

COCOA QUALITY AND FACTORS THAT INFLUENCE IT

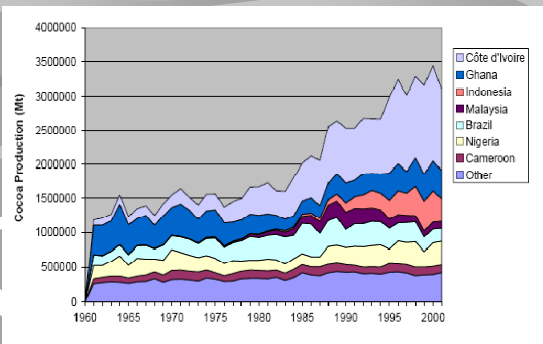


Source: Dr. Smilja Lambert

History of cocoa and chocolate

- Cacao (*Theobroma cacao L.*)
- *Theobroma* – Food of the Gods





Cocoa varieties

- *Criollo*
- *Forastero*
- *Nacional*
- *Trinitario*



Factors effect on quality of cocoa bean and chocolate

- 1- Genetics
- 2- Environment
- 3- Pest/diseases
- 4- Post harvest processing

1-Influence of genetics on quality

- Approx. 3500 genotypes of cocoa are stored in germplasm collections around the world
- Quality parameters are in majority genetically defined
- Majority of these parameters are affected by environment and processing

Genetically defined quality parameters

- Fat content (45-61%)
- Shell content (9-25%)
- Bean count (50-150)
- Flavour
 - fine cocoa
 - fruity/floral/spicy
 - bulk cocoa
 - cocoa (chocolate) flavour potential that is developed during a good fermentation (or killed during bad one)

2- Influence of Environment on quality

2-1 Low rainfall

- During the cocoa pod development
 - lower fat content
 - smaller beans
 - higher shell content
- During post harvest processing
 - smaller pulp - better fermentation
 - quicker drying
 - less mouldy beans

Environment cont.

2-2 Low temperature

- Reduce the cocoa butter hardness (not relevant under 10° latitude)
- Slow down the fermentation process

2-3 Fertilisation and soil composition

- Influence the yield, beans weight, shell %
- Fertilisation influences fat content
- Maybe it influences also flavour

3- Influence of Pests/Diseases on cocoa quality

- In Vietnam just Phytophthora pod rot can influence the cocoa beans quality
- Strongly infested pods should NOT be used
- Dry conditions needed for pod storage to prevent strong black pod infestation







4- Influence of processing on quality

- Harvest
- Pod storage
- Fermentation
- Drying

4-1 Harvest

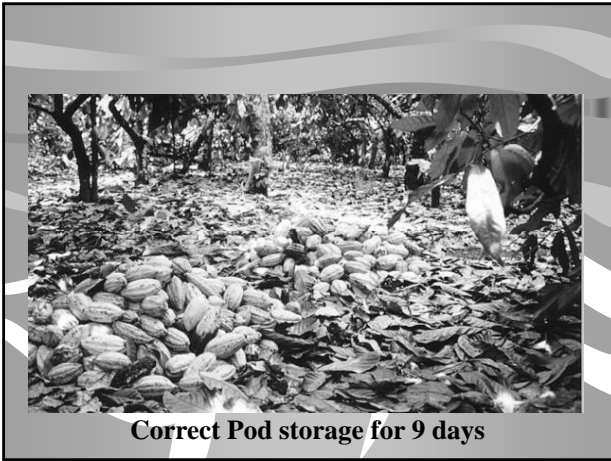
- It is important to harvest ripe pods
- Pods are ready to be harvested for approx. 3 weeks
- Small farmers might take longer time to gather enough pods for good fermentation.

