Cacao

**Family** – Sterculiaceae
**Genus** – Theobroma
**Species** – cacao

**Distribution of Wild Theobroma**

Adapted to Hot, Humid Tropics

**Adaptation of Cacao**
Understorey plant of tropical rain forest

- **Temperature**
  - 18-32°C (23-26°C)
  - 15°C lowest tolerated
  - Below 10°C damages tree

- **Moisture**
  - 1150 – 2500 mm (1500-2000 mm)
  - Well distributed, sensitive to water stress
  - Needs high humidity

- **Wind**
  - Sensitive to wind damage

**Shade**
- Tolerant of shade
- Maximum photosynthesis at 25%
  - full sun
- Tolerates high light as well

**Soil**
- Well drained, no waterlogging
- pH between 5.0 – 7.5
- Good nutrient holding capacity

**Cauliflorous Flowers**

Pollinated by midges
Cacao Flowers on “Cushion”

Fruit form on leafless stems at former leaf axil positions

Harvested Cacao Pods

Cacao Pod

Each Seed (Bean) is Covered by a White Mucilage

Cacao Seed or Bean
Domestication of *Theobroma cacao*

- **Origin**
  - Eastern slopes of Andes
  - Amazon-Orinoco basin
- **Dispersal**
  - North -> Criollo
  - East -> Forastero
- **Domestication**
  - Central America

**Amazonia**
- Acid sweet pulp
- Semi domesticated

**Central America**
- Mayans and Aztecs – lowlands
  - Divine origin
  - Currency
  - Beverage – bitter flavor
  - Cacao beans
  - Ground corn
  - Capsicum pepper

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**Breeding of Cacao**

- **First was to increase yield**
  - Strong environmental influence
- **Disease resistance**
  - Witches’ broom disease in the Americas
  - Ceratostomella wilt
  - Black pod (*Phytophthora palmivora*)
  - Swollen root virus in Africa
- **Drought resistance**
- **Flavor**

**Types of Cacao**

- **Forastero** (green fruit, purple seed)
  - Developed in Amazon
    - Taken to Africa to develop industry
    - Bulk cocoa, 95% of production
- **Criollo** (green to red fruit, white seed)
  - Developed in Central America
  - Fine cocoa, better flavor than Forastero
- **Trinitario**
  - From Trinidad
  - Hybrid type, natural intercrossing

**Cacao Production in the World**

![Cacao Production Chart](chart.png)

- FAOSTAT database, 1970-2004

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (1000s Mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td></td>
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<tr>
<td>1980</td>
<td></td>
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<td>1985</td>
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<tr>
<td>1990</td>
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<td>1995</td>
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<tr>
<td>2000</td>
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</tbody>
</table>
World Production of Cacao

**Region** 1,000s mt %
Africa 2,338 70%
Asia 499 15%
Americas 466 14%
Oceania 48 1%
Total 3,351

FAOSTAT database, 2000-2004

World Production of Cacao

Most grown within 8º of the equator

Cacao Yield in the World

<table>
<thead>
<tr>
<th>Year</th>
<th>Yield (MT/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>3.0</td>
</tr>
<tr>
<td>1975</td>
<td>3.1</td>
</tr>
<tr>
<td>1980</td>
<td>3.2</td>
</tr>
<tr>
<td>1985</td>
<td>3.3</td>
</tr>
<tr>
<td>1990</td>
<td>3.4</td>
</tr>
<tr>
<td>1995</td>
<td>3.5</td>
</tr>
<tr>
<td>2000</td>
<td>3.6</td>
</tr>
</tbody>
</table>

FAOSTAT database, 1970-2004

World Yields of Cacao

<table>
<thead>
<tr>
<th>Region</th>
<th>Mt/ha</th>
<th>Major Producing Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>4.9</td>
<td>Ivory Coast (1335), Ghana (480), Nigeria (348)</td>
</tr>
<tr>
<td>Asia</td>
<td>8.8</td>
<td>Indonesia (433)</td>
</tr>
<tr>
<td>Americas</td>
<td>3.1</td>
<td>Brazil (179), Ecuador (88)</td>
</tr>
<tr>
<td>Oceania</td>
<td>4.3</td>
<td>Papua New Guinea (43)</td>
</tr>
</tbody>
</table>

