





The National Association of Plant Breeders in
 partnership with the Plant Breeding Coordinating
 Committee and The Plant Breeding Genomics
 Community of Practice presents

How to breed new plant varieties: imagining and engineering crops

Kevin Crosby
 Department of Horticultural Sciences
 Texas A&M University








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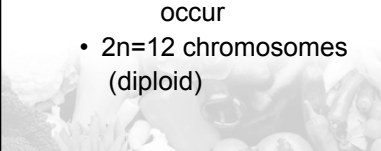
Peppers are the most important part of salsa

Kevin Crosby
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Peppers, Chiles, Ajís, Pimentas

- Family: Solanaceae
- Warm Season Perennials
- Naturally self pollinating
 - protogyny and protandry occur
- $2n=12$ chromosomes (diploid)




Pepper

- Not related to black pepper (*Piper nigrum*)
 - But that's how it got its name
- Center of Origin:
 - Most Species: South America (Colombia to Bolivia)
 - *C. annum* types: Central America to Mexico
- Warm season, self-pollinated, perennial

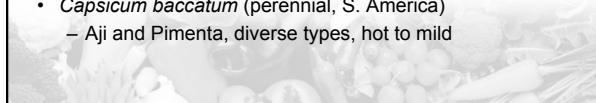


Peppers Center of Origin: Latin America



Pepper

- *Capsicum annum* ("annual" growing plant)
 - Most commercially important peppers belong to this species
- *Capsicum chinense* ("from China" – misnomer)
 - Habanero pepper
- *Capsicum frutescens* ("bushy" or "shrubby" plant growth)
 - Tabasco pepper
- *Capsicum pubescens* ("hairy-like")
 - Distinct form; will not readily cross with other *Capsicum* species- Manzano and Rocoto peppers
- *Capsicum baccatum* (perennial, S. America)
 - Aji and Pimenta, diverse types, hot to mild



Chili pequin- ssp. aviculare

- Grows wild in Texas and Mexico



Pepper

- Types:
 - Bell group
 - Most are non-pungent
 - Includes Pimientos as sub-group
 - Anaheim group
 - Most are mild pungent, but some are non-pungent
 - Includes Ancho & Paprika
 - Jalapeño group
 - Pungent (new varieties are mild-pungent)
 - Cherry group
 - Pungent or non-pungent
 - Wax group
 - Yellow mature color; Pungent or non-pungent
 - Tabasco group
 - Very pungent; most are processed, 'Malagueta'
 - Habanero group
 - Most pungent commercial pepper

U.S. Pepper Industry

- Bell Peppers
 - Most common form in US
 - ~2/3 of total US production
- Anaheim peppers
 - ~15% of total US production
- Pimiento peppers
 - ~5% of total US production
- Jalapeño peppers
 - ~4% of total US production
- Others considered "specialty" types

World Pepper Production

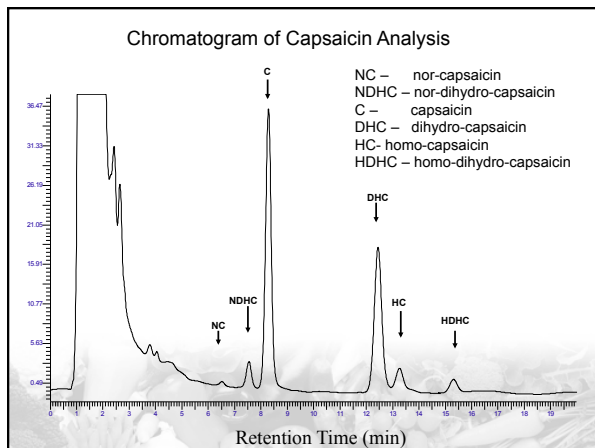
- India- top producer and consumer
- China- 2nd most production- export
- Mexico- largest per capita consumers
- Korea
- Ethiopia
- Pakistan
- Turkey
- Spain

Scoville Units

- Named after Wilbur Scoville
- Method to measure the heat level of a chile pepper
- A dilution-taste procedure:
 - Scoville blended pure ground chilies with a sugar-water solution and a panel of testers then sipped the concoctions, in increasingly diluted concentrations, until they reached the point at which the liquid no longer burned the mouth
 - A number was then assigned to each pepper based on how much it needed to be diluted before you could taste no heat (parts of sugar water to parts of pepper)

