Cucurbita pepo L.

Monograph

Agricultural Science

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Table of contents

1.0 Introduction:

Many people eat zucchini every day in a mix of vegetables, but don't know its name. It's famously known in Rattatouille as a main vegetable used by Remy to cook his famous recipe. Zucchini has its ancestry thousands of years ago in Mesoamerica. It was transformed into the exotic name by the Italians in the 19th century. This monograph sets out to provide the reader an extensive introduction to zucchini, as well as its biology, how it grows, its management and how to take good care of it.

The interaction with planet earth, its origin and ecology are described in chapter two. Chapter three covers its biology, life cycle and interactions with other plants. Chapter four provides detailed information on how to grow and produce zucchini. Finally chapter five talks about the exports and imports of zucchini and a brief description of its culinary uses.

2.0: Ecology

2.1 Origin:

The origins of Zucchini are traced back to Mexico and the Americas back from 7,000 BC to 5,500 BC. Zucchini or *Cucuribita pepo* was a big part of the Mesoamerican diet that consisted of maize, beans and squashes (Zucchini). When Europeans arrived in the 15th century, they brought back to the old continent what they considered to be new foods, like squash or maize. Zucchini eventually arrived in Italy, where it was named zucchino. Many names have risen since the Europeans first saw squash. The French called it courgette and the Americans have adopted the term Summer squash, or field pumpkin. It is probable that Cucurbita pepo seeds from St. Augustine, and possibly also Hontoon Island type-2 and the large seed from Groves Orange Midden, are archaeological examples of domesticated Cucurbita pepo. The older Cucurbita pepo gourd remains from other Florida sites help establish the range and variability of seed size, and corroborate other morphological characteristics associated with independent or free-ranging Cucurbita pepo gourds. This baseline is important because it provides criteria of seed size and rind character that may be employed in determining which prehistoric gourd populations in eastern North America represent free-ranging and which represent truly domesticated forms of Cucurbita pepo, whether introduced or developed in situ. Such determinations are necessary to understand the timing and trajectory of indigenous plant husbandry systems. (Newsom, et al., 1993)

Cucurbita pepo (pumpkin, squash, gourd) is extremely variable in fruit characteristics. According to recent botanical and cultivated-plant taxonomic treatments that were based on variations in allozymes and fruit shape, *C. pepo* consists of three subspecies containing wild and cultivated, inedible, small-fruited sorts (gourds) and eight groups of edible, large-fruited cultivars (pumpkins and squash).

2.2 Present Distribution:

Not only has the cultivation of summer squash expanded in countries in which the crop is familiar, zucchini has spread beyond its origins. The United States and Mexico have been attributed the majority of Zucchini's production, but countries in the Middle East, Turkey, Italy and Egypt are responsible for one-third of the world's production. According to the FAO statistics in 2019, the production of Zucchini exceeded 6,300,000 metric tons per year. Not only that, the production and consumption of zucchini has risen exponentially over the past decades. **Paris (1996).** As seen in figure 1 below, Nowadays the top producer of fresh zucchini is China with 8.4 million metric tons produced each year. China produces around 36.5 % of the world's zucchini. Ukraine follows the list with 1.3 million metric tons produced each year. Russia is the last "millionaire" on the list with 1.2 million metric tons. Countries like Mexico, United States, Turkey, Bangladesh and Spain also appear in the list.

