COCOA PROCESSING EXPECTATIONS

Training

Revised – February 2020

*The training is recorded

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AGENDA

SUMMARY OF CHANGES

COCOA PROCESSING – CCP`S

CCP – VALIDATIONS

COCOA PROCESSING – EXPECTATIONS UPDATE

- ❑ Added that 6 log reduction of *Salmonella* is the primary target
- ❑ Added more detail on use of surrogate organism e.g. *Enterococcus faecium*
- ❑ Added basis for 2 log TVC reduction
- ❑ Clarified where moisture measurements must be made and options for this
- ❑ Added frequency (every 2 years) for heating system temperature verifications
- ❑ Added scenarios where re-validation is required

MINIMUM 6 LOG REDUCTION OF SALMONELLA OR EQUIVALENT

- Mondelēz CCP models applied to raw cocoa beans and nibs, Models 9 and 10 → designed to deliver minimum 6 log reduction of *Salmonella*. No biological validation required when these are validated in place using the critical limits specified.

- Where temperatures described in models cannot be measured e.g. due to equipment design, process shall be validated by setting up a specific validation study.

- Study must prove that equipment will consistently deliver minimum 6 log reduction of *Salmonella*.

- If *Salmonella* is not used in validation study (e.g. for safety reasons), a surrogate organism (e.g. *Enterococcus faecium*) with proven equivalent or higher heat resistance in beans/nibs compared to *Salmonella* may be used.

- Alternatively, a 2 log total viable count (TVC) reduction in the beans/nibs can be used as performance criterion

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BASIS FOR 2 LOG TVC REDUCTION

- During natural fermentation process for cocoa beans, numbers of spore-forming bacteria increase to high levels that survive subsequent drying process.

- Microbial load of raw cocoa beans delivered to processing facilities typically made up with approximately 50% of *Bacillus* spores (Lima *et al*., 2012; Barrile *et al*., 1971).

- *D* values of *Bacillus* spores in lower moisture (3-4%) cocoa material are in range of 6-15 minutes at 120°C (CCFRA, 1998). This process would deliver a predicted 3 fold (x3) higher kill of *Salmonella* under same conditions (HACCP Model 10).

➢ Therefore, assumed that a 2 log reduction in TVC will provide more than adequate process to deliver minimum 6 log reduction in *Salmonella* → includes a large margin of safety, based on understanding that predominant microbes making up TVC will be aerobic spore-forming bacteria

COCOA PROCESSING CCP`S

COCOA BEAN STEAM TREATMENT (DEBACTERISATION) – CCP 9

- Best controlled process
- Debacterisation of beans is typically carried out as a batch process.
- Carried out by the introduction of steam at the beginning of or during process.
- Adequacy of start up procedure to be controlled
- Processing temperatures reach 80°C between the beans

Note - Moisture is not part of CCP as process uses saturated steam.

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COCOA NIB HEAT TREATMENT – CCP 10

- Addition of water must be recorded for each batch or moisture content of the nibs has to be determined once per shift (minimum) → moisture is part of CCP

- Alternatively steam introduced once or at several stages into a continuous system (mostly moved by screws). Water addition is necessary only for quality reasons (getting rid of off flavours).

- Correlation of water addition *vs.* moisture at end of heating process (before cooling) must be done once, documented and filed with HACCP plan.

- If steam is the only heating medium, then verification has to be done to ensure that moisture is always reached when temperature values are reached.

- For cocoa liquor processing: Holding time is residence time in reactor or ball mill. Additional pipes after the reactor may be taken into account, but measurement of product temperature must occur at coldest location in process.

CRITICAL LIMITS FOR CCP 10

Time/Temperature/Moisture as follows:

If moisture 1.0 - 2.5 %, then:		If moisture above 2.5%, then:	
Min. Temperature	Min. Time	Min. Temperature	Min. Time
120°C (248°F)	11.70 min.	110°C (230°F)	4.40 min.
130°C (266°F)	4.93 min.	120°C (248°F)	2.04 min.
140°C (284°F)	2.08 min.	125°C (257°F)	1.39 min.
		130°C (266°F)	0.95 min.
		140°C (284°F)	0.44 min.
z = 26.67 C° (48.08 F°)		z = 30.03 C° (54.06 F°)	

(lowest applicable temperature is 90°C/194°F)

Note: Applicable moisture refers to the level (%) after roasting/alkalization, before cooling/water removal and discharge, once CCP limit is met.

