

Jalapeño

Capsicum annuum L.



Esteban Villegas
Colegio Bolivar
Agriculture
2021-2022

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Introduction

Jalapeños scientific name is *Capsicum annum* which is a species of the plant genus *Capsicum*. *Capsicum annum* originates mainly from Mexico, but is also seen all around the World. *Capsicum annum* is famous for its hot and bitter taste. Some people like it, others not. In this monograph I would talk in chapter 2 about the origin of *Capsicum annum*, then in this same chapter I would talk about the environmental factors that affect the distribution of this fruit. I would also talk about the best climate, soils and elevation for *Capsicum annum* to grow. After this first chapter I would talk in chapter 3 about the biology of the plant. Then I would transition to chapter 3 that has precise information about the vegetation components of *Capsicum annum*. In chapter 4 I would go into more detailed information about the propagation and magnet of the plant. In chapter 5, I would step out of more scientific data and I would show the emerging products of *Capsicum annum* where the exports and imports would be seen via numerical data. I would conclude chapter 5 by showing the food items based on Jalapeño. Lately I would conclude my monograph with Chapter 6 that shows the medical uses of *Capsicum annum*. In overall his monograph is a good opportunity to see in a deep way how important a small plant can be and how there are multiple factors that have an effect on its growth.

2.0 Ecology and Biology

2.1 Ecology

2.1.1 Origin

The oldest macro remains identified as *Capsicum* pepper were recovered from pre-ceramic strata of dry caves located in two states in the central-east of Mexico: Puebla and Tamaulipas. These macro remains were found with macro remains of maize, squash, and other species that are utilized by humans. These macro remains were indirectly dated through associations in archeological strata in the around 9000-7000 B.P indicating a connection with the finding of chili peppers macro remains. Additionally there's evidence that suggests that remains of *Capsicum annuum* were also found, around 6000 B.P in areas with adequate climate conditions. These areas are the western and eastern coast of Mexico, southeast México and northern Guatemala. There was also genetic evidence that was directed during expeditions in the fall of 2006 and 2007. The evidence suggests that molecular-marker-based analyzed of genetic similarity among wild and domesticated types showed a broad area of high similarity in the northeastern part of Mexico, which included the states of San Luis Potosí, Nuevo León and Veracruz. (Kraft et al., 2014) At the end the multiple evidence suggest that long time ago *Capsicum annuum* was found in México primarily in the central east, and northeastern parts of México. Additionally *Capsicum annuum* was also found in the western and eastern coast of Mexico, southeast México and lastly northern Guatemala. *Capsicum annuum* was found mainly around the years 9000 to 6000 B.P Going into other information it has to be noted that the name jalapeño is originated from Xalapa which is the capital of Veracruz. So both in historical evidence and in its name it's seen how the jalapeño main origin comes from México.

2.1.2 Affinities. (Relationship)

The jalapeño (*Capsicum annuum*) is derived from the kingdom of Plantae species and comes from the family of Solanaceae. The jalapeño genus comes from *Capsicum* L. – pepper, and its species is *Capsicum annuum* L. – cayenne pepper. Now going more into detail into the Solanaceae family, it is a plant family that has 102 genera and around 2,5000 species, which are known for having a high economic value, used as drugs or food plants. Members of the Solanaceae family are found all around the world but are more concentrated and broadly distributed in the tropical regions of Latin America, where around 40 genera are endemic. A small number of members are located in temperate regions, and just about 50 species are found in Canada and the United States. Some members of the Solanaceae family are the eggplant (*S. melongena*), potato (*Solanum tuberosum*), tobacco (*Nicotiana tabacum* and *N. rustica*), belladonna (*Atropa belladonna*), and nightshades (*S. nigrum*, *S. dulcamara*, and others) e.t .c. (Encyclopedia Britannica, 2015). The heat of the peppers originates from the chemical compound capsaicin, which is measured by the Scoville scale. The jalapeño is accounted to be relatively mild varying from 1,000 to 8,000 J (Ozores-Hampton & Mcavoy, 2014)

2.1.3 Present Distribution

The top chili-producing countries (figure 1) are China, México, Turkey, Indonesia, Spain, Egypt, Nigeria, United States, Algeria, and Tunisia.

Regardless of not being the top producer of Jalapeño México, is one of the principal exporters of chili in the world. According to the Ministry of Agriculture and Rural Development (Sagraba), 29.71 % of México chile production is destined to the international market. Jalapeño is key in the present distribution because it is the chile with the biggest production. In present times the main location of chile in the international market for México is the United States with 77.99% of the chile being imported from México. Next in the list of imports from México is Canada with 55.45% and Guatemala with 52.25%. The average annual growth of Chile in México is 4.82%, but it estimated by Sagraba that between 2016 and 2030 the growth accumulated growth in production will be 61.40 %, and for exports 139.66% in millions of tons. The regions where Chile is produced the most in Chihuahua with 21.4 % of the production nationally. (Figure 2) Then there is Sinaloa with 18.4 %, followed by Zacatecas with 16.2 %. (Vite, 2019).