HPLC





Scoville Units	
Chile Pepper	Heat Range
Sweet Bell	0
Pepperoncini	100 ~ 500
Poblano	1,000 ~ 2,000
Ancho	1,000 ~ 2,000
Anaheim	500 ~ 2,500
Jalapeno	2,500 ~ 8,000
Chipolte	5,000 ~ 8,000
Hot Wax	5,000 ~ 10,000
Serrano	8,000 ~ 22,000
Tabasco	30,000 ~ 50,000
Cayenne	30,000 ~ 50,000
Piquin	40,000 ~ 58,000
Thai	50,000 ~ 100,000
Carolina Cayenne	100,000 ~ 125,000
Habanero	100,000 ~ 325,000
Red Savina Habanero	350,000 ~ 577,000
Pure Capsaicin	15-16,000,000

Bell Peppers

- Large, blocky & blunt
- Green immature, can be red, yellow, orange, brown or purple when mature
- Nutrient content usually greater in mature (colored) fruit
- Uses: Mostly fresh (salads, cooking ingredients), but also stuffing, stir fry



Multiple Mature Colors



Lamuyo Type



Anthocyanin in Epidermis



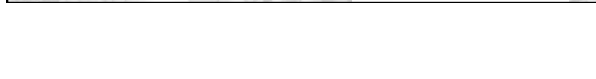
Cayenne Pepper

- Most important processed pepper in USA- hot wings
- Selected in Louisiana
- Hot sauces and dried pepper flakes, powder



Hatch or Anaheim Chile

- New Mexico Origin
- Mild to hot, elongated, long season crop
- Green and red used for different products- canned, roasted, powder, paste



TAM Ben Villalon

- Resistant to TEV, PepMoV, PVY
- High yielding, concentrated set
- Large fruits



Wax Peppers

- Sweet banana
- Hungarian hot
- Santa Fe Grande
- Cascabella



Poblano Peppers

- Poblano (Fresh) & Ancho (Dried)
- Most popular pepper in Mexico
- Heat Index: Mild to Medium
- Scoville Units: 500-2,000
- Uses
 - Fresh: Chili Relleno
 - Dried: Sauces & Powders



Chile Relleno



Jalapeño Peppers

- Round, cylindrical, tapering shape
- Green immature, mature usually red, but can be yellow or orange.
- Heat Index: 2,500 - 5,000 Scoville Units
- Uses: Salsa, preserves, multiple dishes
- Chipotle: Dried, smoked, red Jalapeño
- Name comes from Jalapa, Mexico



Chipotle

- Smoked jalapeño peppers
- Popular for flavoring snacks, meats- spicy



Serrano Peppers

- Round, cylindrical, tapering shape, smaller than Jalapeño
- Green immature, mature usually can be red, yellow, orange or brown
- Heat Index: 5,000 - 20,000 Scoville Units
- Uses: Salsa, preserves, multiple dishes
- Name comes from 'foothills' of Puebla, Mexico



Tabasco Peppers- *C. frutescens*

- Small, round, cylindrical shape
- Light green immature, maturing to yellow, then orange and finally red
- Heat Index: 30,000 - 50,000 Scoville Units
- Uses: Tabasco Sauce
- A soldier fighting in the Mexican War in the mid-1800's returned to Louisiana with some seeds from the Mexican state of Tabasco

Tabasco- *C. frutescens*



Different forms of *C. chinense*



Habanero Peppers

- Lantern-shaped, round or oblong, with a pointed apex
- Green maturing to yellow, orange, bright red, brown
- Hottest commercially available pepper
 - Scoville units: 100,000 – 1,500,000
- Uses: Sauces, salsas, preserves



Caro-Tex 312

- New F1 hybrid- resistant to TSWV, RKN
- Early maturing, high yield





Trinidad Scorpion- world's hottest



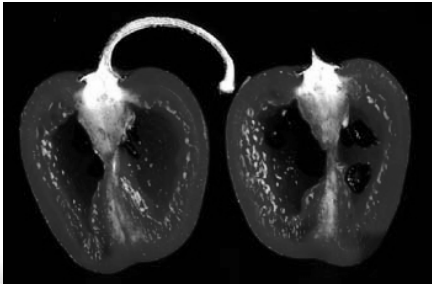
Self-defense



Capsicum pubescens



Capsicum pubescens – Rocoto type
Will not readily cross with other species
Note large black seeds