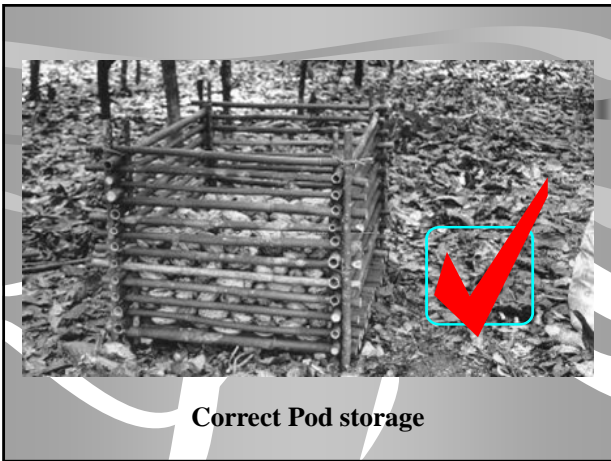


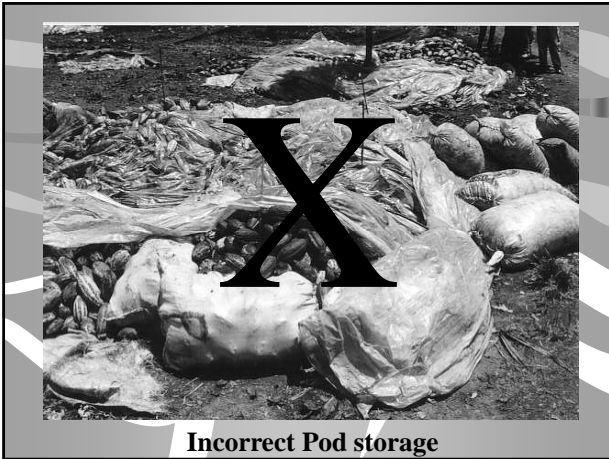
4-2 Pod storage - VERY IMPORTANT

- Pods are harvested and stored for 9 days
- Pods are broken and beans are fermented
- Normal fermentation of 5-6 days
- Benefits of pod storage
 - Improve the cocoa flavour formation
 - Speed up the fermentation
 - Reduce excessive acidity
- Mechanism of pod storage
 - Reduction of pulp volume
 - Very short anaerobic phase causes
 - very low lactic acid production
 - low quantities of alcohol/acetic acid







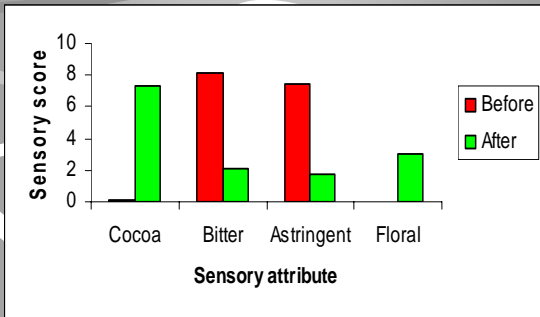




Importance of cocoa fermentation

- There is NO chocolate flavour in cocoa beans without fermentation
- During fermentation are formed compounds (precursors for chocolate flavour) that will react with each other during the roasting to form chocolate flavour
- Chocolate flavour is developed in two stages
 - fermentation - chocolate flavour precursors are formed
 - roasting - these precursors react, forming the chocolate flavour

Fermentation - flavour changes



Fermentation of fresh cocoa beans - how it starts

- Harvesting
- Breaking the pods
- Starting fermentation:
 - heap
 - box
 - baskets.....

Breaking ripe pods



Starting a fermentation heap



Heap ready to Ferment



Fermentation is finished



Cocoa beans in baskets ready to ferment



Seven Day Box Fermentation



Seven Day Box Fermentation





5 Days fermentation with one turn

Mechanized Box Fermentation



Different systems of fermentation

- Africa
 - Heap fermentation with 200-1000kg of cocoa
 - 6 days fermentation, actually just 3-5
 - 2 turns, actually one or none, sundrying
- Brazil
 - Box fermentation, approx. 70-80 cm deep
 - 6-7 days of fermentation
 - turns after 48 hours and then every day
 - Sundrying or wood fired dryers in rainy season
- PNG
 - Box fermentation, 7-8 days
 - turns every day
 - Wood or diesel fired dryers

What is cocoa fermentation?

