong and lustrous and prevent them from being dry and flaky.

**According to Singh (2022) the following are the health benefits:**

**Potential Uses of Bottle Gourd for Liver:** Bottle gourd might have properties that may be good for the liver, as per several animal studies. Bottle gourd may offer many potential benefits, helpful in liver condition and functions. These possible benefits have been observed in animal trials. You must still contact your healthcare provider before using a bottle gourd for any liver ailment.

**Potential Uses of Bottle Gourd for the Brain:** Consuming bottle gourd may show beneficial effects on the memory. Certain compounds in bottle gourd may show pain-relieving and central nervous system (CNS) depressant activity by acting on the brain. CNS depressant activity might indicate its possible effects on calming the mind. Before using a bottle gourd for its benefits for the brain, you should contact your healthcare provider and get a proper diagnosis and treatment.

**Potential Uses of Bottle Gourd for Cancer:** Bottle gourd extract might act against the cancerous cells, as per an animal study. In addition, its stem extract may show potent cytotoxic (a group of medicines that contain chemicals which are toxic to cells, preventing their replication or growth, and so are used to treat cancer) activity against cancer cell lines as per a laboratory study. This anticancer activity of bottle gourd may be attributed to its potential antioxidant and cytotoxic abilities. These potential benefits of bottle gourd have been studied in laboratory studies. However, you must consult your doctor before using any herbal supplement or remedy to replace or discontinue ongoing treatment.

**Potential Uses of Bottle Gourd for Diabetes:** Bottle Gourd has been traditionally used to help with diabetes. Because of the low fat and high fibre content, bottle gourd may be recommended as the food of choice for people having diabetes. Bottle gourd extract could effectively reduce the blood glucose levels in diabetic animals, as indicated by an animal trial. The potential anti-diabetic benefits of bottle gourd have been observed in animal trials, and more studies are needed to validate these properties in humans.

**Potential Uses of Bottle Gourd for Obesity:** Bottle gourd might be a good option for losing weight as it is low in calories and contains mostly water. It is also rich in dietary fibre and contains low fat and cholesterol. These properties may help with weight management. You can add bottle gourd to your regular diet to help you manage weight. However, before using any herbal remedy for weight loss, you need to consult your healthcare provider about its potential uses and side effects.

Potential Uses of Bottle Gourd for Skin: Bottle gourd is a good source of vitamin C and zinc that may offer several skin benefits. Vitamin C is an essential vitamin for overall skin health. It may protect the skin from the damage caused by ultraviolet radiation. It may also help to prevent signs of skin ageing, such as skin sagging. It may also help strengthen the skin barrier by enhancing the production of skin barrier lipids. If you are suffering from any skin ailments, contact a skincare doctor or dermatologist, as they will be able to guide you about the uses and limitations of herbs and vegetables.

**FEB (2022) repoted the following Health Benefits of Bottle gourd:** Bottle gourd possess high amount of fiber which prevents the constipation, piles and flatulence. The cholesterol and fat in Bottle gourd is very low. The richness in Vitamin B and C assists in anti-oxidant properties. It consists of 92% water. The juiced or cooked Bottle gourd possesses anti-bilious and sedative properties.

**Acts as an antioxidant:** It is a well-established fact that reactive oxygen species (ROS) are implicated in more than 100 diseases, such as heart disease, stroke, arteriosclerosis, malaria, acquired immune-deficiency syndrome (AIDS), diabetes, and cancer. It is, therefore, important for researchers to seek natural sources of antioxidant. Such effects are generally credited to antioxidant components including plant phenolics such as phenyl propanoids and flavonoids Gallic acid was used as a reference antioxidant compound. The samples showed appreciably high DPPH radical scavenging effect at all concentrations. However, the ethyl acetate extract of fresh fruits was more active than the rest of the samples. The ethanol extract of fruits of *L. siceraria* was also evaluated for antioxidant activity. The results obtained in this study also indicated that the fruits are a potential source of natural antioxidants.