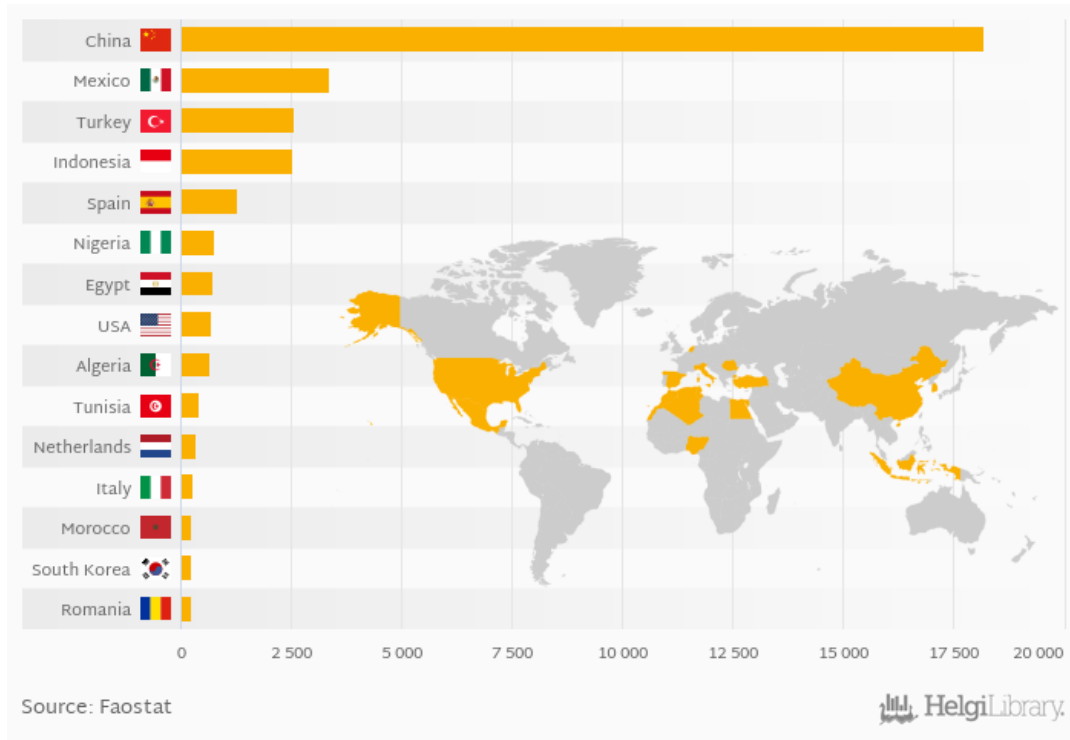
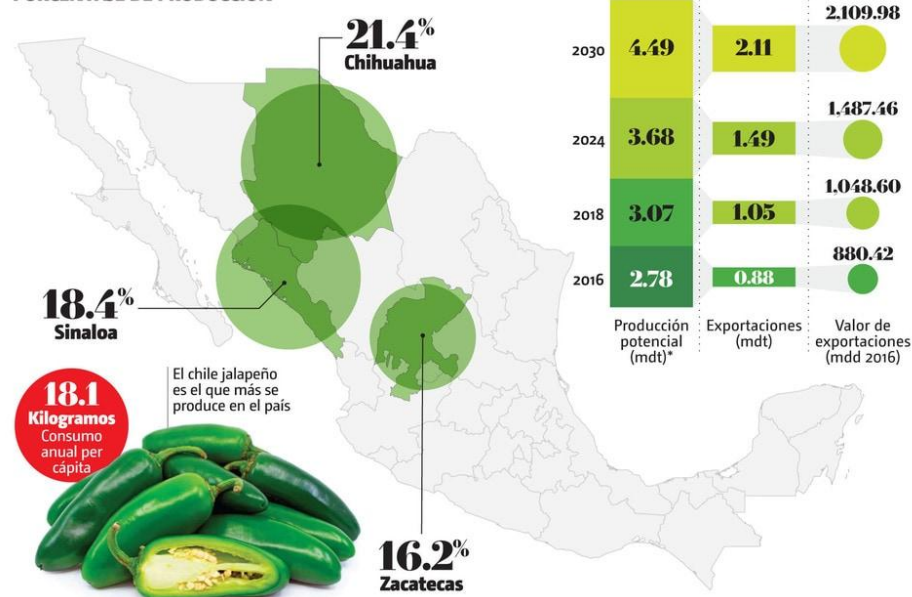


Figure 1: (Production of peppers by country)

Amantes del chile

Durante 2017 México comercializó el fruto a 13 países, siendo el principal destino Estados Unidos, al que se exportó un millón 53 mil toneladas de éste.

PORCENTAJE DE PRODUCCIÓN



· FUENTE: Sagarpa

*Estimaciones

Figure 2 (Chile jalapeño commercialization and exportation in México)

2.2 Environmental Factors in distribution

2.2.1 Elevation

The ideal elevation for *Capsicum annuum* to grow is between 60 and 1600 m.s.n.m. Although *Capsicum annuum* can grow in the elevation presented before, the most optimum elevation is between 300 and 600 m.s.n.m. in optimum conditions. (Lardizábal, 2002). *Capsicum annuum* has a big range of elevation to grow, so this is a good characteristic about the plant. Additionally, of the elevation, there are other environmental factors that affect the plant growth. Some of these factors are connected to the elevation, for example, the climate or the rainfall.

2.2.2 Climate

Jalapeño growth is best suited under a climate that has hot days between 85-95 °F and cool nights between 65-70°F. This climate is the ideal environment for high fruit yield. Although during the day Jalapeño is exposed to higher temperatures and during the night to colder temperatures, the ideal temperature for Jalapeños to grow in a general basis would be between 68 °F and 85 °F. During the day, the ideal environment for Jalapeño is to be exposed to full sunlight. (McCullough et al., 2021). The heat is positive for jalapeño because it causes its flavor to generally be more concentrated, which produces a potent taste. A dry and hot climate is also good for jalapeños because it increases the concentration of alkaloids present in them. Alkaloids is a substance that sticks to heat receptors on the tongue. The days that are long and hot cause jalapeños to produce more *capsaicin*, this is important because *capsaicin* is the specific

alkaloid that delivers the spicy kick. (Ramde, 2012)



(Figure 3 Jalapeño harvest)

2.2.3 Rainfall, potential evapotranspiration, and water deficits.

The ideal precipitation for jalapeño to receive is 0 mm due to the bacterial freckle problems and other diseases that can be caused by the rainfall but in seasons of production, Jalapeño can be produced up to precipitations of 1,2000 mm. Rain can also serve to reduce the flavor concentrations in jalapeño. The absence of rainfall causes the vegetable to be less juicier and smaller, but the flavor is less diluted. Lower water concentrations cause jalapeño to have a sharpened taste. The maximum evapotranspiration measured for (*Capsicum annuum L*) was between 4.0 and 5.0 mm day⁻¹.

“A correlation technique (EC) was used to measure ET. Results showed that Agribon film protected crops from low temperature, diseases, and pests, and strongly reduced ET. ET increased 57 % after the film was removed. High values of relative humidity persisted during this period. The maximum ET value measured was about 5.5 mm day⁻¹, while previous to harvest and during this, ET value was around 4.0 to 5.0 mm

day-1. The highest value for crop coefficient (K_c) was registered previous to harvest and was close to 1 and before harvest K_c was kept between 0.80 and 0.90.” (Rodríguez et al., 2011)

2.2.4 Geology, and soils

Jalapeño peppers grow best in well-drained, loamy soil that is characterized by being rich in organic matter. Jalapeño’s also grown better in warm soil. Ideally, large rocks, sticks and other debris should be taken out of the soil. Additionally, any clumps of dirt should be broken up. Lastly, the solid should ideally have some compost, because this can enhance solid drainage and aeration and also add organic matter to the soil. (Duvauchelle, 2021). Jalapeños develop in soils with pH between 6.0 and 6.8. This is a near-neutral pH level, although they can also tolerate soils that are a little more acidic or alkaline, whereas the other conditions are correct. (Christensen, 2021)



(Figure 4 jalapeño soil and its development after 4 weeks.)