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Cocoa Bean Roasting

Table 1. D and z-values calculated for *S.* Typhimurium ATCC 14028 and *E.faecium* NRRL B-2354 in low Aw foods

	D-value (minutes)					z-value (C°)
Organism	100°C	120°C	130°C	150°C	170°C	
Salmonella Typhimurium ATCC 14028	152.3	20.9	10.4	4.3	1.6	37.0
Enterococcus faecium NRRL B-2354	270.0	36.0	18.0	5.0	2.3	34.2

Limburn, R. et al "Study of the validation of low Aw food roasting processes targeting *Salmonella* spp., using cocoa bean roasting as a model system" Poster at IAFP Europe 2015, Cardiff, Wales

Cocoa Bean roasting is not considered a validated biological control step !

MONITORING ACTIVITY / FREQUENCY

Temperature – Batch & continuous systems: No change to previous expectations
Temperature (processes with holding tube): No change to previous expectations
Time (continuous process): No change to previous expectations

Moisture: Two ways to verify appropriate moisture content for effective pathogen reduction in cocoa nib heat treatment:
1. Water addition (volume) is measured and recorded for each batch, or
2. Moisture measured at end of heating process, minimum frequency once per shift.

When using option 1, moisture of nibs at exit of roaster must be measured during validation study to determine which set of temperature/time parameters will be used for processing.
Note: Correlation of worst case processing conditions (min. water addition and max. weight of nibs) vs. moisture of nibs at end of heating process (roasting/alkalization) must be documented and filed with HACCP plan. Correct water-to-product ratio must be applied to ensure that water is above a minimum level and product below a maximum load, so that it is consistent with the ratio used in validation study.

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RECORD LOCATION

All records must have a designated location. Examples of records include temperature charts and calibration log, Hold and Release Records, Corrective Action Records, Validation and Verification Records, Traceability Records, **Moisture Measurements or Water Added and Maximum Weight of Nibs.**

HACCP PLAN VERIFICATION ACTIVITIES

Comparison of temperature readings from heating vessel, from temperature probes placed in heating vessel or in product, with readings obtained during validation at a minimum frequency of every two years, to verify that temperatures achieved in heating system match with temperatures measured during validation, using same volume of nibs/beans as used in validation.

POLL QUESTION 1

The purpose of heat treatment of cocoa beans and nibs is to provide minimum 6 log reduction of Salmonella or an appropriate surrogate organism, alternatively 2 log TVC reduction.

Is it true or false?

- A/ TRUE
- B/ FALSE

Correct answer: A, see slide no 19

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CCP VALIDATIONS

VALIDATION CONCEPT

Definition of “Validation” as given by Codex Alimentarius “GUIDELINES FOR THE VALIDATION OF FOOD SAFETY CONTROL MEASURES” (2008):

“Obtaining evidence that a control measure or combination of control measures, if properly implemented, is capable of controlling the hazard to a specified outcome.”

VALIDATION OF CONTROL MEASURES

Scientific & Technical Literature:

- no official guidelines respective specific control measures
- some studies performed in 1990's, other ones published in 2008 and 2010:

Leatherhead Food Research Association. 1990. Effect of moisture level on the heat resistance of *Salmonella* in cocoa liquor, Research Report No. 666, April 1990.

Krapf, T. and Gantenbein-Demarchi, C. (2010) Thermal inactivation of *Salmonella* spp. during conching. LWT – Food Science and Technology 43: 720-723

COCOA PROCESSING - VALIDATIONS

A validation report shall be available to prove that the equipment and process fulfills MDLZ requirements with respect to the lethality required!

Note: Cocoa bean steam heat treatment is the preferred option for cocoa bean processing.

MICROBIOLOGICAL TARGET

- ❑ 6 log *Salmonella* reduction on cocoa beans/nibs or 6 log reduction of an appropriate surrogate organism (with equivalent or higher heat resistance than *Salmonella* under same conditions of heating), using worst case conditions, and minimum of three controlled runs;

Or

- ❑ 2 log TVC reduction of the cocoa beans/nibs. Records of time/temperature/moisture (water added at start and weight of nibs or % moisture at end of roasting/alkalization)/TVC measurements from 30 different batches shall be provided.

