

Quality of traded raw cocoa: Origin specific variation, correlations of quality determining factors and development of a „cocoa quality system“

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Introduction - Quality of cocoa

is determined by

- origin
- Category „bulk“ cocoa or „fine or flavour“ cocoa

is evaluated by various physical, chemical and or organoleptical analysis:

- Cut-test
- analysing contaminants
- absence of off-flavours // presence of Fine aroma notes

Cocoa experts often describe origin or even provenance specific differences between traded cocoa lots -

But what exactly makes the difference?



Approaches - Methods

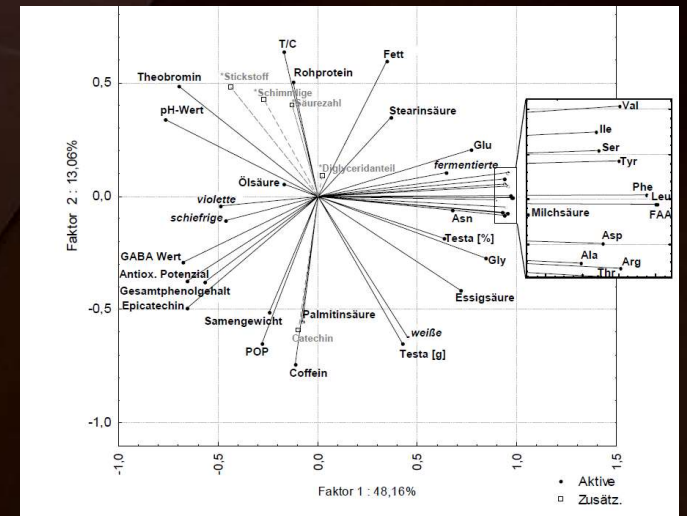
1. Measure the Heterogeneity of 230 traded cocoa samples from 33 origin

physico chemical parameters:

Cut test, seed weight, weight distribution...
photos of the cut beans

biochemical parameters

pH, acetic- and lactic acid
Theobromine, coffeine, nitrogen, free amino acid content
epicatechin and catechin content, total polyphenols
fat content and fat composition, free fatty acids...




PCA, Discriminant Analysis were conducted on a sample set including 120 samples and 22 origins.

Approaches - Methods

2. Approach: Inkubation and Fermentation tests, analysing Fermentation stages

- pH
- epicatechine, catechine, cyanidin-3-arabinosid, cyanidin-3-galactosid
- activity of Polyphenoloxidase
- activity of Aspartylendoprotease
- theobromine- und caffeine content
- free amino acid content



duration	0-24 h	24-48 h	48-120 h
temperature	30°C	40°C	50°C
pH of media (200 mmol L ⁻¹ acetic acid solution)	pH 4,5		pH 5,5
gas / air	nitrogen		air
drying	35°C, 6 days		

	0 h	24 h	48 h	72 h	96 h	
	<-30°C->	<-40°C->	<-50°C->			Incubated, dried
						With Testa
						Without Testa

	0	1	2	3	4	5	6	7 Tage	
Fermentation									
Trocknung									
Röstung									

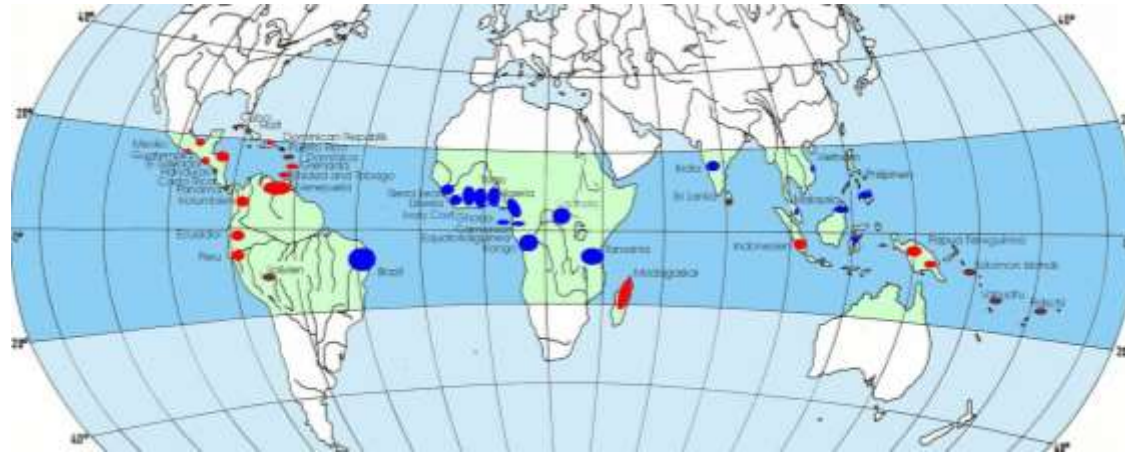
Fermentation test conducted in Trinidad and Incubation tests from the Laboratory in Germany delivered further background information in understanding the dynamics and correlation between quality determining factors.