It is a process that occurs in two steps and two locations:

- 1- **Fermentation of sugars in pulp** surrounding cocoa beans. Sugars transformed into alcohol and then to acetic acid (similar to the grape fermentation to produce wine and then vinegar)
- 2 - Acidic acid, produced externally, penetrate through the husk and cause **biochemical reactions in the bean** that are responsible for the formation of chocolate flavour precursors.

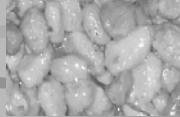
Fresh cocoa beans with pulp**



Fermentation of pulp sugars

Caused by a microbial succession (yeast, lactic acid bacteria, acetobacter)

- 1- **Anaerobic phase - first 48 hours** (pulp does not allow air circulation)
 - Yeast fermentation - pulp sugars are transformed to alcohol - ethanol
 - Temperature increasing - exothermic reaction
 - Formation of lactic acid
 - Pulp breaks down - drains away - air penetration



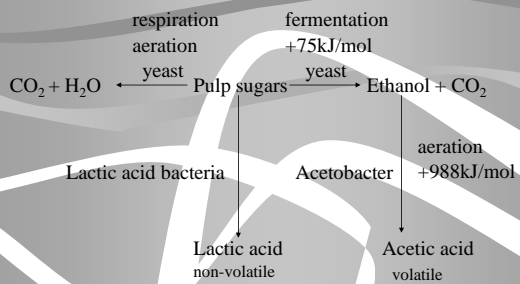
PULP composition	
	%
Water	82-87
Sugars	10-13
Pentosans	2- 3
Citric acid	1- 2
Salts	8-10

Fermentation of pulp sugars - cont.

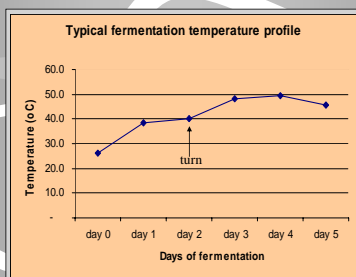
2- Aerobic phase - day 3 onwards

- Aeration (drained pulp and turn after 48 hours) allows strong growth of Acetobacter (aerobic bacteria)
- Acetobacter transforms alcohol to acetic acid
- Very exothermic reaction and increase of temperature up to 50°C
- Acetic acid penetrates into the bean and causes changes that lead to formation of chocolate flavour precursors

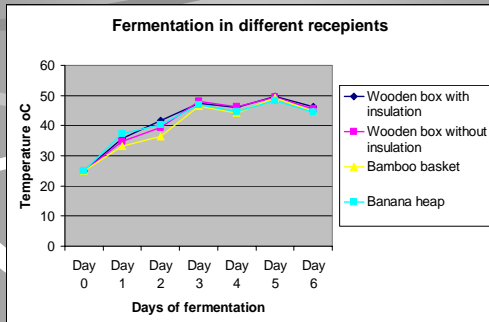
Microbial actions in the pulp



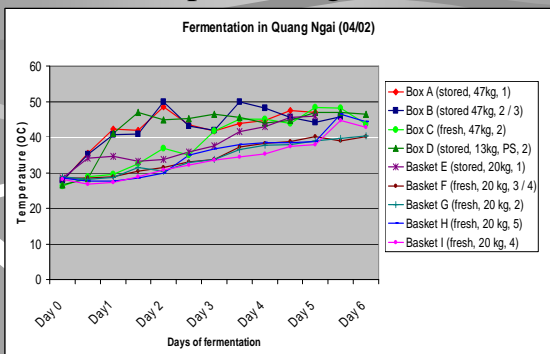
Temperature profile of typical fermentation