PROCESS CONTROLS

- Whole cocoa bean Steam Treatment (Debacterisation) – **CCP 9**
  - Processing temperatures reach 80°C between the beans

- Cocoa Nib Heat Treatment – **CCP 10**
  - Processing time and temperatures necessary to reduce the microbiological load on the nibs or in cocoa liquor at a given moisture content

BUT

How to prove / validate that conditions are met in reality / production ?

PROCESS VALIDATIONS

Equipment validation can be performed by two means:

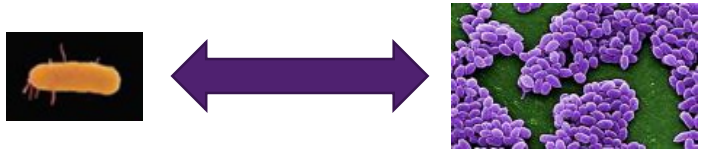
- Validation using surrogate microorganisms – minimum of 3 runs under worst case conditions

- Validation of processing parameters in relation to established control measure
  - Due to equipment design not feasible in all cases

PROCESS VALIDATIONS

How to translate /transfer to known and measurable variables in processing?

☹ Natural contamination of cocoa beans with *Salmonella* un-reliable & too low to use during validation



☺ Natural micro flora of cocoa beans carries high amounts of spores (*Bacillus* species)

CCFRA study "Determination of the heat resistance of *Bacillus* spp. in cocoa mass" October 1998

PROCESS VALIDATIONS

Results enabled us to establish a connection between *Salmonella* reduction and TVC reduction, where the latter could be incorporated as one means of equipment validation:

TVC to *Salmonella* Correlation: The results show a <1:6 ratio for log reduction of TVC to *Salmonella* (target), therefore the original assumption of a 1:2 ratio was too conservative.

Data	Moisture	z-value	Temp.	Time	Log red.
Campden Study	2.88%	25.1°C	120°C	13.5 min.	1 TVC
Leatherhead Study* (CCP Model)	>2.5%	30°C	120°C	2.0 min	6 *Salmonella*

The study has to prove that the equipment will consistently deliver a **2 log TVC reduction** of the cocoa nibs. The parameters used during validation will then become the critical limits for that equipment.

COCOA PROCESSING - VALIDATIONS

Specific Option for cocoa processing

…The study has to prove that the equipment will consistently deliver a 2 log TVC reduction in the beans / nibs. The parameters used during validation will then become the critical limits for that equipment including water added at start and weight of nibs or % moisture at end of roasting/alkalization.

NOTE:

Since variation between batches is always greater than within one batch, for Validation 30 different batches shall be sampled, but not 30 samples from one batch.

Need to verify that 2 logs contains spores from spore-forming bacteria for at least three of the batches

COCOA PROCESSING - VALIDATIONS

Specific Option(s) for cocoa processing

1. Validate processing parameters
   e.g. CCP 10: Time / Temperature / Moisture

2. Validate using TVC log reduction (as explained before)

Note: Ensure that TVC is compared directly before & after CCP treatment !

EQUIPMENT VALIDATION

The main questions we want to answer are:

- Are the controls sufficient to manage the given hazards ? e.g. kill step adequately delivered,
- correct critical parameters identified and controlled ?
- correct location of temperature sensors ?
- tolerance of temperature sensors included in CCP settings ?
- start up procedure adequate ?
- adequate corrective actions defined & followed ?
- incoming material temperature controlled ?
- separation between raw & processed areas adequate ?

EQUIPMENT VALIDATION

correct critical parameters identified and controlled:

Has the validation been performed close to critical limits previously defined and / or at “worst case” recipes ?

“worst case” recipes examples:

- Lowest water / steam addition
- Lower pressure
- Lowest temperatures
- Shortest times

EQUIPMENT VALIDATION

Correct critical parameters identified and controlled:

Moisture is important in ensuring the lethal effect.

How is the moisture controlled / monitored in the process:

↳Is water / steam added?

↳Is pressure applied to ensure equal distribution?