results: Heterogeneity of traded cocoa

Origin ?

Parameter ?

Post Harvest ?

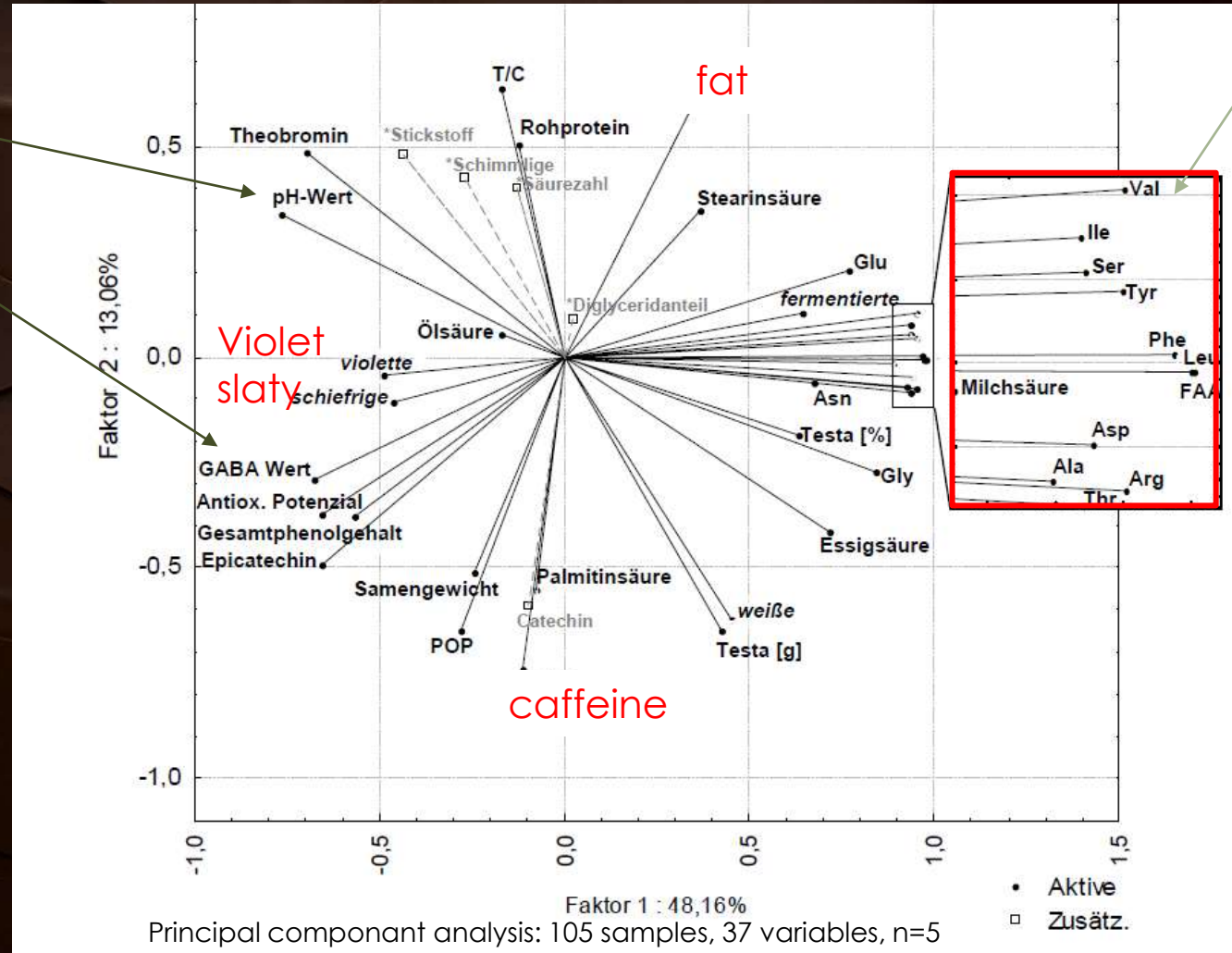


based on results of 37 parameters:
amount of slaty, violet, brown
bean weight
testa=shell [g], testa=shell [%]
pH-value
nitrogen
epicatechin, total phenolics
antioxidative capacity
acetic acid, lactic acid
caffeine (c), theobromine (t), ratio t/c
GABA-value
total and single free amino acids
fat content, POP-triglycerides
stearic acid, oleic acid, palmitic acid