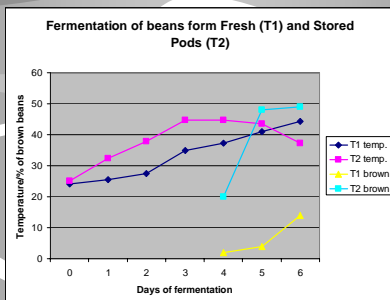
Typical fermentation of stored cocoa - Ben Tre Dec. 06

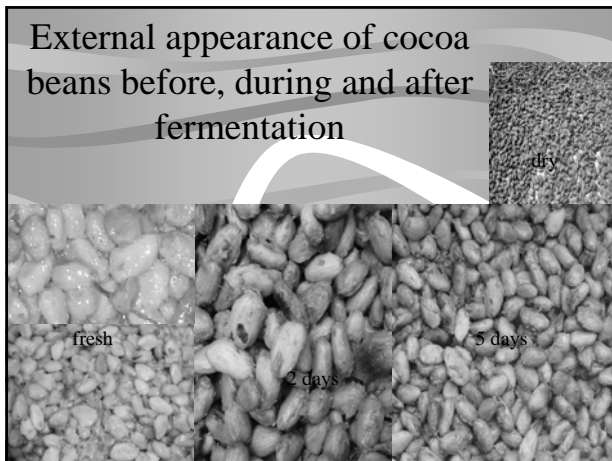


Fermentation with and without pod storage



Fermentation of fresh and stored cocoa beans





Changes inside the cocoa bean during the fermentation process

- Acetic acid penetrates through testa (husk) into cocoa bean
- High temperature and influx of acid:
 - kill the bean
 - disrupt internal cellular structure

Changes inside the cocoa bean

Internal structure and composition of fresh cocoa bean

Cotyledon composition	
	%
Water	32-39
Cellulose	2 - 3
Starch	4 - 6
Pentosans	4 - 6
Sucrose	2 - 3
Fat	30 - 32
Protein	8 - 10
Theobromine	2 - 3
Caffeine	1
Polyphenols	5 - 6
Acids	1
Salts	2 - 3

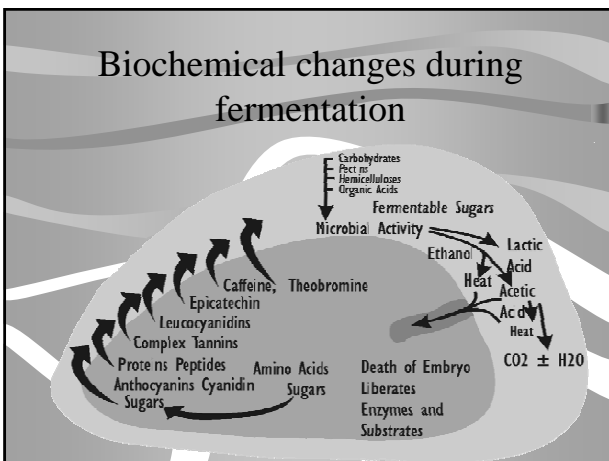
Changes inside the bean, cont.

- Cocoa beans are composed of white cells (fat/butter, proteins) and purple cells (polyphenols)
- High temperature and acid influx disrupt internal cellular structure
- Due to this disruption compounds in the bean are mixing and reacting between themselves
- Reactions between storage proteins, enzymes (proteolytic, polyphenol oxidase, invertase) and polyphenols result in formation of the crucial chocolate flavour precursors

Changes inside the bean, cont.