↳Is vacuum applied at the end of the process to reduce the moisture? – How to evaluate / calculate the moisture during processing?

EQUIPMENT VALIDATION

Batch Processes:

- Heating up of equipment
- Normally less concerns, since batch can be processed until values achieved

Continuous Processes:

- How are first materials adequately processed?
- Has validation been performed with lowest ingoing product temperature?
- How is flow rate controlled?

EQUIPMENT VALIDATION

Testing of underprocessed materials is not an adequate / acceptable corrective action!

Batch Processes:

- How can unload / discharge be organized in case of longer term problems?

Continuous Processes:

- Is there a divert?
- How fast is the reaction time & flow time between signal & divert?
- How is the line cleaned / disinfected afterwards? Coolers? – is flushing used?

2-3 times of volume as guidance

EQUIPMENT VALIDATION - ZONING

CCP equipment can be located in

Raw or Controlled Zone – BUT:

Either way the other part of process has to be **enclosed** during processing
&
Procedures must be in place to **manage the risk during maintenance / repairs**.

OUTBREAK IN CANADA/US IN 1973/74

- ❑ 286 environmental samples taken
- ❑ 98 chocolate samples
- ➢ No in-line chocolate samples tested +ve
- ➢ Only 6 (1.6%) samples were +ve
  - — Bean processing rooms (4 +ves)
  - — Moulding plant samples (2 +ves)
- ➢ Sampling of the production environment is key

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IN-DEPTH VERIFICATION

- Every 2 years
- Comparison of temperature readings from the heating vessel, from temperature probes placed in the heating vessel or in product, with readings obtained during the validation
  - to verify that temperatures achieved in the heating system match with temperatures measured during the validation, using the same volume of nibs/beans as used in the validation

WHERE RE-VALIDATION IS REQUIRED

- When there is a system failure resulting in process deviations that cannot be identified;
- Whenever there is a change in the design of the processing equipment or conditions used - only that part of the system affected by the change needs to be re-validated – this includes where nib moisture content is lower than specified e.g. through pre-drying;
- Where Mondelēz International updates the target organism or log reduction target required, based on new information.

POLL QUESTION 2

What is the frequency of heating system temperature verification?

Select correct answer.

- A/ NOT SPECIFIED
- B/ EVERY 3 YEARS
- C/ EVERY 2 YEARS

Correct answer: C, see slide no 33

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THANK YOU FOR YOUR ATTENTION!

QUESTIONS???

To confirm your attendance in the Webinar, please send the name of the company which you represent to the following e-mail address: alicja.alchimowicz@mdlz.com

Support information is on our portal:
https://www.mondelezinternational.com/en/Procurement.aspx

Q&A

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1. **30 batches - do they have to be consecutive runs?**

- No, these do not have to be consecutive runes but will be quicker to complete when they are carried together

2. **Which method is applied determine % moisture present?**

- One of the easier methods for calculating % moisture is to weigh material before and after heating in an oven (e.g. at 100oC) where the difference in weight will be the weight of water present.

3. **Could I do 3 batches worst case scenario for 2tvc log reduction?**

- No, where 2 log TVC reduction is used for validation, this must use 30 batches

4. **If 2 log TVC far exceeds 6log salmonella, how does 6log salmonella guarantee 2log TVC?**

- A 6 log Salmonella reduction does not guarantee a 2 log TVC reduction – the important point is that the 2 log TVC will always be more than a 6 log Salmonella reduction

5. **What would be the verification when the validation was done through 2 log reduction for TVC?**

- An in-depth verification would be looking for a 2 log TVC reduction but over a limited number of runs e.g. 4 runs

6. Is the time in the cooler ever considered as part of the time temp equation?

- Not usually since the conditions cannot be controlled as well as in the heating vessel

7. Can you provide a little more details to how to use the z value?

- If the z value is for 10 C^o for example, this means that when the heating temperature is 10^o higher than the reference temperature, the D value is 10-fold lower. So, if the D value at 120^oC is 2 minutes, and the z value is 10 C^o, then the D value at 130^oC will be 0.2 minutes. For temperatures lower than the reference temperature, the D values will be higher, so at 110^oC, the D value will be 20 minutes (10-fold higher than the D value at the reference temperature.