105 samples, 37 variables, n=5

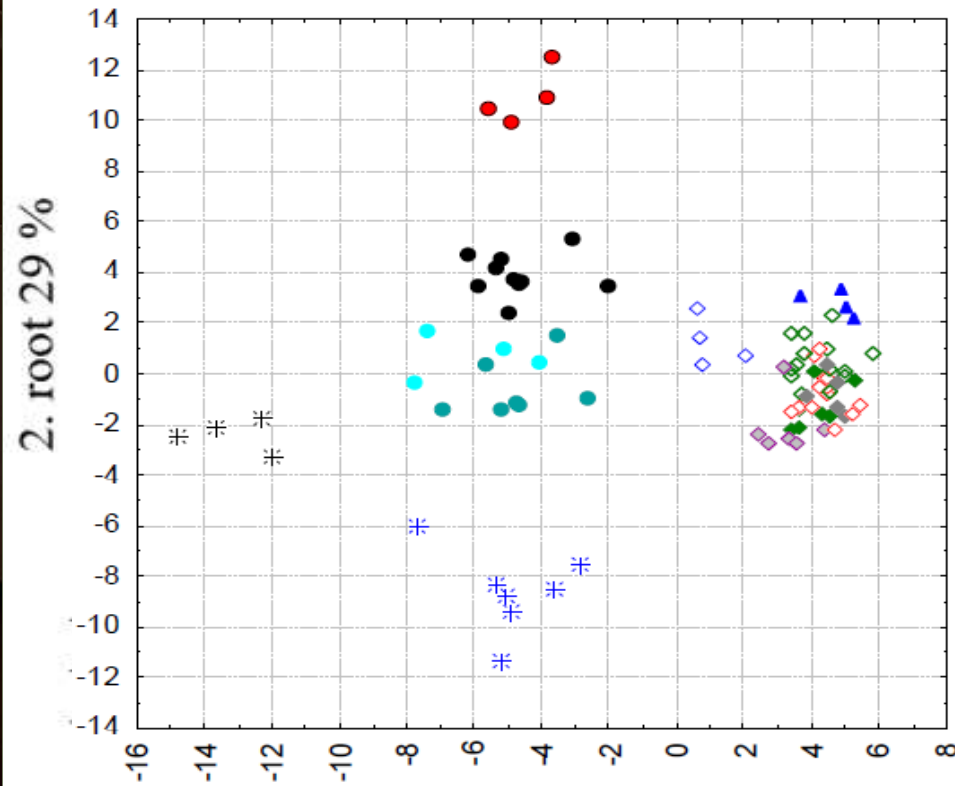
results: PCA from 37 Parameters

pH
Polyphenols
% Violet
% Slaty



Free amino acids
Lactic acid

Results: discriminant analysis



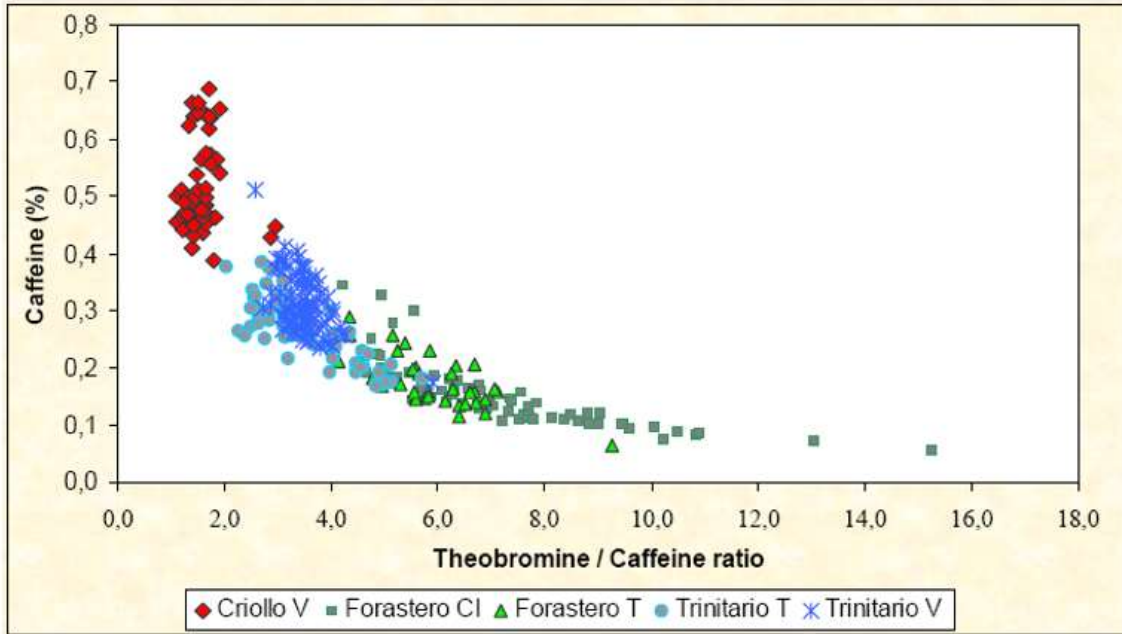
- ◇ Ivory Coast
- Ghana
- Madagascar
- ◇ Nigeria
- ◇ Tanzania
- ◇ Togo
- ◇ Uganda
- ▲ Haiti
- Ecuador
- EET 95, 103; CCN 31
- Venezuela
- * Java
- * Papua New-Guiney
- other

based on results of 37 parameters:
amount of slaty, violet, brown
bean weight
testa=shell [g], testa=shell [%]
pH-value
nitrogen
epicatechin, total phenolics
antioxidative capacity
acetic acid, lactic acid
caffeine (c), theobromin (t), ratio t/c
GABA-value
total and single free amino acids
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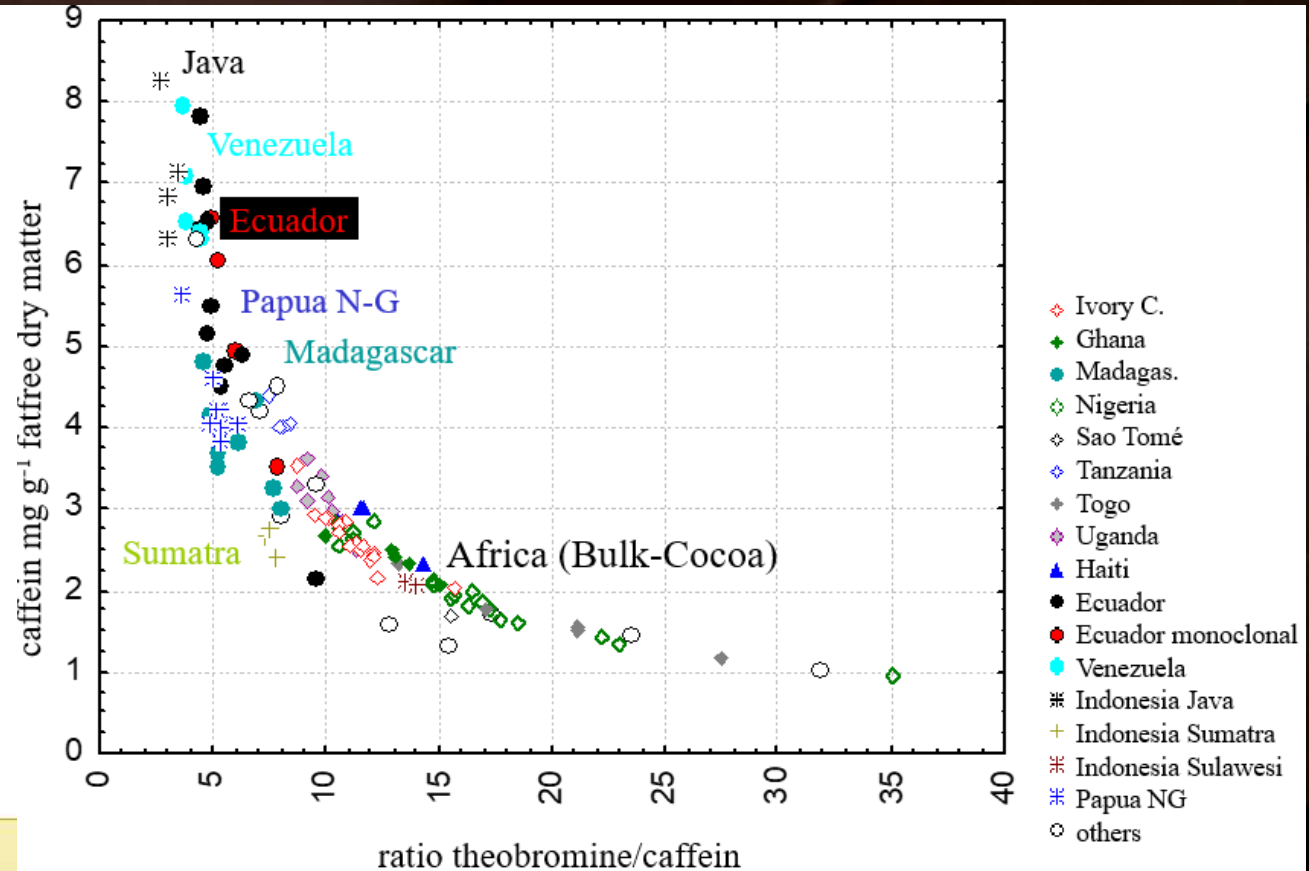
Differences were caused by both factors: the genotype and the post harvest process

