Safety of Cocoa and Cocoa Products: Hazards and Control

JINAP SELAMAT & SAMINATHAN MOOKIAH

Faculty of Food Science and Technology / Institute of Tropical Agriculture and Food Security
Universiti Putra Malaysia

INDONESIAN INTERNATIONAL COCOA SYMPOSIUM 2017 (INCOSY 2017)
Jakarta 18-20 October 2017
Chocolate: The rise of the cocoa purists

By Denise Winterman
BBC News Magazine

NUTRITIONAL BENEFITS OF DARK CHOCOLATE

12 GRAMS OF ORGANIC CHOCOLATE EACH DAY

HEALTH BENEFITS

65% OR MORE OF COCOA CONTENT CAN

- DECREASE BLOOD PRESSURE LEVELS AND THE RISK OF DIABETES AND HEART DISEASE
- INCREASE BLOOD FLOW TO THE BRAIN AND HEART
- ABUNDANT IN VITAMINS & MINERALS
- MAGNESIUM: PREVENTS DISEASES, HIGH BLOOD PRESSURE AND HEART DISEASE
- IRON: PREVENTS ANAEMIA
- COPPER: PREVENTS STROKE AND CARDIOVASCULAR DISEASES
- CONTAINS 8X THE ANTIOXIDANTS FOUND IN STRAWBERRIES

Living the choc 'n' roll lifestyle: Chocolate snorting offers a new way to a cocoa high

- Chocolate shooter was designed by Belgian Dominique Persoone, 46

(-)-Epicatechin (2R, 3R)

(-)-Catechin (2S, 3R)

(+)-Epicatechin (2S, 3S)
Content

• Food Safety
• Hazards
• Chemical & Microbiological hazards
  – Occurrence
  – Regulations
  – Control measures
• Food Safety and Climate Change
• Conclusions
Access to sufficient amounts of safe and nutritious food is key to sustaining life and promoting good health.

Unsafe food causes more than 200 diseases – ranging from diarrhoea to cancers.

600 million – almost 1 / 10 people – fall ill after eating contaminated food and 420,000 die every year.

Children under 5 years of age carry 40% of the foodborne disease burden, with 125,000 deaths every year.

WHO, 2017 facts
Food safety refers to the hazards that may harm consumers.

**Food borne hazard**

“a biological, chemical or physical agent in, or condition of, food, with the potential to cause an adverse health effect” (Codex)

- Biological hazard
- Chemical hazard, including allergen
- Physical hazard
Food Safety

- Farm to fork
- Risk-based (management, assessment, communication)
  - Risk assessment is science-based
- Risk depends on:
  - severity of hazards
  - amount hazard in food
  - how much food is consumed
- Hazards: Prevent – Eliminate – Reduce
- Cause food poisoning, cancer, other diseases
Inter-related factors

- Many factors are related each other and have impacts on human health and FOOD SAFETY.
- Some have correlation, others have trade-off
- We need to address to multiple challenges all together.
Food Safety in Food Security

“FOOD SECURITY exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy lifestyle” (World Food Summit, 1996)
Globalisation

Food supply chains cross multiple national borders
Cocoa is grown in the tropics – food safety?

1,000 metric tons
Cocoa harvesting and pre-processing

Post Harvest Handling

C P

B

C P

B, P

C B P

C B
Main products obtained from Cocoa beans

- Cocoa Beans
  - Cleaning, fermenting, shelling, roasting, winnowing
- Roasted Nibs
  - Grinding, refining
- Mass/Liquor
  - Pressing
  - Cocoa Cake
    - Milling, sieving
  - Cocoa Powder
  - Chocolate
  - Cocoa Butter
    - Mixing, grinding, conching
    - Other uses/as a standalone product
Possible Contaminants in Cocoa and Cocoa Products

- Heavy Metals
- Mycotoxins - Ochratoxin A (OTA) - Aflatoxins
- Polycyclic Aromatic Hydrocarbons (PAH)
- Pesticide Residues
- Allergens
- Biological
- Foreign Matter

Chemical
Organisations establish standards for food safety

- The Codex Alimentarius Commission - Created in 1963 by FAO and WHO (http://www.codexalimentarius.org/),


Cadmium (Cd) and lead (Pb) are major heavy metals in cocoa and cocoa products.