BACKUP SLIDES

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HISTORY

Examples of *Salmonella* outbreaks related to dry foods:

1970/71	Sweden	cocoa powder	?
1973/74	Canada	chocolate	2.5 cfu/g
1982	Italy	chocolate	low number
1985/86	Canada	chocolate	0.043-0.24 cfu/g
1993	Germany	potato chips	0.04cfu/g
1996	Australia	peanut butter	<3-4cfu/g
2001	USA	(raw) almonds	0.012-0.029 cfu/g
2001	Germany	chocolate	1.1-2.8 cfu/g
2002	Australia	Tahini	?
2006	UK	chocolate	0.03 cfu/g
2007/2008	USA	peanut butter	?

Data refer to a very low amount of microorganisms that could cause illness!!

HISTORY

Root-Cause investigations…or: How did the microbes get in the products???

1970 (cocoa powder)
Cocoa can act as carrier / food matrix for human salmonellosis

1973/74 (chocolate)
Cocoa beans – processed only for quality

2001 (chocolate)
Recontamination of cocoa liquor

2012 cocoa powder (S. Senftenberg) – no outbreak, but found during testing of product

Rework stored in unprocessed / raw zone during construction

HISTORY

1. Extremely low level contamination with *Salmonella* can cause illness in dry & high fatty foods!

Examples: 3 cfu/g in 1996 peanut butter
2 cfu/g in chocolate (1983)
0.3 cfu/ 10g in chocolate (2006)

2. Heat resistance of *Salmonella* depends on water activity / moisture of the materials to be heat-treated.

Examples:

Salmonella Senftenberg in raw milk	D-value at 67.5°C: 0.046min
Salmonella Senftenberg in chocolate	D-value at 70°C: min. 440 min

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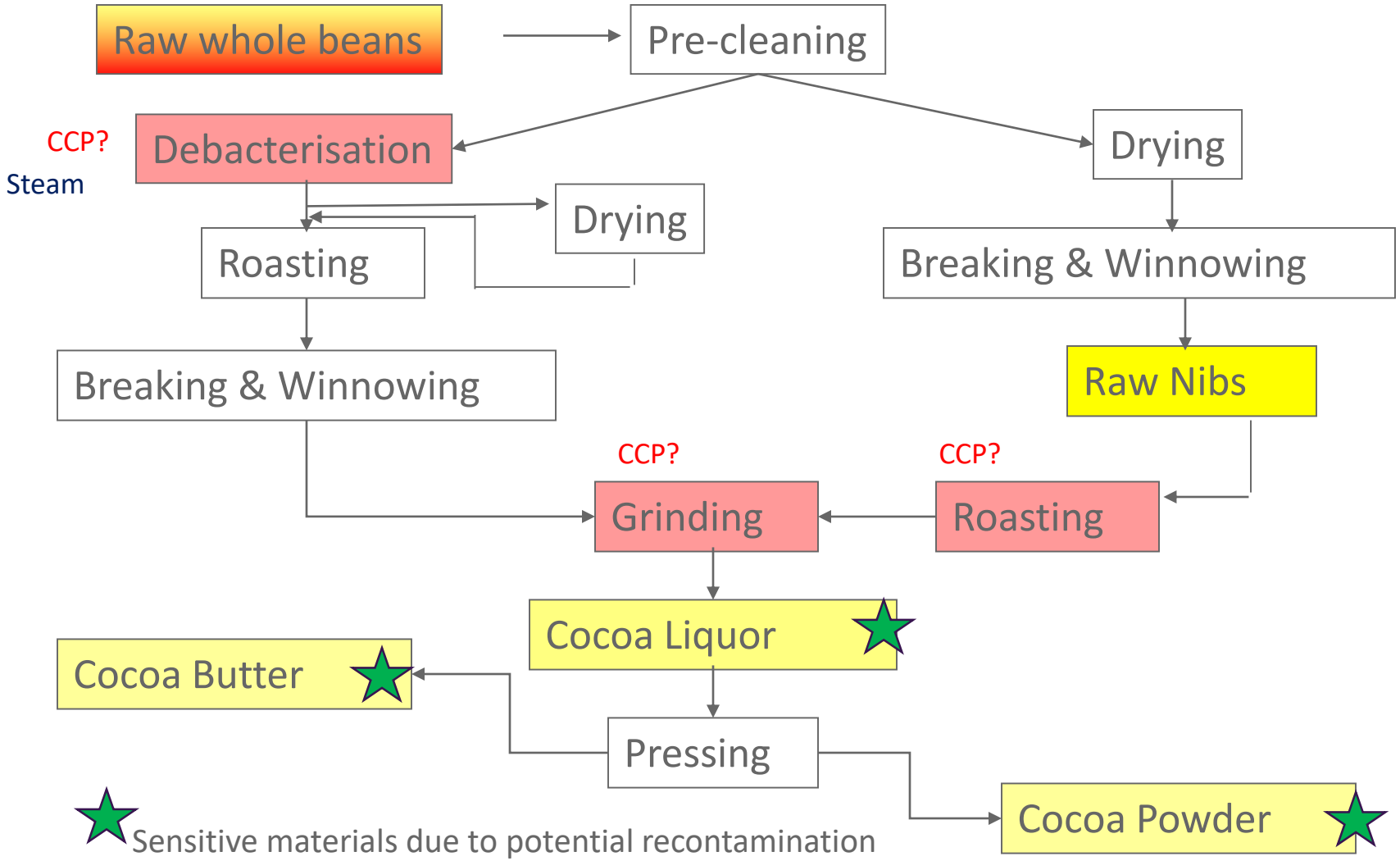
COCOA PROCESSING