Results: further correlations...

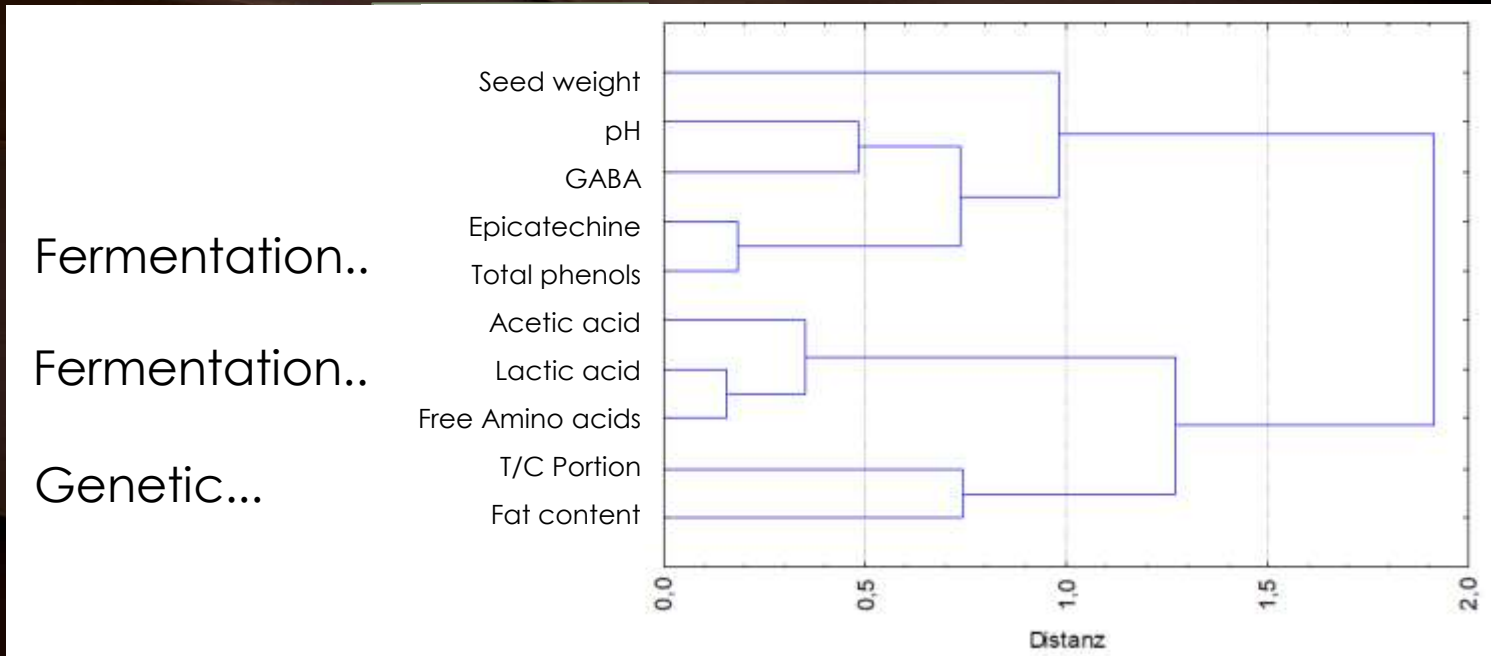
Fine or Flavour Cocoa: low ratio of Theobromine/Caffeine