2.3 Biology

2.3.1 Chromosome Complement

Studies done on *Capsicum* species have shown that it has 24 chromosomes. ($2n=2x=24$). In the genus, there are two different groups present. Some species have 24 chromosomes as I explained before, and other species have 26 species $2n=2x=26$). (Smith and Heiser, 1951; Lippert et al., 1966; Pickersgill, 1971, 1977, 1991; Limaye, 1989; Moscone, 1993 ; Pozzobon et al., 2005).

2.3.2 Life Cycle and Phenology

2.3.2.1 Life Cycle

Jalapeño's life cycle is marked by different stages. The first stage is the seedling stage. This stage lasted from the day when the first seed germination and continues for around 3 weeks. After receiving the correct amount of sunlight and water, the plant would continue to develop until it got to fertilization. Fertilization lasts about 1-2 weeks at reduced strength. Then the 2nd stage starts. The second stage occurs between 3 to 4 weeks. In here the plant would already have developed some 'true leaves'. In this stage the plant is able to handle harsher feeding, and can also be transported out of the seed cells trays, into bigger pots with a standard potting mix. Then the third stage occurs between 4 and 8 week. In this stage the jalapeño plant grows at a faster rate. Nitrogen is needed for the jalapeños to stay healthy. Also in this stage more flowering starts to occur on the plant. The 4 th stage takes a longer time and it is between 2-4 months. Here the jalapeño plants continue to grow in a mature size. Here the size of jalapeño can change drastically. The 5th stage is flowering. Here jalapeño plants would usually begin to produce flowers after being outdoors for about 2 to 4 weeks. The final stage is the 6th one. Here the plant

would pass from having flowers to Jalapeños, so the initial jalapeño plant will turn into peppers. If the flower is fertile correctly, then it would drop the petals, and a fruit and seed would begin to form. Then the peppers would pass from light to a dark green color, and at the end it would finally have an almost black color, and finally, it would be red. (Taylor, 2021)

2.3.2.2 Phenology

2.3.2.2.1 Flowering and Fruiting

The flowering stage on jalapeño plants occurs when the plants begin to produce flowers after being outdoors for about 2-4 weeks. Usually, jalapeño plant flowers drop in consequence of high temperatures, poor pollination, or overwatering. It is natural that some plants fall off, but it should never be all of them (Calvin, 2020).

Fruiting occurs when jalapeño plant flowers transform into peppers. The forming of jalapeño peppers is the last stage. If the flower is properly fertilized, it will drop its petals and start to form fruit and seeds. If the fertilization was successful, full-size green peppers would develop in about 55 days. However, to produce red peppers with more heat, jalapeño plants need about 150 days until fully ripe (Rodriguez, 2018).

2.3.3 Reproductive Biology

2.3.3.1 Pollen

The pollen size of *Capsicum annuum* ranges from 17.6 to 40 μm . Additionally, the shape of the pollen grains varieties from sub -oblate, oblate-spheroidal to prolate-spheroidal (Av & Ja, 2006).

Jalapeño peppers can also readily cross-pollinate with other pepper species. Regardless of this the peppers that cross pollinated that year are not affected, but the future generations that grow from the plant's seeds are affected. All peppers species cross-pollinate with jalapeños expect one (Hansen, 2022).

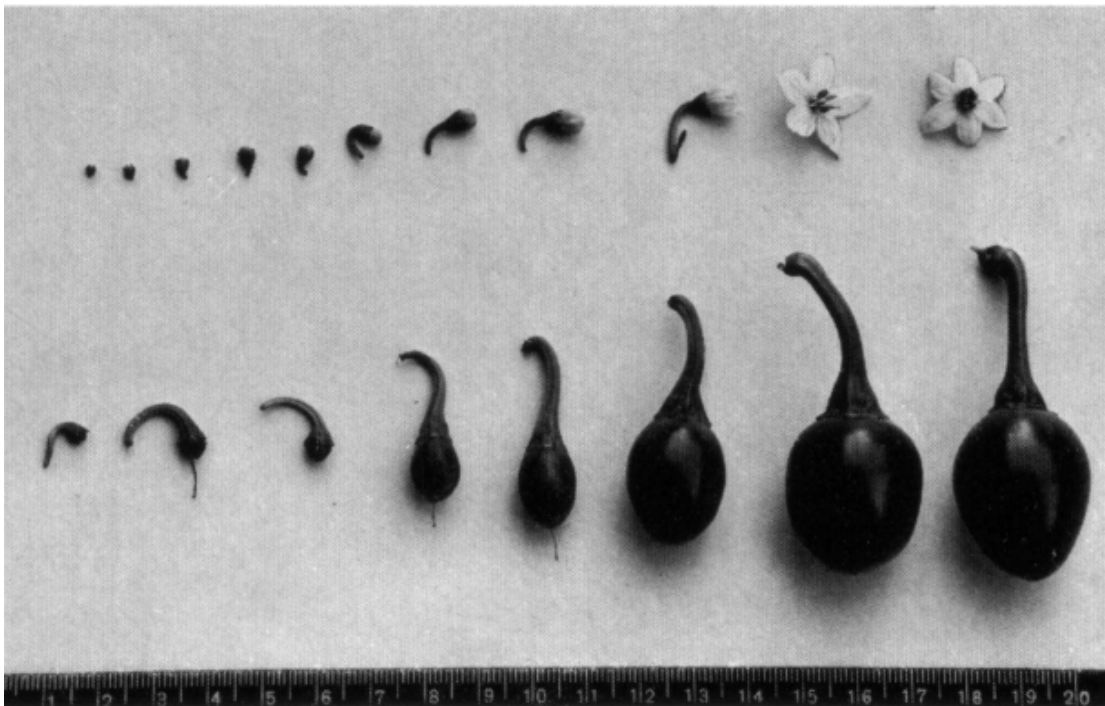
2.3.3.2 Sexuality and pollination

Sexual diversity is important for plants because it is what helps keep diversity within a plant population. The flowers have males that create pollen and by the other hand female parts that have at least one ovary that has the function of receiving pollen. Once the flower is pollinated, the ovary develops a seed, which marks the beginning of a new plant. The new plant will have characteristics of the plant that initially contributed the pollen to them, as well as the one with the ovary. This process is key because it explains how sexuality in jalapeños work and the process of pollination. It has to be remarked that jalapeño peppers have perfect flowers and that the pepper fruit has the seeds. All peppers without mattering their cross-pollination process have seeds. (Gardener, 2013)