GENERAL PROCESS FLOW



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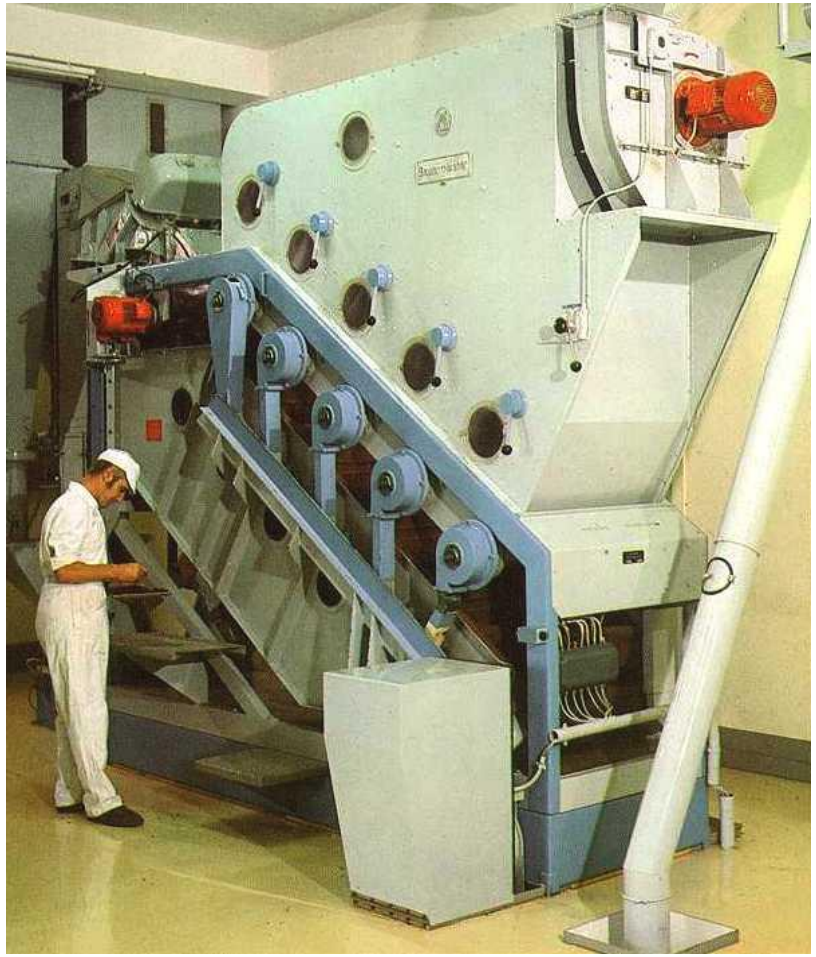
BREAKING & WINNOWING



- The goal is to separate the shells from the beans
- After breaking the particles are divided into a number of fractions by means of sieves.
- Breaking discs are easily worn. Preventative maintenance!
- Check for lubricants dripping in to the product - food grade?