**Antihyperglycemic activity:** The anti-hyperglycemic activity of methanol extract of *L. siceraria* was evaluated in hyperglycemic rats. Extract was given at doses of 200 and 400 mg/kg per os (p.o.) to streptozotocin induced hyperglycemic rats for a period of 14 days. Fasting blood glucose (FBG) was measured on days 0, 4, 8, and 15 after treatment. There occurred significant reduction ($P < 0.001$) in FBG levels; other biochemical tests (SGPT, SGOT, ALP, total cholesterol, triglycerides), antioxidant assay (lipid peroxide, catalase, and glutathione), and histological study of the liver, the liver, kidney, and pancreas tissue, supported the conclusion. The research showed the potent anti-hyperglycemic activity of *L. siceraria*, which is probably attributable to its rich flavonoid content.

**Helpful for allergies:** The anti-asthmatic and anti-allergic activity of the aqueous extract of leaf of *L. siceraria* (LSA) was evaluated in different animal models. The histamine and acetylcholine induced broncho-constriction model in guinea pigs, the compound 48/80 induced mast cell degranulation model in rats, and the paw edema model in mice were used. The results of the study revealed a significant bronchodilator activity by LSA at doses of 150 and 300 mg/kg. Anti-inflammatory activity was observed at doses of 50, 75, and 100 mg/kg (intraperitoneal injection) against compound 48/80 induced paw edema in rats. These results support the traditional claim of the drug as a treatment for asthmatic disorders. It was also reported that the triter pene bryonolic acid, an anti-allergic compound, was isolated from callus culture of the roots of *L. siceraria*.

**Acts as Anti-hyperlipidemic:** Traditionally the fruit of *L. siceraria* had been used in the management of hyperlipidemia and atherosclerosis, as it had been thought to possess cardioprotective and cardio tonic potential. The effects of methanol extract of *L. siceraria* were investigated in experimentally induced hyperlipidemia in rats. Methanol extract of *L. siceraria* fruits (LSFE) at doses of 100, 200 and 300 mg/kg p.o. was given to the high fat diet induced hyperlipidemic rats for 1 month to evaluate its anti-hyperlipidemic potential. Oral administration of the extracts dose-dependently inhibited the total choles terol, triglycerides, and low-density lipoproteins level, and significantly increased the high-density lipoproteins level. The results of the study showed that the methanol extract from the fruits of L. siceraria has a definite anti-hyperlipi demic potential. In the study, petroleum ether, chloro form, alcoholic, and aqueous extracts of *L. siceraria* were evaluated for anti-hyperlipidemic activity. Out of the four different extracts, only the petroleum ether extract did not show anti-hyperlipidemic activity, while the other extracts showed good anti-hyperlipidemic activity.

**Cardiovascular health:** *L. siceraria* fruit is traditionally used for its cardioprotective effect. The cardioprotective activity of L. siceraria fruit was investigated using a doxorubicin induced cardiotoxicity model of Wistar rats. Group I of the Wistar rats (250–300 g) was the control group, and it received 2% gum acacia; group II was the doxorubicin treated group, and it received doxo rubicin 10 mg/kg; and group III was the doxorubicin with *L. siceraria* treated group, and it received *L. siceraria* fruit powder 200 mg/kg for a period of 18 days. The results of the study showed that after administration of L. siceraria there was a significant decrease in QT ($p < 0.01$) and in ST ($p < 0.05$), whereas there was a non-significant increase in heart rate, and a significant decrease in serum creatine kinase MB isoenzyme (a marker used to assist diagnoses of an acute myocardial infarction), aspartate amino transferase ($p < 0.001$), and lactate dehydrogenase ($p < 0.05$) compared with the doxorubicin group. The cardioprotective efficacy of L. siceraria fruit in isoproterenol induced myocardial infarction was also investigated in albino rat models. The results of this study showed that *L. siceraria* fruits possess cardioprotective activity on experimentally induced cardiotoxic myocardial infarcted rats.