2.3.3.5 Fruit development and seed set

A macroscopic morphology showed that the growth of the fruit does not take place usually over the whole length of the fruit, and that it rather had a growth zone located at the base of the fruit. If the fruit is injured by marking, these would cause the growth to be distributed and the fruit would

become deformed. In the stage of fruit development, first the pedicel is erect together with the flower primordium. Also the pedicel curves during further development. This curving continues to happen during the development of the fruit. Full grown fruits are found on drooping pedicels. The number of floral parts might vary. The flower is pentamerous (20%), hexamerous (67%), heptamerous (2%) and octamerous (1%). The ovary is bilocular (94%) or trilocular (6%). It has to be remarked that the septum is in all cases incomplete and not attached to the top of the ovary. The characteristics and distribution of the flowers are the same as for the previous variety. The number of olives is about 150 and the number of seeds varies and is dependent on the effect of pollination. The fruit is full-grown about 25 days after the pollination. (Rodriguez, 2018)



(Figure 5. Development of flower and fruit of *Capsicum annuum*)

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3.0 Vegetation Components

3.1 Associated Species

Capsicum annuum is related to different species that come from the same genus that is *capsicum*. *Capsicum* is a genus of flowering plants that comes from the Solanaceae Family. *Capsicum* is composed of 20-27 species. *Capsicum annuum* is one of the species that is domesticated. Additionally, some of the other species that are domesticated, and that are closely related to *C annuum* are *C. baccatum*, *C. chinense*, *C. frutescens*, and *C. pubescens*. Phylogenetic relationships between species have been researched using different mechanisms like biogeographical, hybridization, morphological, genetic, and chemo systematic data. Another interesting characteristic is that fruit between *Capsicum* can change enormously in color, shape and size both between and within species, which is something that creates confusion over the relationship among taxa. Numerous varieties of the same species can be used in multiple ways. In the specific case of *Capsicum annuum* it includes “bell pepper”, and additionally from this also other varieties like Anaheim, chilies usually for stuffing. (Eshbaugh, 1975)

Capsicum baccatum is a member of the genus *Capsicum*, it is one of the species that is the closest to *C. annuum*. The characteristic that makes it closer to *C. annuum*, is that both species are domesticated. This fruit has a tendency to be very pungent and registers 30,000 to 50,000 on the Scoville Heat Unit scale. Chili pepper varieties of the *C baccatum*, species have white or cream-colored flowers, and usually have a green or gold corolla. On the other hand, the flowers are either insect or self-pollinated. *C baccatum* species, specifically the Aji Amarillo chili, has

its origins in ancient Peru and also across the Andean region of South America. (Rêgo et al., 2011).

Another species closely related to *Capsicum annuum* is *Capsicum frutescens*. This species is similar to *Capsicum annuum* because it also domesticated. *Capsicum frutescens* is a wild chili pepper, that has white flowers with greenish white or greenish corolla. Also, they are either insect or self-pollinated. The berries of the plant usually grow erect; ellipsoild-conical to lanceoloid shapped. This species is generally very small and pungent, growing in a range between 10 to 20 millimeters in long and 3 to 7 millimeters in diameters. *Capsicum frutescens* had a smaller variety of shapes in comparison to other *capsicum* species. (Carvalho et al., 2014)

3. 2 Soil Interactions

Jalapeño peppers, similarly to most vegetables, thrive in soils with a near-neutral soil pH between 6.0 and 6.8. They can also tolerate soils, that are a little more acid or alkaline, as long as other soil conditions are correct. In most cases, soil pH is less worrisome than the composition of the soil. Jalapeños additionally need warm, well-draining soi to grow adequately. The growth of Jalapeño can be slowed in heavy, clay soil, which can also cause root rot diseases. Additionally, to proper soil pH and drainage, jalapeños grow better in moderately fertile soil. (Christensen, n.d.)

Jalapeño plants generally do not require fertilizer unless they are in containers, regardless of this they might be fertilized if the fits are undersized. Over-fertilizing can be negative because

it can kill the plant. (Bray, 2016). Usually, a balanced fertilizer works for peppers. However, if the soil testing shows enough phosphorus, a low or no phosphorus fertilizer should be chosen. Nitrogen is also key for stimulating goof pepper growth, but it is also important to know the best time to fertilize peppers to get the best results. Adding the right quantity of nitrogen will stimulate stem and foliage growth so that the paper plant will grow big enough to support multiple fruits each. (Elis, 2021)

3.3. Relationship with animals and insects

The aphid species that attack jalapeño crops are *Aphis gossypii* and *Myzus persicae* (Hemiptera: Aphididae.) (Frank et al., 1988). *Gossypii* Is a filamentous fungus, which means that it is an infectious agent of the fungus kingdom. It is small, adaptable, and can spread easily. Additionally, it has a fast reproductive rate. *Gossypii* causes damage by sucking sap, therefore weakening the plants, and also by excreting a sticky honeydew that grows into a sooty-like mold on leaves that makes plants unable to do photosynthetic activities. Consequently, they reduce the crop yield and reduce its market value (Edde, 2022).