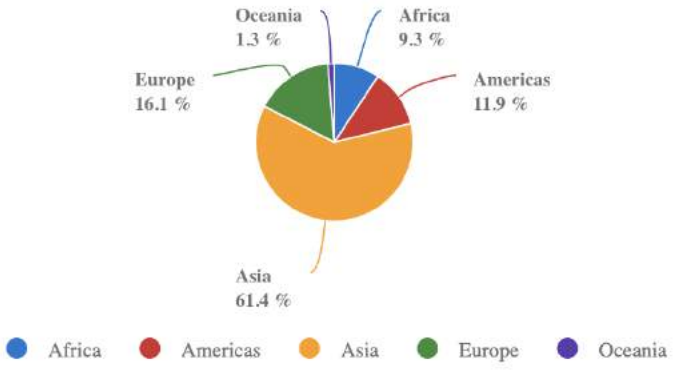
Figure 1

Global Production of Fresh Zucchini

Rank	Country	Country 2019	Production Quantity 2019	1-Year Growth in Qty 2018-2019	3-Year Growth in Qty 2016-2019	5-Year Growth in Qty 2014-2019
1	China	36.65%	8.38M	+2.17%	+6.79%	+15.92%
2	Ukraine	5.89%	1.35M	≈ 0.61%	+11.27%	+21.87%
3	Russia	5.23%	1.20M	≈ 0.34%	≈ -0.08%	-2.97%
4	Spain	3.21%	734.64K	+2.37%	+8.25%	+58.92%
5	Mexico	2.97%	679.15K	-12.49%	≈ 0.31%	+19.79%
6	Bangladesh	2.78%	634.95K	+5.8%	+118.32%	+49.75%
7	United States	2.67%	610.12K	-12.7%	-21.71%	-29.34%
8	Turkey	2.58%	590.41K	-4.27%	+20.49%	+50.03%
9	Italy	2.49%	569.12K	+3.77%	-2.22%	≈ -0.17%
10	Indonesia	2.29%	522.49K	+15.08%	-13.4%	+46.12%

Figure 2

Production share of Pumpkins, squash, and gourds by regions.



2.3 Taxonomy:

C. pepo consists of three subspecies containing wild and cultivated, inedible, small-fruited sorts (gourds) and eight groups of edible, large-fruited cultivars (pumpkins and squash). *C. pepo* subsp. *fraterna* (Bailey) Andres, *C. pepo* subsp. *texana* (Scheele) Filov, and *C. pepo* subsp. *pepo.* The first has been considered as the putative wild ancestor for the species as a whole and consists exclusively of wild gourd forms from northeastern Mexico (Andres, 1987). The second contains wild gourd forms from the United States as well cultivated ornamental gourds and edible-fruited forms. *C. pepo* subsp. *pepo* has not yet been found growing wild, but its presumed geographic area of origin is the most southerly of the three subspecies; it too contains ornamental gourds and edible-fruited forms. Variations in fruit shape, an easily observable, highly polygenic characteristic, are the basis for the cultivated-plant classification of *C. pepo* to eight groups of edible-fruited domesticates (Paris, 1986). To these are added two groups of domesticated, ornamental gourds.

Tomás Böhmer Eder: *Cucurbita pepo* L.

Taxonomic Tree

Kingdom: Plantae
Subkingdom: Viridiplantae
Infrakingdom: Streptophyta
Superdivision: Embryophyta
Division: Tracheophyta
Subdivision: Spermatophytina
Class: Magnoliopsida
Superorder: Rosanae
Order: Cucurbitales
Family: Cucurbitaceae
Genus: *Cucurbita*
Species: *Cucurbita pepo*

Figure 4

Related species of Zucchini

2.4 Elevation and climate:

Cucurbita pepo can be grown from the temperate zone to the tropics, so long as there is a warm growing season of at least 120 days. It can be grown at elevations from 500 - 1,000 metres in the tropics. It grows best in areas where annual daytime temperatures are within the range 17 - 30°c, but can tolerate 6 - 40°c. It can be killed by temperatures of 0°c or lower. It prefers a mean annual rainfall in the range 600 - 1,500mm, but tolerates 300 - 2,800mm Requires a rich, well-drained moisture retentive soil and a very warm, sunny and sheltered position]. Prefers a pH of 5.5 to 5.9, but tolerates up to 6.8. Plants are tolerant of light shade. *Cucurbita pepo*. (Lirira 2009)

The plant is demanding in terms of humidity. Brightness is important, especially during early growth and flowering periods. The light deficiency causes a decrease in the number of fruits, likewise, the light intensity determines the final ratio of staminate and pistillate flowers. It adapts to different types of soil, however it is a plant that requires a large amount of organic matter. Optimal pH values range between 5.6 and 6.8. It is a species moderately tolerant to the salinity of the soil and irrigation water. (Lira 2009)