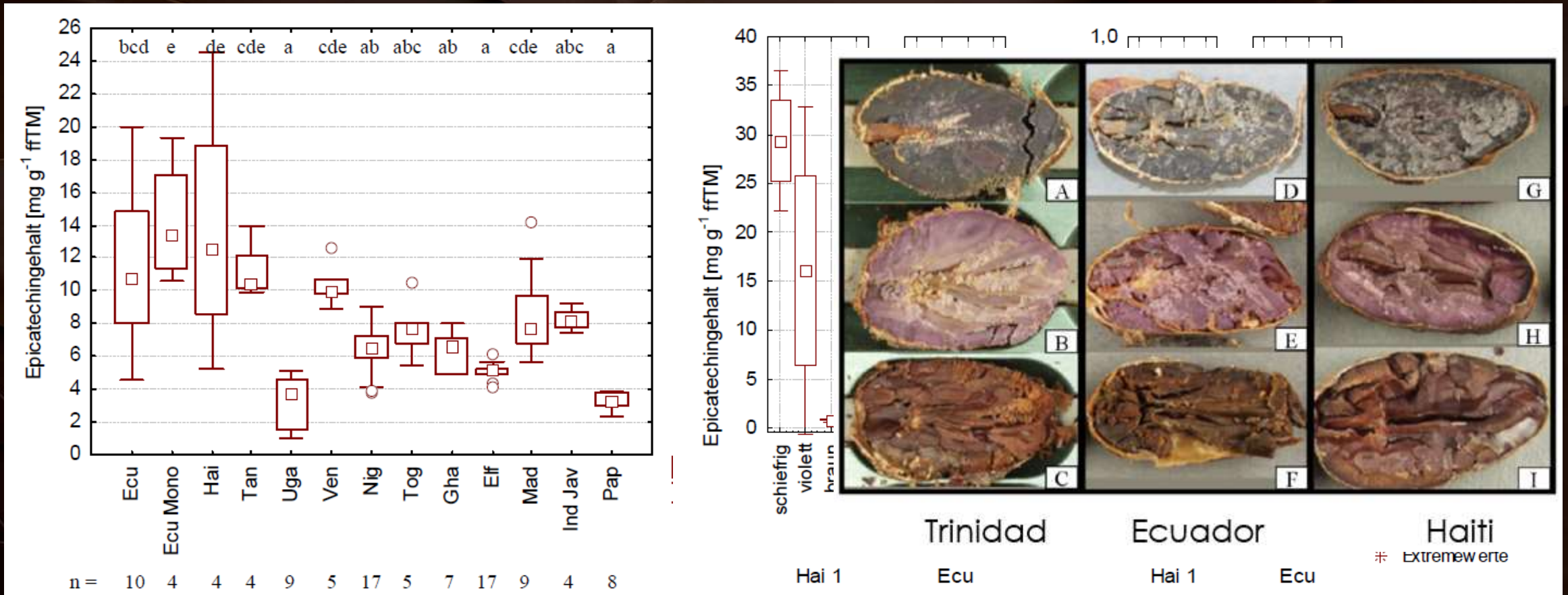
Cros, E. cocoa Meeting in Paris, 2006



Results: further correlations...