**Immunomodulatory activity:** The immunomodulatory effects of n-butanol soluble and ethyl acetate soluble fraction of the successive methanol extract of *L. siceraria* have been evaluated. The fractions were administered through the oral route at doses of 100, 200, and 500 mg/kg. There was a significant inhibition in the delayed type hypersensitivity reaction in rats. The method of Doherty was used to induce delayed type hypersensitivity response in rats. A dose-dependent increase in both primary and secondary antibody titer was observed. Fractions also significantly increased both white blood cell and lymphocyte count.

**Antibacterial, Anthelmintic, and Antifungal activity:** Hydroalcoholic and aqueous extracts of the leaves of *L. siceraria* were evaluated for anthelmintic activity against Hymenolepis nana (tapeworm) and Pheretima posthuma (earthworm) by using the method of Mali. In Ethiopian traditional medicine, *L. siceraria* is widely used for the treatment of skin disorders. Goji et al. evaluated the antimicrobial activity of methanolic extracts of the leaves, seeds, and fruit flesh of *L. siceraria* using the agar-well diffusion method. Results revealed the extract to show activity against *Pseudomonas aeruginosa* and *Streptococcus pyogenes*, but not against clinical isolates of *Staphylococcus aureus* and *Escherichia coli*. Thus *L. siceraria* can be used to treat various skin disorders. The extracts also exhibited moderate antifungal action against *Aspergillus niger* and *Candida albicans*. The standard drugs used for comparison were ciprofloxacin for bacterial strains and griseofulvin for fungal strains.

**Benefits of bottle gourd (Kobme, 2022).**

- Bottle gourd is rich in dietary fiber, both, soluble and insoluble. Hence, it helps in curing constipation, flatulence, and even piles. It is also easy to digest.
- It promotes weight loss. The vitamins, minerals, and dietary fiber in lauki keep the body well-nourished and curb unnecessary appetite, especially if you drink its juice in the morning on an empty stomach. Its fat and cholesterol content is extremely low.
- It consists of approximately 96% of water and is, therefore, a great thirst quencher. It also prevents fatigue and keeps the body cool and refreshed during summer.
- Apart from the iron content it is also rich in vitamins B and C and helps in anti-oxidative actions.
- It also contains sodium, potassium, essential minerals, and trace elements, which regulate blood pressure and prevent the risk of heart ailments.
- High in sodium and potassium, bottle gourd is also an excellent vegetable for people with hypertension.
- It is a suitable vegetable for light, low-calorie diets as well as for children, people with digestive problems, diabetics, and those recovering from an illness or injury.
- Bottle gourd is recommended by Ayurveda physicians for balancing the liver function when the liver is inflamed and unable to process food efficiently for nutrition and assimilation.

**Traditional uses for Health Benefits (EEB, 2022)**

- Fruits are used as cardioprotective, general tonic, cardiotonic, aphrodisiac, diuretic, antidote to poisons and stings.
- The juice of bottle gourd is used to treat cardiovascular disorder, indigestion, stomach acidity and ulcers.

- It is used to treat of allergic and inflammatory disorders such as rhinitis, bronchial asthma, bronchitis, rheumatism and diabetes.
- A decoction of bottle gourd is used to treat of ascites, anasarca and beriberi.
- In India, the seeds are taken internally to cure headache.
- In Indian medicine, leaves are used as a purgative and soup of young shoots is used against constipation.
- In Benin, decoction of leaves is used for icterus.
- In India and Nigeria, a decoction made from leaf is used to treat jaundice.
- In Madagascar, a decoction made from root is used as enema.