C. pubescens flowers



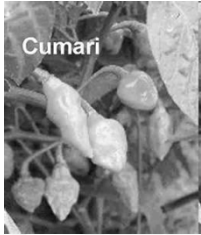
Capsicum baccatum

- Popular in Peru, Bolivia, Brazil



Ys gene

Peruvian Types



Breeding Strategies

- Pedigree selection most common for developing inbred lines
- Mass Selection common in landrace types
- Recurrent selection and Backcross methods important for enhancing variation

Pepper Plant Physiology

- Mostly bushes less than 1 m
- Generation time: 90-140 days
- First flowers may occur 40 days after germination, will continue for life of the plant- may live 10 yrs or more

Mating Systems

- Open pollinated cultivars from self-pollinating progenies
- Outcrossing rates highly variable : 2-90 %
- F1 hybrid cultivars- manual emasculations and male sterility

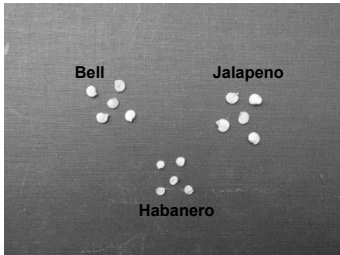
Male Sterility

- Genic- one recessive gene (*ms*), stable
- Cytoplasmic male sterility- several genes, not very stable (temperature sensitive)
- Honeybees do not favor pepper pollen, so other species may be used

Seed Attributes

- Somewhat delicate- shelf-life less than 2 yrs at room temperature, >15 at -20 °C
- Numbers range from 10 to 300 per fruit
- Most in bells, large sweet types
- Least in Habanero and Tabasco

Seed Size Variation



Important Traits

- Yield and fruit quality, size, color
- Disease resistance
- Early maturity
- Plant habit and stress tolerance

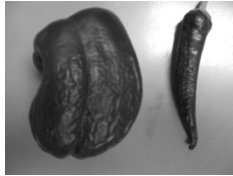
Flesh Morphology

- Mesocarp thickness
- Firmness- S gene
- Color- *y*, *sw1*
- Moisture content

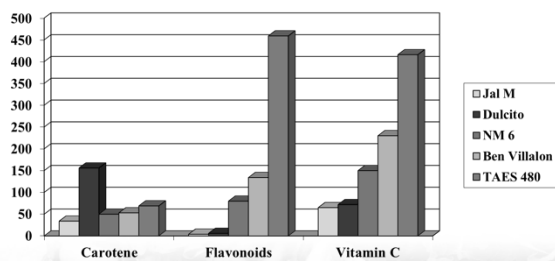


Phytochemical Content

- Ascorbic Acid
- Flavonoids
- Carotenoids- *t* and *B* high carotene
- Capsaicin- *Pun1*



Pepper Beneficial Phytochemicals

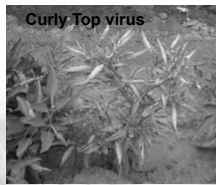
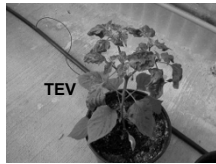
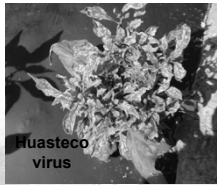


Bacterial Leaf Spot

- At least 10 races to date
- Seven resistance genes *Bs-1*, *Bs-2*,....
- Mostly gene for gene interaction- HR
- Horizontal resistance- race non-specific, *bs5*, *bs6*



Insect Vectored Viruses



Virus Resistance Genes

- Potyviruses- Mostly recessive: *pvr1*, *pvr2*...
- Tobamoviruses- Mostly dominant: *L1-L4*
- Tospoviruses- *Tsw*
- Begamoviruses- no R genes characterized

Fungal Diseases



Powdery mildew



Phytophthora capsici

Nematodes

- *N* gene in Santaka, other lines
- Carolina Wonder, Truhart pimento
- Single dominant gene- *C. chinense*



Resistance Genes

- Powdery mildew- multiple dominant genes reported, mostly a problem in *C. annuum*
- Phytophthora- multiple dominant genes from CM334 and 201234 (linkage drag)
- 2 recessive genes from Fidel (Author), no linkage drag noted in chile types

Peppers & Capsaicin

- Capsaicin is not water soluble
 - Drinking water will spread capsaicin (same goes for beer)
- Recommended first-aid:
 - Drink milk or eat dairy products
- Capsaicin will penetrate skin
- The intense burning sensation one experiences when eating hot peppers can trigger the body into releasing morphine-like endorphins, often resulting in mild euphoria

National Association of Plant Breeders

NAB

Improving Plants to Improve Lives

PLANT BREEDING & GENOMICS

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