FAOSTAT database, 2000-2004

Propagation

- **Seedlings**
  - Most common
  - Ivy orchards

- **Vegetative propagation**
  - Rooted cuttings
  - Rootability varies with cultivar
  - Budding
Site Establishment

- Shade needed for young plants
  - Develop proper tree architecture
  - Too little light
  - Too much light
  - Short internodes with excessive branching
- Establish shade trees before planting cacao
  - Fast growing leguminous species
  - Banana for temporary shade for young cacao
  - Coconut
  - Thinned forest (common in West Africa)
- Less to no shade for mature plants

Planting

- Density
  - Closer spacing -> greater early yields
  - 2.5 m x 2.5m (1600/ha) – West Africa
  - 4 m x 4 m (625/ha) – Americas
  - 5m x 5m (400/ha) – Sri Lanka
- Planting materials, rainy season
  - Seed-at-stake, West Africa
  - Transplanting nursery plants
- Time to first flowering
  - 18 months from transplanting

Shade and Yield in Mature Cacao

- Develop convenient tree shape
  - Allow easy entry to tree
  - Height of 1st branching
  - Number of branches
  - Open canopy
    - Increase light penetration
    - Decrease humidity
- Facilitate pest and disease control
  - Remove diseased, damaged or dead wood

Pollination

- Degree of pollination depends on midge population
  - Increase population of midges
    - Banana pseudostems in cacao orchards
    - Midge bred in these pseudostems
  - Increase pollination up to 15%
- Hand pollination increases fruit set
  - Natural set is ~ 5%
  - Hand pollination increase 200% to 500%

Harvesting

- Time to develop fruit
  - 4.5 to 7 months after flowering
- Harvest time
  - Flower set only at > 20°C
  - Maximum set in rainy season
  - No set during dry season
- Tropical areas
  - Flowering from February to July
  - Harvest from August to January
Harvest period of months

- Harvest at 10-14 day intervals
- Cut off tree when fully ripe
  - Maximize flavor
  - Minimize seed germination
  - Minimize pest and disease problems

Remove Seed from Pod to Ferment

Cut off tree when fully ripe

Fermentation

- Remove mucilage from beans
- Kill embryo
- Develop chocolate flavor
- Reduce moisture content

Dry to Prevent Deterioration

- Most sun dried
- Moisture content: 6-7%
- Dried beans are bagged

Processing of Dried Beans

Most done in developed countries

- Cleaning
- Roasting
  - Develop chocolate flavor
  - Temperature, 100-150 C
  - Time 20-49 minutes
- Kibbling and Winnowing
  - Break up the beans
  - Eliminate testa (shell) with air current
  - Broken cotyledons = nibs

Processing of Dried Beans

Most done in developed countries

- Grinding (50-70°C)
  - Nibs -> paste-like chocolate liquor or bitter chocolate
  - 55% fat (cocoa butter)
- Extraction of Cocoa Butter
  - Press to produce
    - Cocoa cake with fat content to 10-20%
    - Cocoa butter
- Cocoa Powder Finishing
  - Cocoa cake is ground and sieved
  - Alkalized to stabilize color and increase water dispersal
  - Dried and packaged
Manufactured Products

- Cocoa powder
  - Syrups, ice cream toppings
  - Cake mixes, cookies, puddings
- Chocolate
  - Bitter chocolate = chocolate liquor
  - Bitter sweet chocolate =
    - 35% chocolate liquor
  - Sweet chocolate =
    - Sweeteners plus 15% chocolate liquor
  - Milk chocolate =
    - Sweeteners plus 12% milk solids and 10% chocolate liquor

Any Questions?

Fermentation and Roasting

Grinding