2.5 Geology and Soils:

Zucchini doesn't necessarily require rich soil to grow, but they carry out best in soils that are high in organic matter with a pH of 6.5. Zucchini can struggle growing quality fruit in a different p.h scenario. The pH in the soil can affect the availability of many different nutrients. Zucchini can also struggle with excessive nitrogen. Excessive nitrogen can result in uncontrolled growth of green leaves, leaving a big expense on fruit production. (Walliser et al., 2020)

Zucchini is very easy to cultivate in temperate climates, therefore it has the prominence among garderes of massive production. To grow the best possible Zucchini water is a key component. You'll need to water the plant constantly. It needs about an inch of water, depending on the soil moisture. If it needs more water, add another inch of water. In countries with seasons, Zucchini needs water almost every week in springtime, increasing the times you water it after the temperature rises. Good soil is also essential for a healthy crop of zucchini. Usually the best soil is a combination of three; 40% sand, 40% silt, and 20% clay. Organic matter and compost should also improve the zucchini's health. Organic and natural pesticide works best for zucchini. Zucchini can be prone to pests like squash vine borers ,cucumber beetles and squash bugs (Figure 3).

2.6 Fossil Record

Under the Cucurbitaceae family, which Zucchini is a part of, the oldest fossil record of these types of plants are recorded back in the Paleocene epoch, almost 60 million years ago in Shirley Canal, Montana (McAndrews et al., 2010) Squash (Cucurbita spp.) had entirely different evolutionary partners tens of thousands of years ago in North America—mastodons, woolly

mammoths, and elephants—a relationship that influenced its gourds to be significantly smaller what we know now, and with bitter poisonous meat (Barrat 2015).

3.0. Biology:

3.1 Chromosome Complement:

Zucchini has 20 chromosomes (Montero-Pau et al., 2018)

3.2 Life cycle and phenology

3.2.1 Life cycle

According to the San Francisco Gate's gardening section, which quotes a research made by Missouri's Botanical Garden, the Zucchini's life cycle in the United States lasts for approximately one growing season. On the other hand, Zucchini's seeds can last for almost 5 years if stored correctly. The ideal spot for extended storage is a cool, dry place, which helps to prevent premature germination from taking place. Zucchini is a short-season crop, meaning that it takes only 60 days for the plant to reach maturity. After the 60 days, Zucchini squashes are ready to pick about a week after the flowers have been pollinated. (Contributor, S. G. 2020)

3.3 Reproductive Biology

Studies of floral morphology and reproductive biology in Cucurbitaceae which Zucchini is part of, are very important given the broad agronomic implications of this family and the high rate of fertilization and fruit set failure present among their members. Once the Current Microscopy Contributions to Advances in Science and Technology (A. Méndez-Vilas, Ed.) basic reproductive structure becomes clearly determined, it will be possible to analyze the behavior of commercial lines, hybrids, plants with different ploidy levels, etc. in order to improve some aspects of their reproduction, such as pollen loading, pollination efficiency and, finally, production of cucurbits. (Zienkiewicz, A et al., 2012)

3.3.1 Pollen

Zucchini (and other plants like cucumbers) may develop a dozen or more blooms early in the season, but these are mainly male flowers carrying pollen. There is no need for pollen if there are no female flowers. Because female flowers bloom before male flowers, pollen isn't always available. Female flowers will dry up and fall off if they are not pollinated. Pollination is influenced by the weather as well. Bees may not be present to help transport pollen from male flowers to female blossoms if the weather isn't dry and warm enough. Too little or too much water, as well as poor soil conditions, can cause plants to lose their flowers. (Torpey, 2014)

3.3.2 Sexuality

Some flowers have both male and female parts, others may only have male parts (staminate) or female parts (pistillate). When separate male (staminate) and female (pistillate) flowers are borne on the same plant, the plant is monoecious, meaning 'one house'. Zucchini is a monoecious plant. Because it has both male and female flowers, one zucchini plant will produce many zucchini to eat. Where separate male (staminate) and female (pistillate) flowers are borne on different plants, the plant is dioecious, that is two separate houses are required for reproduction (Hilton, 2007).