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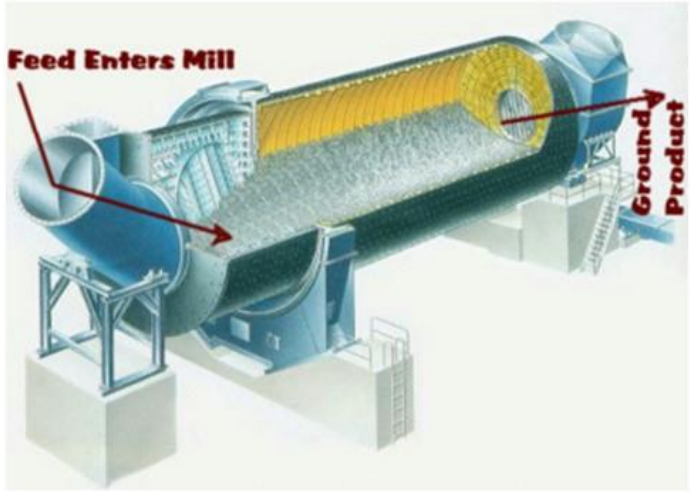
2nd stage Grinding - Ball Mills



2nd stage Grinding - Stone Mills

COCOA LIQUOR PRESSING

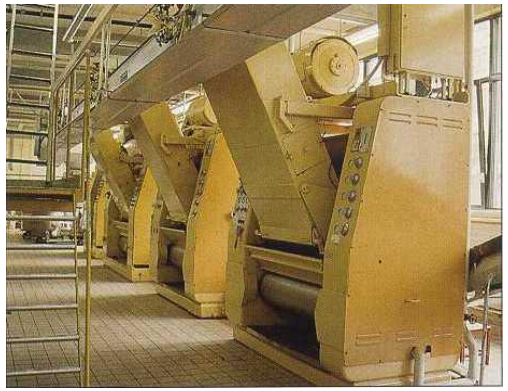
- Cocoa butter, along with cocoa powder, are manufactured by the mechanical pressing of the cocoa liquor.
- This occurs in a neutral zone and is an open process.
- Watch-outs in this area are hazards such as lubricants, physical hazards (fibres from seals, wires from mesh), microbiological - recontamination.
- Additional deodorisation step with steam - in this case the product is not sensitive.

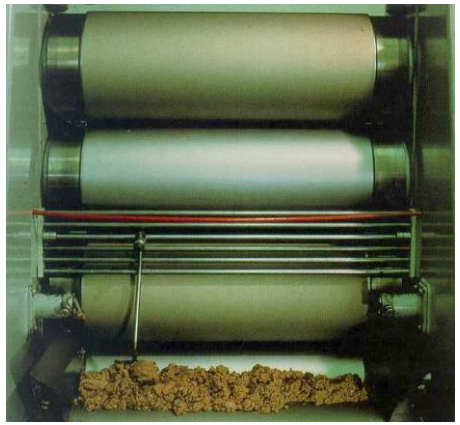
COCOA LIQUOR - EXPELLER

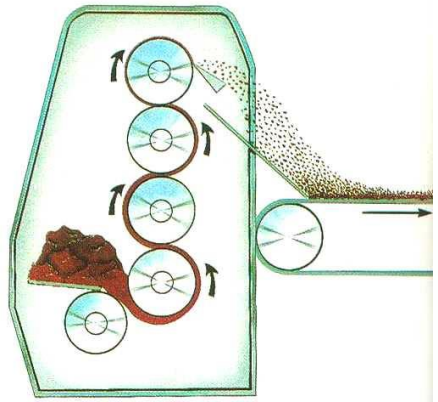
“Squeezing“ of cocoa liquor via screws:

- !! Foreign matter
- !! Condensation niches
- !! Build-up of old material

REFINING







- Is the process of progressively reducing the particle size in the cocoa liquor to give smooth texture.
- Check for circulated water, for any leaks into the refiner

THANK YOU FOR YOUR ATTENTION!