- Proteins are degraded by enzymes to polypeptides and amino acids - chocolate flavour precursors
- Reducing sugars (glucose/fructose) are released - chocolate flavour precursors
- Part of polyphenols is oxidised and complexed into large tannin molecules - reduction of astringency
- Part of polyphenols and theobromine/caffeine (20%) are diffused and exudated from the bean, reducing the astringent and bitter taste

Biochemical changes during fermentation



End of fermentation - start drying

- Length of fermentation is usually:
 - Foresteiro 5-7 days
 - Criollo 2-3 days
- Open internal structure of beans with brownish middle and external area
- Temperature decrease
- With lower temperatures the putrefaction bacteria will start to proliferate and longer fermentation would cause hammy off-flavour typical for over-fermented cocoa

4-4 Drying of fermented cocoa beans

- Reduction of moisture from 45% to 7%
- Cocoa beans are ready to be transported
- Extended part of fermentation
- Until there is enough of moisture, flavour forming reactions in the beans continue
- Strong browning reactions - oxidation of polyphenols with reduction of astringent and bitter taste
- Sun-drying is the best for good quality
- Mechanical drying is not recommended
 - more expensive
 - danger of smoke contamination
 - high acidity that is retained



Importance of sun-drying

- Sun-drying is the best for good quality
- Significant lowering of sour/acid flavour:
 - Volatile acetic acid evaporates through the husk
 - During slow drying also non-volatile lactic acid is partly transported by the water from the bean to the husk
- Strong oxidation-browning of polyphenols, leading to reduced astringency and bitterness
- More flavour forming reactions still occur

Well fermented vs. Under fermented



Colour of well fermented beans



Sun-drying in Ghana



Dancing the Beans - Brazil



Sun-drying in Sulawesi-Indonesia



Large plantation sun-drying in Indonesia



Small scale sun-drying in Vietnam



Mechanical Drying



Factors influencing the fermentation

- Ripeness of the pods
- Pod storage
- Quantity of beans
- Quantity of pulp
- Type of cocoa
- Duration of fermentation
- Turning
- Seasonal effects/climate
- Pod's diseases

Critical conditions for production of good fermented cocoa

- Ripe pods in sufficient quantity (50-100kg wet beans minimum)
- Small pulp to favorise low acidity and better quality - flavour (pod storage or bean spreading)
- 5 days fermentation will result in lower acidity
- Sun-drying will assure:
 - lower acidity
 - lower astringency and bitterness
 - better chocolate flavour

Reasons/solutions for very sour cocoa beans

- Reasons:
 - Very large pulp with much sugars that give large quantities of acids
 - Long anaerobic phase with strong production of lactic acid and alcohol
 - Quick drying that traps all acids inside the cocoa bean
- Additional problem of acidic beans is very low pH of nibs causing less intensive cocoa flavour precursors formation due to enzyme inhibition

Reasons/solutions for very sour cocoa beans

- Solutions:
 - Pod storage (9 days)
 - reduce pulp volume and speed-up fermentation
 - short anaerobic phase causing less acidity
 - less lactic acid due to reduced lactic bacteria proliferation
 - less acetic acid production due to increased respiration of yeast and reduced alcohol production
 - better cocoa flavour development due to less acidity and more active enzymes producing cocoa flavour precursors
 - Sun-drying
 - Slow evaporation of acetic acid
 - Partly elimination of lactic acid by slow migration in water

Why West African cocoa flavour quality is the best?

- Genetic material - Amelonado
 - proportions of reducing sugars/amino acids
 - Amelonado 1/1.2
 - Malaysia (Upper Amazon) 1/2.6
 - PNG (Trinitario and Upper Amazon) 1/3.6
 - low lactic and acetic acid
- Harvest of ripe pods
- Pod storage to get enough pods to ferment
- Small pulp
- Heap fermentation
- Exclusively sundrying

What is so special about the chocolate flavour

- **Chocolate flavour was never planned by the nature**
- It is in fact result of cocoa bean death and reactions following the destruction of internal cellular bean structure
- Chocolate flavour is extremely complex mixture of more than 500 compounds
- As analytical methods improve this number increases
- No really good artificial chocolate flavour exists

So, we should be all very happy that this special chocolate flavour exists !!!!!