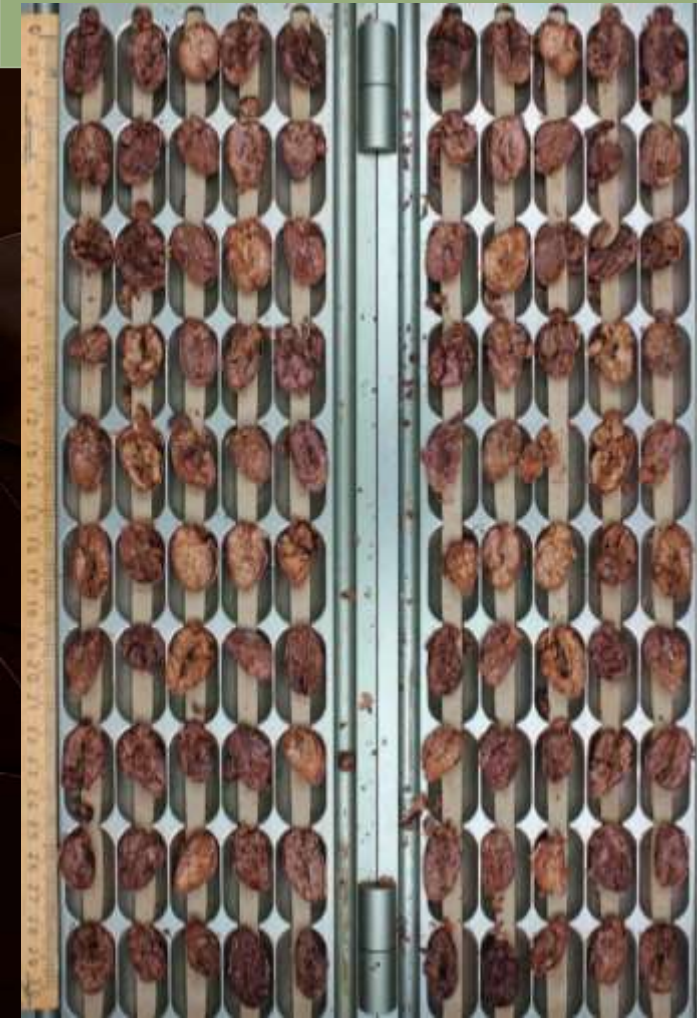


Results: variability within origin...



Fermentation stages = highest variability

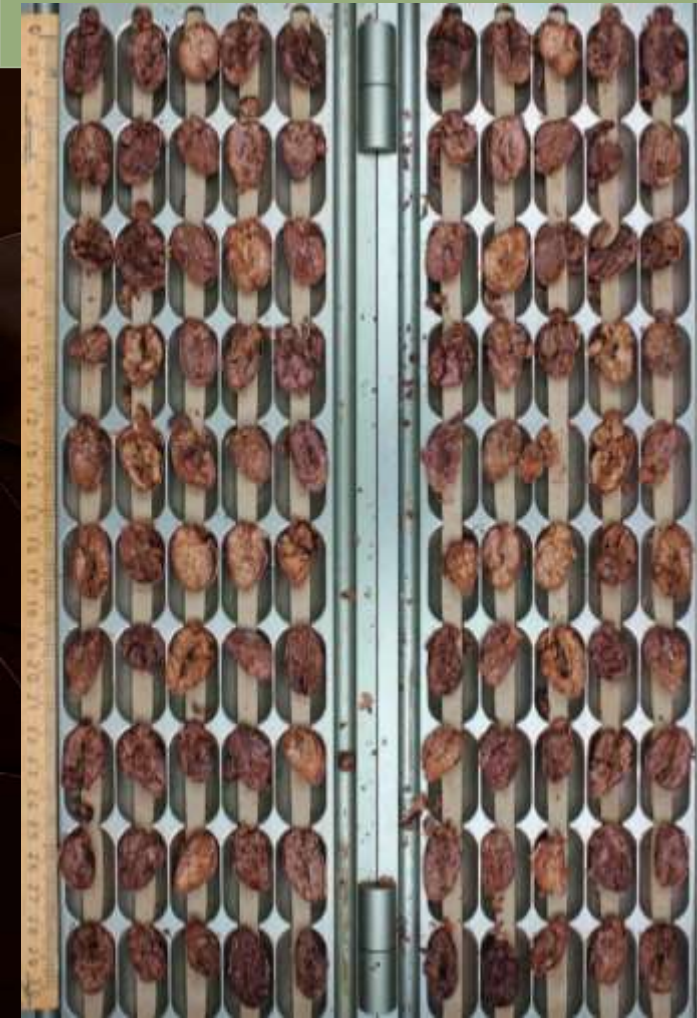
How to classify a unknown sample?