Myzus persicae is another of the aphid species that attack jalapeño crops. *Myzus persicae* is pale yellow-green with three dark lines on the back. It is found all over the world. This species is seen as a pest primarily due to its ability to transmit plant viruses. Jalapeño is especially affected due to the ability of this species to infest vegetables and plants. However, when young plants are infested in the greenhouse and then transplanted into the field, the field will be inoculated with aphids, and insecticide resistance can occur. (University of Florida, 2017)

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4.0 Propagation and Management

Capsicum Anuum plants can be retarded due to cool weather, and this tends to make them harder and seldom the vigorous growth necessary for high yields. In times of cold weather, the fruit stays small hard and malformed in consequences of uneven pollination. Additionally it might also have multiple growth cracks. Having a really hot weather is also bad. When temperatures are above 33 °C the fruit can show poor setting and poor coloring. Additionally to have a good management soil must be well-drained, with optimum pH of 5.0-6.0 (measures in calcium chloride), and low salinity. (Government of Western Australia, 2016)

4. 1 Natural Regeneration

The part of the flower of *Capsicum Anuum* that offers rise to larger gametes can be referenced of as female, by the other hand, the parts of a flower that offers rise to larger gametes can be referenced of as male. The larger gametes are resource-intensive, and also a few them are located in the ovary at the heart of the plant. The Ovary will develop into a fruit that is located around the seeds that were formed after fertilization. In the figure below, a picture of the anatomy of *Capsicum Anuum* can be seen. The stamens are structures that give rise to little, mobile gametes. Due to their size, the plant needs to spend less resources on them than it does on the female gametes. Once it lands on the sticky stigma of the other lower the male gametes come out of the microsporangia and move to travel down the style in order to wait for the ovules of the female gametes. The ovary is located at the center of the flower and the style rise out of it, surpassed by the stigma. A statement filament also emerges down the ovary on both sides of the simplified cross-section, surpassed by an anther. (Bristow, 2018)

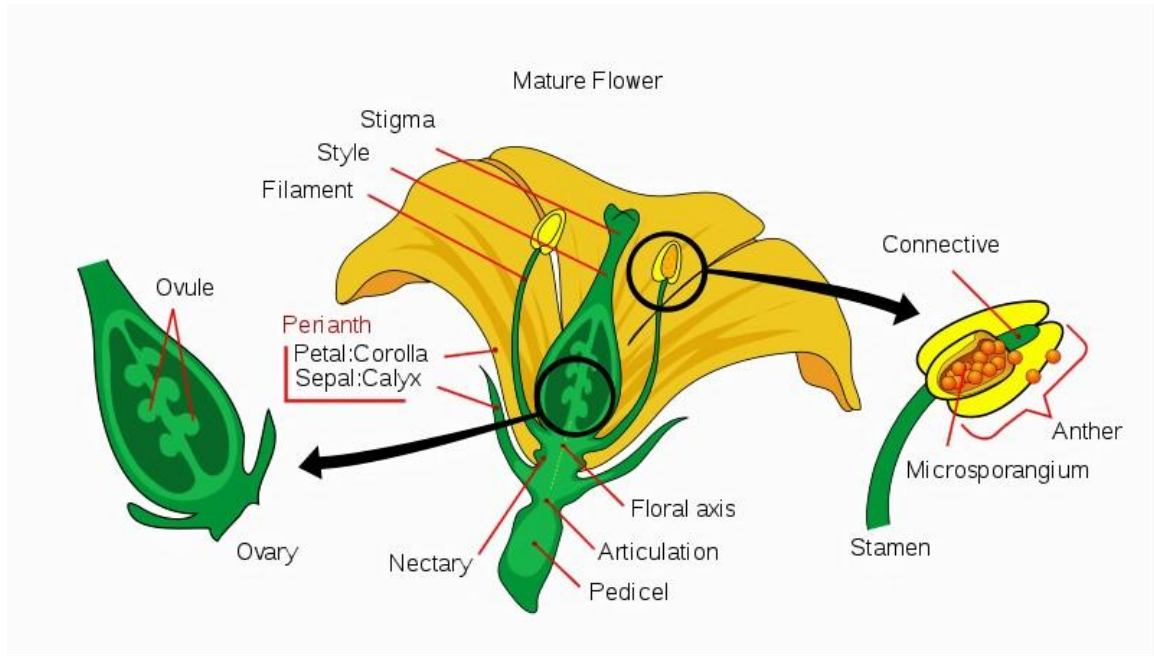


Figure 6 Anatomy of a flower by Mariana Ruiz

4.2 Nursery Propagation

4.2.1 Vegetative Propagation

4.2.1.2 Cuttings

Cutting is a plant section that emerges from the stem, leaf or root and is capable on developing into a new plant. The cutting is generally placed in moist and warm sand. (Britannica, T. Editors of Encyclopaedia, 2009). Gardeners often think of jalapeños as annual plants wich need to be started from seeds each spring. Actually jalapeños are perrenianls that create woody bush-like plants in frost-free climates in order to survive in winter. In these process cutting is key because it is what lets the mislabeled paper to regrow. Rooting a pepper cutting requires the plant to put its energy into making the roots toward the reproduction. (Miller, 2021)

4.3 Planting

In 2019 México was the most prolific country for producing jalapeño peppers, with an estimated 70,000 acres used to grow them (Calvin, 2019). A behavior of jalapeño pepper production was made between 1999 to 2018, with statistical information on volume (t), prices (\$/kg), area harvested (ha), Yield (t/ha) at the national level and for the state of Quintana Roo which is one of the states with the most planting of Jalapeños in México. In the year 2014, the value of production rose dramatically to \$ 3,863,762.6 (constant value) continuing with the same trend until the end of the period, in consequence primarily to the 73.0% growth of the price. In Quintana Roo it was found out that most of the surface planted is seasonal so this caused the terrain to be more susceptible to extreme floods and rains that end up affecting local production. In Quintana Roo the best time to plant Jalapeños is from May 15 to July 15. In this period of time generally the storm has been established and the research suggests that a lower risk of damage from viruses would occur because the whitefly population which is the main transmitter of these diseases decreases significantly in rainy seasons. The sowing that are moved out outside this period of time would have a higher risk of contracting viral diseases. (Revista La Campiña, 2021)

4.4 Management

In Quintana Roo the best types of soils recommended for its cultivation are those that are connected to Luvisol crómico (Yaax-hoom) y Luvisol ródico (K'ankab). The Vertisoles gleycos (Ak'alchés) soils can also be used and they are characterized by retaining high quantity of moisture that could be detrimental to the crop, unless those drainage structures are added to their management. Corn barriers before or right after planting Jalapeños is necessary in order to reduce the introduction of pest from surrounding areas. It is necessary that the cultivation stays free of weeds throughout the cycle, since in addition to competing with it they serve as a refuge for pest that can transmit viral diseases. Therefore, manual weeding throughout the cycle

are precise to keep the crop clean. Additionally chemical products for post-emergence control such as fluazifop P-butyl and bentazone can also be used to eliminate weeds in doses of 1.5 and 2.0 liters per hectare, respectively. Jalaapeño plants don't require fertilizer unless they are in containers, however if they are undersized they might be fertilized. It has to be noted that over-fertilizing can be negative because it can kill the plant. Generally a balanced fertilizer works for pepper. If the soil testing shows enough phosphorus, a low or no phosphorus fertilizer might be chosen. Nitrogen is also essential for stimulating growth. Adding the precise quantity of nitrogen will stimulate stem and foliage growth so that the pepper plant will grow in a good size for it to support multiple fruits. (Elis, 2021).