**Cadmium**: Adverse effects on kidney, bone, immune and nervous systems.

**Lead**: Kidney failure and brain damage.

- **Cadmium (Cd) and lead (Pb) Accumulation Mechanisms in Cacao**
  - **Natural:**
    1. Soils of Volcanic Origin
    2. Recycling of contaminated Leaf Litter
  - **Anthropogenic:**
    1. Fertilizers
    2. Pollutants from Flood-Prone Areas (Flooding/Irrigation)
    3. Biosolids/Manures
    4. Atmospheric deposition
    5. Atmospheric emissions of leaded gasoline

Lead can be also come from processing.
• Some recent notable incidents

- 19 July 2017 - ConsumerLab Finds Cadmium Contamination in Dark Chocolate and Cocoa Powders

  Cocoa powders should not contain more than 0.3mcg/g (WHO)

- 4 July 2017 - EU regulator has set new max limits for cadmium in chocolate effective from 2019.
  (Killing at source: How to avoid cadmium and lead in chocolate, by Oliver Nieburg).
**Limits for Cd and Pb in Cocoa and Cocoa product**

### Cadmium (Cd)

- **Maximum permissible level (MPL) of Cd proposed by EU**

<table>
<thead>
<tr>
<th>Products</th>
<th>Limits (ng/g)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk chocolate with &lt;30% total cocoa solids</td>
<td>100</td>
</tr>
<tr>
<td>Chocolate between 30 – 50% total cocoa solids</td>
<td>300</td>
</tr>
<tr>
<td>Chocolate with ≥50% total cocoa solids</td>
<td>800</td>
</tr>
<tr>
<td>Cocoa powder sold to consumers</td>
<td>600</td>
</tr>
</tbody>
</table>

* [be applicable from 1st January 2019 (EU,2014)]

- **Maximum permissible level (MPL) of Cd proposed by Codex Alimentarius Commission (CAC)**

<table>
<thead>
<tr>
<th>Products</th>
<th>Limits (ng/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocoa liquor</td>
<td>3000</td>
</tr>
<tr>
<td>Cocoa powder</td>
<td>4000</td>
</tr>
</tbody>
</table>

### Lead

- **Maximum permissible level (MPL) of Pb proposed by Codex Alimentarius Commission (CAC)**

<table>
<thead>
<tr>
<th>Products</th>
<th>Limits (ng/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocoa butter</td>
<td>100</td>
</tr>
<tr>
<td>Cocoa mass and cocoa powder</td>
<td>1000</td>
</tr>
</tbody>
</table>

- **EU : maximum limits for Pb in cocoa (powder and beans) and chocolate products are not currently under consideration.**
### Cd in cocoa liquor and cocoa powder, presented by ECA

#### Cocoa Liquor

<table>
<thead>
<tr>
<th>Continent</th>
<th>Country</th>
<th>N</th>
<th>Min (ng/g)</th>
<th>Max (ng/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>Cameroon, Ivory Coast, Ghana, Guinea, Madagascar, Sao Tome and Principe, Uganda</td>
<td>326</td>
<td>0.00*</td>
<td>720</td>
</tr>
<tr>
<td>Latin America, Caribbean</td>
<td>Brazil, Costa Rica, Ecuador, Granada, Mexico, Peru, Dominican Republic, Trinidad and Tobago, Venezuela</td>
<td>483</td>
<td>0.00*</td>
<td>3900 (&gt; MPL set by Codex)</td>
</tr>
<tr>
<td>Asia</td>
<td>Indonesia, Malaysia</td>
<td>99</td>
<td>0.00*</td>
<td>600</td>
</tr>
</tbody>
</table>