It takes two flowers to make zucchini. Most members of the *Cucurbitaceae* are monoecious, which means each plant has flowers with only stamens along with other flowers which are only pistillate. These are commonly called male and female flowers. They are easy to tell apart if you look beneath the corolla. The ovary is inferior (located beneath the other flower parts) or, to put it another way, the other flower parts are epigynous (they sit on top the ovary). Figure 4a and 4b below shows the staminate flower and the pistillate flower of zucchini.

Studies in our research group have shown that this delay in abscission of the floral organ correlates with an arrest of the female bud development, and its conversion into a bisexual bud: this phenotype is known as ‘‘sticky flower’’. (Gomez et al., 2004)

Figure 4a &b

Flowers of C. pepo (Hilton, 2007).

Tomás Böhmer Eder: *Cucurbita pepo* L.

3.3.4 Anthesis

To get a fruit of commercial value from the zucchini squash, Cucurbita pepo, a well-coordinated abscission of the female flower during fruit set is required. In Spain, zucchini is primarily grown in greenhouses in Almeria, where high temperatures during the spring and summer cause a cultivar-dependent fruit defect known as the "sticky blossom" syndrome. This condition is marked by a halt in floral organ growth and maturation, as well as a lack of female floral abscission, which reduces fruit shelf life, commercial quality, and value.

A well coordinated abscission of the female flower is essential for good fruit quality, since the failure of abscission and manual removal of the fruit accelerates rotting and infection of the crop. However, very little is known about floral organ abscission and its regulation by ethylene in cucurbits. In this work we present a characterisation of the flower abscission zone of Cucurbita pepo, morphotype zucchini, an evaluation of the role played by ethylene and auxins in the floral abscission, and the involvement of hydrolytic enzymes in the process. (Gomez et al.., 2004)

Figure 5

Anthesis process in a female flower of Zucchini

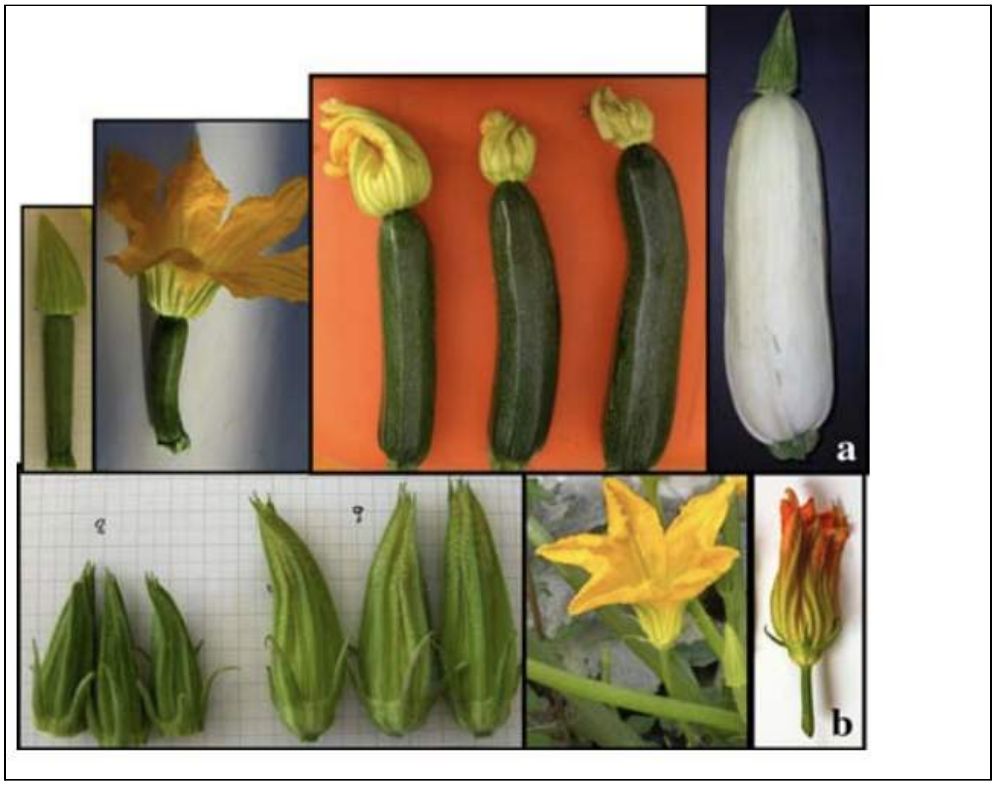


Fig. 5: Developmental stages of female flowers, from left to right: pre-anthesis 4, anthesis, postanthesis 1, postanthesis 2, postanthesis 3 and mature sticky flower. b Developmental stages of male flowers, from left to right: pre-anthesis 3 (three flowers), pre anthesis 4 (three flowers), anthesis and post-anthesis 1.