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5. Emerging products and potential markets

5.1 World Trade

5.1.1 Exports

Export Trends of Top 10 Exporters of Value Added Jalapeno

This is the export trends of the top 10 exporters of Value Added Jalapeno from 2013 to 2020.

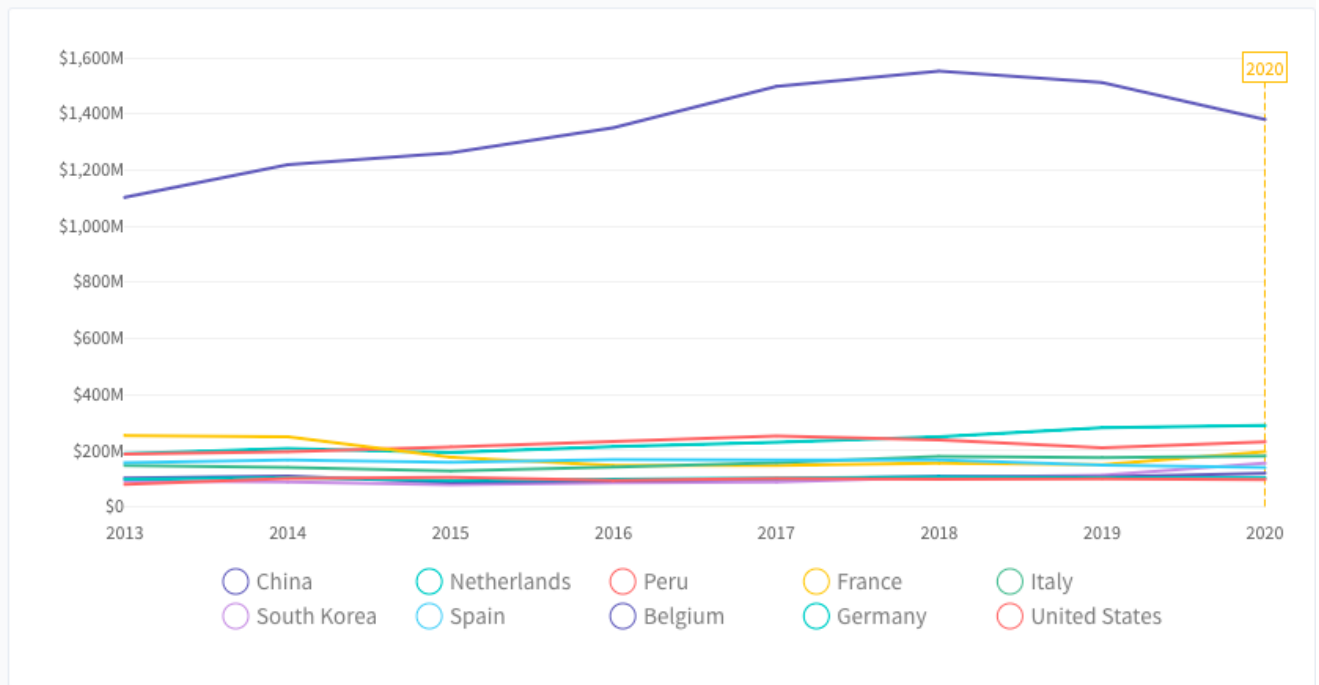


Figure 7: Export Trends of Top 10 Exporters (Countries) of Value Added Jalapeño from 2013 to 2019 (Tridge, 2020)

Country	Share in Export Value 2020	Export Value 2020, USD	1-Year Growth in Export Value 2019-2020	3-Year Growth in Export Value 2017-2020	5-Year Growth in Export Value 2015-2020
China	35.26%	\$1.38B	-8.74%	-7.9%	+9.44%
Netherlands	7.41%	\$289.89M	+2.61%	+25.96%	+49.88%
Peru	5.91%	\$231.27M	+9.52%	-8.34%	+8%
France	5.03%	\$196.90M	+30.43%	+32.83%	+11.42%
Italy	4.64%	\$181.63M	+3.35%	+15.68%	+41.69%
South Korea	3.98%	\$155.54M	+37.57%	+75.69%	+96.68%
Spain	3.58%	\$139.98M	-6.18%	-15.94%	-11.76%
Belgium	3.07%	\$120.26M	+13%	+19.46%	+37.46%
Germany	2.64%	\$103.50M	-1.02%	≈ 0.86%	+9%
United States	2.49%	\$97.32M	-3.32%	-4.3%	-8.19%

Table 1: The top 10 exporting countries of Value Added Jalapeño in 2020.

In figure 7 a line graph can be seen showing the pattern of export trends of the top 10 Exporters (Countries) of Value Added jalapeño from the years 2013 to 2020. By the other hand, table 1 shows in a numerical way the information that can be seen in the line of the year 2020 of figure 7. Additionally, table 1 shows the growth in export value of each country from a range that includes 1-year Growth in Export Value (2019-2020), 3 years Growth in Export Value (2017-2020), and 5 years of Growth in Export Value (2015-2020).

5.1.2 Imports

Import Trends of Top 10 Importers of Value Added Jalapeno

This is the import trends of the top 10 importers of Value Added Jalapeno from 2013 to 2020.