**Bottle gourd Juice**

According to Swami Ramdev, by drinking the bottle gourd juice daily, one can get rid of the problems of *Vata, Pitta and Kapha*. It also relieves stress and improves heart health. Bottle Gourd juice is very easy to make. All one has to do is peel off the thin outer layer of the vegetable and put the rest in a mixer grinder to get a smooth paste. You can sieve it if you want or can drink it as it is. Many people do not like the taste of the bottle gourd juice. However, its health benefits are immense. Swami Ramdev shared a simple method of making bottle gourd juice that tastes delicious and helps to keep the body fit. According to Swami Ramdev, people who have problems of *pitta* and phlegm (*kapha*) apart from *vata* should drink 1 glass of bottle gourd juice daily. This will give a lot of relaxation to their body. Vitamin, potassium and iron are found in large quantities in bottle gourd juice other than fibre which helps lose weight. Therefore, consume it every morning on an empty stomach. Bottle gourd contains soluble fibre which helps in proper digestion. Potassium is found in bottle gourd juice, which helps in controlling blood pressure. Drinking bottle gourd juice regularly makes the heart strong as well as healthy. It improves the heart health very effectively. Many times there is a problem of inflammation in the liver due to wrong eating and lifestyle. For this, mix some ginger juice with bottle gourd juice and drink it. Consuming this will reduce the swelling of your liver (Health Desk, 2021).

**Benefits of bottle gourd juice (Kobme, 2022)**

Bottle gourd juice has a cooling effect on your body and keeps your body hydrated especially during summers. It keeps your stomach cool and reduces body heat. Since you tend to sweat a lot during summers, drinking bottle-gourd juice regularly helps in replenishing the water loss. In her book, 'Back to Nature with Ayurveda', Asha Devi suggests that bottle gourd juice is a great remedy for any kind of heat-related ailment like nose bleeding, pimples, or ulcers.

**Helps in weight loss:** Bottle gourd juice is widely used for weight loss. It is packed with fiber which helps in keeping you full for longer and it is also low in calories. In her book, '25 Fat Burning Juice Recipes' Asha Thorat explains that bottle gourd has been prescribed in Ayurvedic medicine to reduce flab." Fiber is the key to weight loss. Bottle gourd contains fewer calories with no fat. It also contains essential vitamins and minerals like Vitamin C Vitamin B, Vitamin K, Vitamin A, Vitamin E, Iron, Folate, Potassium, and Manganese," she says.

**Treats urinary tract infections:** Drinking freshly squeezed bottle gourd juice mixed with some lime juice is one of the bets natural remedies to treat urinary tract infections. Cures tummy troubles. Bottle gourd juice helps in curing constipation and also treats diarrhoea. The water and fiber content help in cleaning your digestive track and allows easy bowel movement. To treat diarrhoea, drink bottle gourd juice with a pinch of salt. This concoction helps in maintain the electrolyte balance of the body. According to Ayurveda, bottle gourd juice is great for digestion.

**Keep your heart healthy:** Regular consumption of bottle gourd juice on an empty stomach every morning helps in lowering your blood cholesterol levels and maintains healthy heart functions.

**Relieves stress:** Bottle gourd contains a good amount of choline –a kind of neurotransmitter that helps in improving the functions of the brain and helps in preventing stress, depression, and other mental disorders.

**An excellent post-workout drink:** Bottle gourd juice acts as a natural post-workout drink due to the presence of natural sugars in the vegetable which help in restoring the glucose levels and also replace the carbohydrates lost during your training session. Being rich in protein and other nutrients, bottle gourd juice also improves the efficiency of your muscles. A quick tip: Bottle gourd juice should always be consumed fresh. Peel and gourd and try a bit of flesh before blending, it shouldn't taste bitter. If it does, discard it. Also, it is advised to have bottle gourd juice alone and not mixed with other vegetables. However, you can add amla, ginger, fresh mint leave and some rock salt to spruce up the flavour.

**Toxicity (EEB, 2022).**

Like other members of the Cucurbitaceae family, gourds contain cucurbitacins that are known to be cytotoxic at a high concentration. The tetracyclic triterpenoid cucurbitacins present in fruits and vegetables of the cucumber family are responsible for the bitter taste, and could cause ulcers in the stomach. In extreme cases, people have died from drinking the juice of gourds. The toxic cases are usually due to the gourd being used to make juice, which the drinkers attested to being unusually bitter. Moreover, the victims in the three lethal cases were all diabetics in their 50 s and 60 s. However, the plant is not normally toxic when eaten and is safe to consume. The excessively bitter (and toxic) gourds are due to improper storage (temperature swings or high temperature) and over-ripening.

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