4.0: Propagation and Management

4.1: Cultivation of *Cucurbita pepo.*

Cultivated *C. pepo* is usually propagated by planting seeds in the ground. Sometimes, seeds are germinated in small pots and seedlings are transplanted to the field when climatic and edaphic factors are favorable . Transplant seedlings are often used to establish an early season crop or when using permanent beds. It has been reported that Cucurbita species that are developed from transplanted seedlings have luxuriant growth, larger fruit size and significantly higher seed yield compared to direct sowing methods. Commercially cultivated varieties are sometimes grown with traditional crops, like maize, beans or even in vegetable gardens along with other species. Plant density affects fruit size, yield and its number per plant. (Salehi et al., 2019)

4.2: Propagation from seed

To find success while planting Zucchini plants is finding good, reliable seeds. There are varieties of seeds like cocozelle, zephyr, and black beauty. Zucchini is a summer plant, meaning that the plant will have success growing in the summer. However, professional zucchini growers start seeding their zucchinis indoors in May. In addition to that, to grow the zucchini successfully, preparing the ground is necessary. This means, that the plant needs the obvious, sun and a rich soil. The soil needs to be fixed, loosed up, and mixed with compost. Beds seen in the Colegio Bolivar garden should be perfect to sow the seeds. One example is seen in **Figure 6** below.
Furthermore, the soil's temperature should be around 25-35ºC and the PH level should be 6-6.8 maximum. If you are planting from seeds, just sow 2-3 seeds of zucchini in 1-2 inches holes of the garden soil. Covet the holes with dirt and water gently to keep the garden and seeds moist. Make sure you leave 18-24 inches of space between holes. (Ya'u, 2021)

Figure 6

Zucchini plant grown in Beds

4.3: Irrigation

The first irrigation is important just after planting, and subsequent irrigation is given on a weekly basis or depending upon growth of the plant and soil condition. Waterlogging should be avoided throughout the cultivation process. However, in the absence of rain, the crop should be regularly watered. Irrigation is vital during flowering, fruit set and fruit fill, but should be minimized at the time of fruit maturity. Various types of irrigation methods are practiced in *Cucurbita* species cultivation, such as furrow, drip and overhead irrigation. (Salehi et al., 2019)

4.4: Management

In its native area of distribution (Mexico), *Cucurbita Pepo* is usually combined with maize, beans and with other species of the *Cucurbita* family. Where it's grown commercially, like in China, it's generally found as the sole crop. In the region of Mixteca Alta, Mexico, and particularly in San Andres Lagunas, some local variants have been found which are grown under two different sets of conditions and at two different times. One of these is known as heavy rain gourd (calabaza de temporal); it is grown on rocky ground, generally with abundant outcrops of limestone and commonly with little soil—that is, on dry ground. Sowing takes place in April and May, depending on the appearance of the first rains, and the ripe fruit is harvested in October and November. Another variant is known as the bowl gourd (calabaza de cajete); it is grown on ground called *cajete* (bowl), which is very flat and humid and situated in small valleys which are said to have once been occupied by lakes. In this form, it is sown at the start of the driest period of the year (February or March) and the ripe fruit is harvested between July and September. (Paris, 1996)

4.5: Tending: Pest and disease control

Cucurbita species are very prone to pests and diseases, and some pathogens attack this economically important crop. Thus, it is important to protect them to obtain a good quality and high commercial yield *Cucurbita*. Several notorious fungal pathogens are associated with *Cucurbita* species, e.g., *Cladosporium cucumerinum* which causes a scab or gummosis. (Zitter T.A 1986). The top 11 Zucchini diseases are:

1. Alternaria Leaf Blight
2. Bacterial Leaf Spot
3. Bacterial Wilt
4. Blossom End Rot
5. Cucumber Mosaic Virus
6. Downy Mildew
7. Fusarium Crown and Foot Rot
8. Powdery Mildew
9. Septoria Leaf Spot
10. Verticillium Wilt
11. Zucchini Yellow Mosaic Virus (Lofgren, 2022)

Zucchini can be prone to pests like squash vine borers ,cucumber beetles and squash bugs (Figure 7). Protecting these plants from pests can be easy and straightforward. Row covers can be effective to keep the adult bugs from laying their eggs. Other gardeners prefer using aluminium foil on the base of the plants to repel squash bugs. Another interesting method of protection is interplanting, to lure away the insects from the crop. These insects dislike lavender, catnipp, dill and marigold. It is obvious that insecticide can also be used. For Squash bugs, it's only effective in the eggs and the vine borers; it's effective when applied to the stem of the plant. For a more organic output in pesticide, growers use Neem oil as a non-toxic insecticide. (Grant, 2020)

Figure 7

Three prominent pest bugs of C. pepo. From left to right, vine borers, cucumber beetles and below, squash bugs.

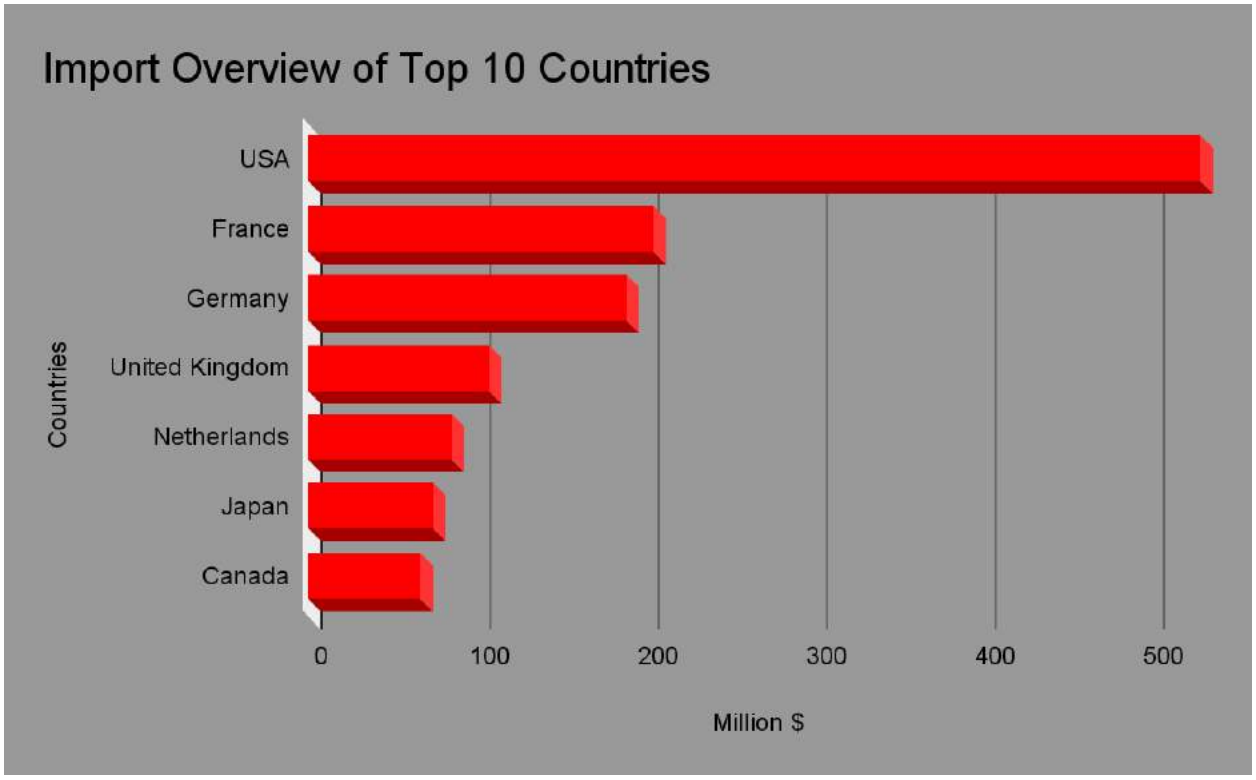
5.0: Products and Marketing

5.1: World Trade

5.1.1: Imports

Figure 8

Import overview of Top 10 countries measured by how much money spent per country in 2020. (Adapted from Tridge, 2022)