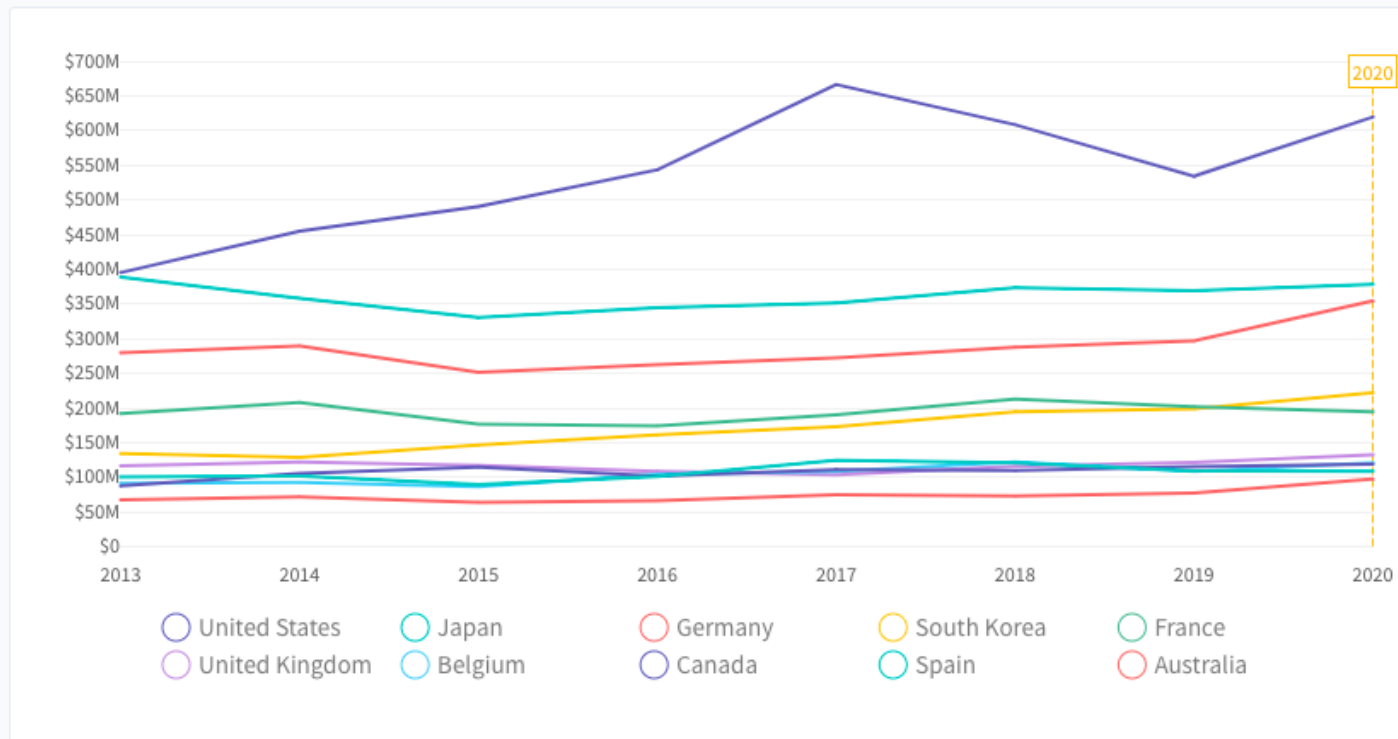


Figure 8: Import Trends of Top 10 importer (Countries) of Value Added Jalapeño from 2013 to 2019 (Tridge, 2020)

Country	Share in Import Value 2020	Import Value 2020, USD	1-Year Growth in Import Value 2019-2020	3-Year Growth in Import Value 2017-2020	5-Year Growth in Import Value 2015-2020
United States	18.55%	\$619.38M	+15.97%	-7.03%	+26.32%
Japan	11.33%	\$378.51M	+2.54%	+7.78%	+14.54%
Germany	10.61%	\$354.32M	+19.46%	+30.09%	+40.82%
South Korea	6.65%	\$222.09M	+11.88%	+28.2%	+51.23%
France	5.83%	\$194.53M	-3.64%	+2.24%	+10.07%
United Kingdom	3.96%	\$132.35M	+8.63%	+27.71%	+13.06%
Belgium	3.61%	\$120.67M	+11.09%	+10.78%	+39.39%
Canada	3.57%	\$119.37M	+3.32%	+7.12%	+3.82%
Spain	3.25%	\$108.46M	≈ -0.64%	-13.03%	+20.65%
Australia	2.92%	\$97.38M	+25.38%	+30.25%	+51.63%

Table 2: The top 10 importing countries of Value Added Jalapeño in 2020.

(Tridge, 2020)

The relationship of the line graph of In figure 8 and the table 2 that can be seen above is similar to the graph and data shown for exports, just that in this case we can see data from the top 10 importing countries of Value Added. However, we can see how the import trend seen in figure 8 and the data from table 2 are more dispersed than the graph and table of exports, although we can see that the top country in export value (China) has a bigger standard deviation in comparison with the other countries of exports in comparison to the standard deviation that can be seen from the top country in imports that is the United States.

5.2 Flavor in *Capsicum annuum*

The sweet and sour taste that we get from fruits and vegetables are primarily determined by organic acids and sugars. Also, tannins and (non) hydrolysable phenolic compounds have an effect on taste, some showed to be responsible for astringency. It can be seen that sourness and astringency decreases while sweetness increases in the process of growth and ripening of fruits. (Rhodes, 1980; Eskin, 1988)

Bell pepper *Capsicum. annum* were evaluated on their sensorily on flavor attributes at three different maturation stages. Green Bell pepper showed mainly attributes of bitterness, by the other hand the red bell pepper had attributes of sweetness and sourness. Principal component analysis (PCA) suggested that HPLC data of , glucose, fructose dry matter and total sugar, were linked to the characteristic of sweetness in the red maturation stage. Contents were related to the attribute sweetness in the red maturation stage. By the other hand HPLC concentrations of ascorbic acid and citric as well as calculated concentrations of undissociated ascorbic and dissociated citric 1 and citric 2, appeared to manifest a close connection with the characteristic of sourness. (Luning,van der Vuurst de Vries, Yuksel, Ebbenhorst-Seller, Wichers, & Roozen, 1994).

Leucine is one of the three essential branched chain amino acids (BCAAs). These amino acids are important because they are used by the skeletal muscle in order to give energy during exercise. Additionally, BCAAs usually show to have an extremely bitter taste. University of Rochester, 2022). Jumping in into more scientific information, it was deduced that leucine is a

precursor in the biosynthesis of 2-isobutyl-3-methoxypyrazine in *Capsicum* fruits, as proposed by Murray et al. (1970) in the figure below.