	Composition						Aroma						contaminants											
Shipping	Epicatechin	Catechin	FAA	Protein	lactic acid	acetic acid	pH	theobromine	catechin	tryglycerids	FFA	Bitterness	high adstringency	Fine or F flavour	Mouldy notes	Urinic notes	Hammy notes	Chemical notes	mycotoxins	pesticides	mineral oils	(Mosh/Moah)	cadmium	harmful bacteria
slaty	x	x			x	↑						x	x											
violets	x	x	x		x	x	↓					x	x	x										
mouldy beans				x	x	x	↑		x					x	x	x		x						
insect infested							↑	x		x					x	x	x	x						
overfermented				x	x	x	↑							x	x	x								
doubles														x	x	x								
germinated			x	x	x	x				x														
bean weight																								
different bean sizes									x															

Characterisation of fermentation stages and possible constellation of related parameters.

Cocoa Quality System



	Variety/mix of variety	high temperatures	low temperatures	humid conditions	dry conditions	Soil conditions	type of plantation	Fertilizer	Lime	Pesticides	Yield	Season	Diseased Material	Time lag: opening up to start of fermentation in box	unripe	ripe	overripe	predrying	underfermentation	overfermentation	fermentation	wash after fermentation	Drying	contamination via animals	Grading	Transport	Storage	Shipping	
Genes	Growing condition										Yield				Post-harvest						Storage/Export								
x																	x	x											slaty
x																	x	x											violets
											x						x	x	x	x					x	x			mouldy beans
																									x	x			insect infested
																				x	x								overfermented
												x											x						doubles
										x	x	x					x	x											germinated
	x												x																bean weight
x	x	x		x																									different bean sizes

Cocoa Quality System: Assistance to understand the interrelation of Quality determining factors.

Cocoa Quality System

	Yield/risk of yield	high temperatures low temperatures humidity dry conditions Soil conditions Type of plantation Fertiliser Irrigation	Pests/diseases	Yield & season	Time of harvest	Time of opening up to start of fermentation in bag	over-ripe predrying	under-ripe/dull overfermentation	Fermentation wash after fermentation	Drying	contamination via animals	Grading Tray sort Storage Shipping	Epicatechin flavanols	FAA	Protein lactic acid acetic acid pH	Theobromine catechins pyrrolizidine FAA	Bitterness high astringency Fine or flavour	Mouldy notes Urnic notes Hammy notes Chemical notes	mycotoxins pesticides mineral oils	contaminants		
	Genes	Growing condition	Yield	Post-harvest	Storage/Export	Composition	Aroma	contaminants														
Cocoa Bean	x			x																		
	x																					
Cocoa Paste																						
Cocoa Liquor																						
Cocoa Butter																						

Cocoa quality summary gives advice where adjustment is needed, or what to expect.
To be continued...

Thank you for your attention !

Data sets are based on the projects:

- “Kakaobohnenprüfung 2003/6” and Kakao Atlas 2010, both founded by the Foundation of the German Cocoa and Chocolate Industry. Results were publicated in Lieberei, R.; Rohsius, C. (2010) Cocoa Atlas 2002 (deutsch: Cacao Atlas 2002). Stiftung der deutschen Kakao- und Schokoladen-Wirtschaft (ed) 1st. edn. dresenfunke pr/kommunikation produktion gmbH, Leverkusen CD-Rom 3-9808866-0-3,
- “Charakterisierung chemischer Indikatoren in Rohkakao unterschiedlicher Fermentationsstadien” (founded by the german industrial collective research, IGF "Otto-von-Guericke" e.V. AiF (AiF-FV-Nr. 14491-N)
- „Die Heterogenität der biologischen Ressource Rohkakao (*Theobroma cacao* L.)“ (2007), Dissertation, C. Rohsius