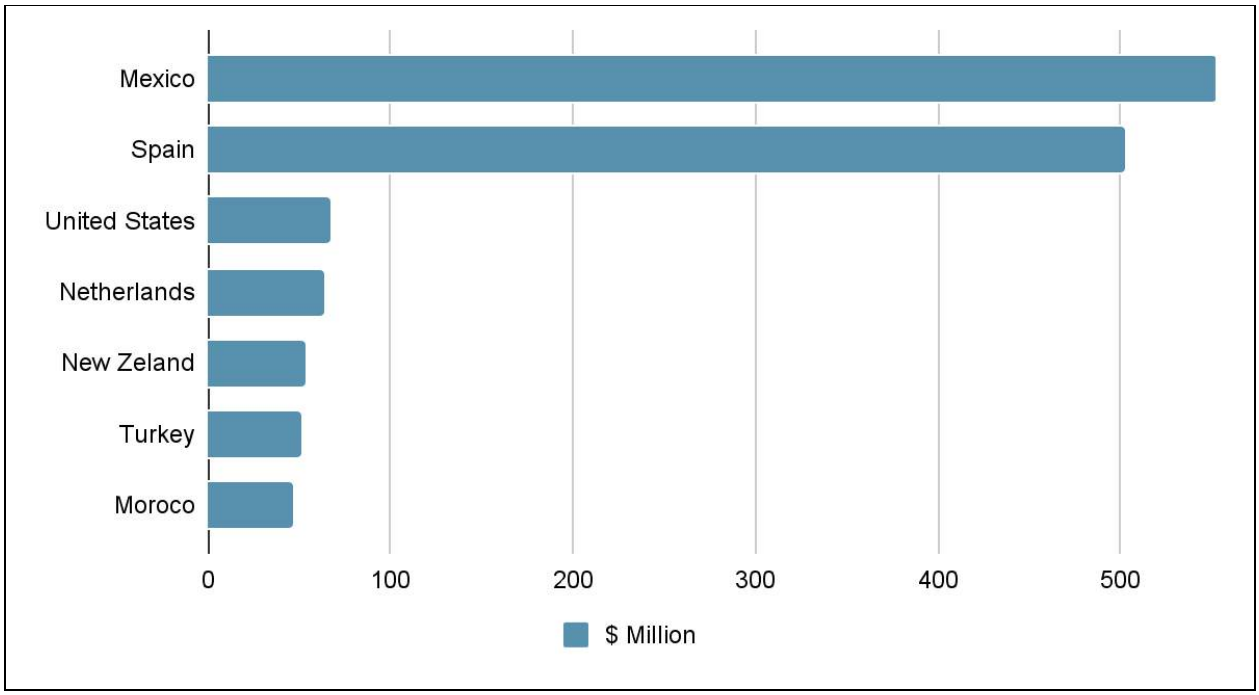


5.1.2: Exports

The main countries that export Zucchini are provided below in Figure 9

Figure 9:

Export overview of top ten countries that have the highest export values. (Adapted from from Tridge, 2022)



5.3 Products

5.3.1 Zucchini as food.

Zucchini can be prepared in a variety of ways. In contrast to cucumber, zucchini is typically served cooked. Steamed, boiled, grilled, filled and baked, barbecued, fried, or incorporated into other recipes such as soufflés and breads. It's also delicious when deep fried like tempura. Below figure 10 a, b and c will show the different presentation of zucchini as food.

One large zucchini (about 323 grams) contains 55 calories, 3.9g of protein, 1.0g of fat, 10.1g of carbohydrates, 3.2g of fiber, and 8.1g of sugar. Zucchini possesses many valuable minerals, including calcium, iron, magnesium, phosphorus, and plenty of potassium.

Figure 10a

Tempura Zucchini

Figure 10b

Baked Zucchini

Figure 10c

Zucchini in Ratatoullie

Tomás Böhmer Eder: *Cucurbita pepo* L.

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