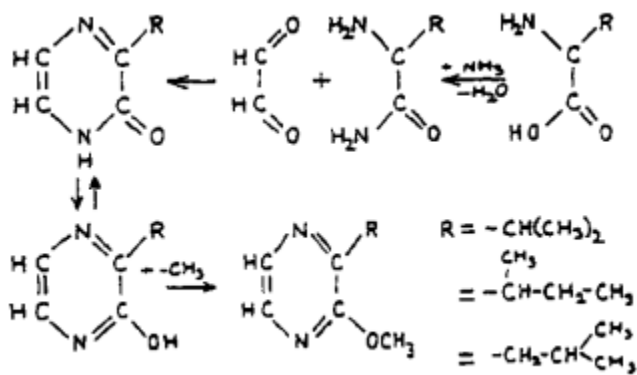


Figure 9: Proposed pathway for the biosynthesis of 2-methoxy-3-alkyl pyrazines (Murray, et al., 1970).

5.3 Food Item Based on Jalapeño

5.3.1 preserved Jalapeños

Jalapeños can be preserved over time. Some of the best ways to preserve the Jalapeños and keep them fresh is to can the Jalapeños. This method is done by washing the jalapeño with cold water, then they air dry. After this, they are cooked in boiling water for around three minutes, and lastly, they are packed into a quart-size glass jar. Additionally, to keep them fresh jalapeño can also be frozen, dehydrated or refrigerated for around one week. (MasterClass staff, 2022)

5.3.2 Roasted Jalapeños

Jalapeños can be roasted easily. Once they are roasted they can be used as a topping for sandwiches, tacos pizzas e.t.c (Hultquist, 2014)



Figure 10: Jalapeños being roasted (Hultquist, 2014)

5.3.3 Sauces

Jalapeño's fascinating flavor make it a good item for sauces. Some of the sauces than can be made using jalapeño as an ingredient are: sweet and sour sauce, Thai Sweet Chili Sauce Recipe, Creamy Jalapeno Sauce Recipe, Chipotle Aioli, Gochujang Sauce, Spicy Arrabbiata Sauce e.t.c (Hultquist, 2013)

5.3.3 Soups

Jalapeño spicy and bitter taste make it a good ingredient for soups. In the figure below some delicious soups where jalapeño is present can be seen in the figure below

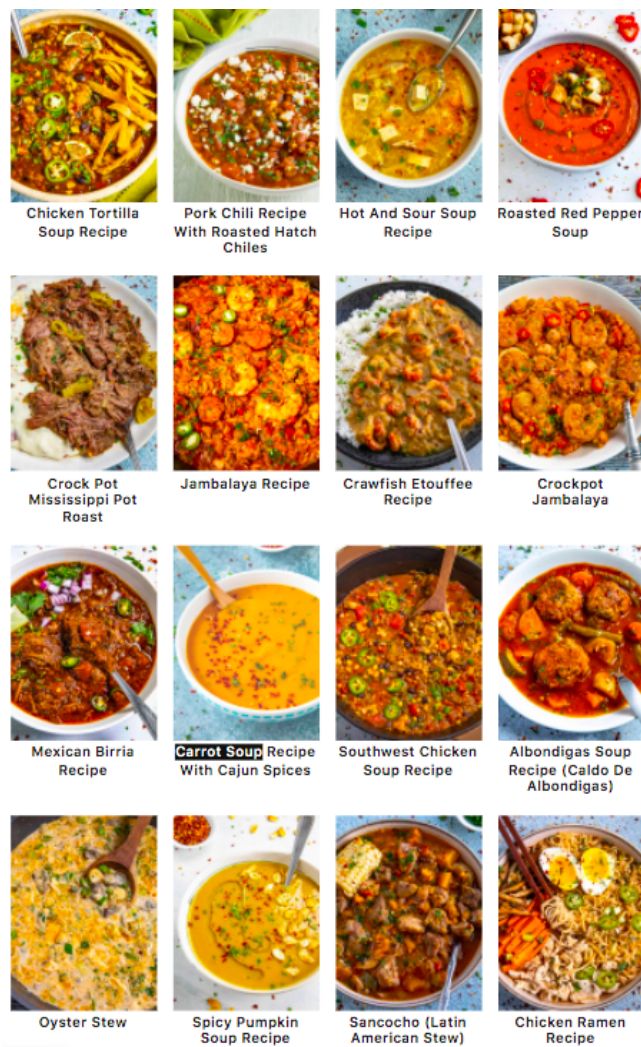


Figure 11: 12 soups that have jalapeño as an ingredient (Hultquist, 2013)

5.3.1 Jalapeños in Sandwich/fast food

To conclude with the food item section, I would like to share a sandwich with Jalapeños. This is personally my favorite use of Jalapeño because it gives a strong taste to the sandwich, and it has a good combination taste with the bread and with other vegetables like lettuce and tomato. Although its use is not so popular, Jalapeño can also be added to other fast food like pizza or hamburgers.



Figure 12: Jalapeño Sandwich of Subway

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6.0 Medicinal uses of *Capsicum annuum*

Capsicum annuum has multiple carotenoids, including *capsanthin*, *capsorubin*, *beta-carotene*, *cryptoxanthin*, *lutein*, *phytofluene*, and *xanthophyll*, and steroids, including *capsicoside*. One of the major components is *Capsaicin*. *Capsaicin* is used intentionally for multiple conditions which include colic and for improving peripheral circulation. It is also used externally for unbroken chilblains (Aronson, 2016). *Capsaicin* can also work medically as herbal supplement. Its mechanism of action function as selective impairment of pain (C-type) fibers, which cause pain sensation from the abdominal viscera to the CNS. Also in a study 2.5 mg of red pepper powder that were given daily improved epigastric pain, nausea and bloating. (Feldman, 2021). *Capsaicin* appeared to have strong anti-cancer properties in lab studies. It was seen that it was able to kill over 40 types of cancer cells without harming the normal cells. *Capsaicin* can also prevent stomach ulcers. This occurs because it reduces stomach inflammation in people with *H. pylori*, it can also help kill the infection. Jalapeños can also function to reduce stomach damage that comes as a consequence of overuse of NSAID pain relievers and alcohol consumption (Julson, 2018).

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