#### Cocoa Powder

<table>
<thead>
<tr>
<th>Continent</th>
<th>Country</th>
<th>N</th>
<th>Min (ng/g)</th>
<th>Max (ng/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>Cameroon, Ivory Coast, Ghana, Tanzania</td>
<td>53</td>
<td>0.00*</td>
<td>1300</td>
</tr>
<tr>
<td>Latin America, Caribbean</td>
<td>Brazil, Ecuador, Mexico, Peru, Dominicana Republica</td>
<td>154</td>
<td>0.00*</td>
<td>2000</td>
</tr>
<tr>
<td>Asia</td>
<td>Indonesia, Malaysia, Thailand</td>
<td>59</td>
<td>0.00*</td>
<td>1000</td>
</tr>
</tbody>
</table>

**SOURCE:** European Cocoa Association – ECA, 2016

* This value has not been set to ND, since this data has been reported as the source.
Detectable concentrations found in samples from some areas:

- **Nib** Cd levels exceed proposed Max Limit (MPL) (i.e. 800 ng/g ≥ 50% Cocoa Solids) for some areas. (Comparison with Cd Food Safety Standards)

![Nib Cd levels exceed proposed Max Limit (MPL) (i.e. 800 ng/g ≥ 50% Cocoa Solids) for some areas. (Comparison with Cd Food Safety Standards)](image)

Scatter-plot of Cd conc. in Nibs vs. Cd conc. in Shells (Ramthahal et al., 2016)

- Leaves (540-5210 ng/g)
- Pods (530-4490 ng/g)
- Shells (440-4410 ng/g)
- Nibs (350-3820 ng/g)
- Soils (300-1700 ng/g)

Pearson correlation coefficient ($r$), Significant ($p < 0.05$) (Ramthahal et al., 2015)
Lead conc in cocoa and cocoa products in Nigeria

Average lead concentrations (ng/g) for analyzed cocoa beans, cocoa bean shells, chocolate products, and manufactured cocoa.

- Max level (MPL) by Codex Alimentarius Commission (CAC) and EU.
- Shell has high capacity to absorb Pb during fermentation and sun-drying.
- High Pb in manufactured cocoa occurs during shipping and/or processing of the cocoa beans & manufacture of cocoa & chocolate products.

(Charley et al., 2005)
Heavy metals in cocoa beans in Ghana

The number of chocolate cubes needs to be consumed by a child to reach the daily consumption limit of Pb

<table>
<thead>
<tr>
<th>Cocoa solids concentration (%)</th>
<th>Number of chocolate cubes to exceed the daily limit of lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brand E</td>
<td>27  30  40  47</td>
</tr>
<tr>
<td></td>
<td>22  22  19  13</td>
</tr>
<tr>
<td>Brand D</td>
<td>53  73</td>
</tr>
<tr>
<td></td>
<td>13  9</td>
</tr>
<tr>
<td>Brand B</td>
<td>70  85</td>
</tr>
<tr>
<td></td>
<td>15  13</td>
</tr>
<tr>
<td>Brand A</td>
<td>60  72  85</td>
</tr>
<tr>
<td></td>
<td>17  15  15</td>
</tr>
</tbody>
</table>

Plots of Pb concentrations vs. percentage of cocoa solids in different brands of chocolate.

- A linear correlation between the level of Pb in chocolate and the cocoa solids content
- Children, big consumers of chocolates, may be at risk of exceeding the daily limit of Pb.

(Yanus et al., 2014)
Mitigation Strategies Cd contamination

- Mapping cadmium distribution and avoidance of contaminated areas
- Reducing cadmium input into soils
- Bioremediation of soils

- Soil factors – immobilisation, sequestration, competition, leaching
- Cultural – age, coppicing, breaking bioaccumulation cycle.

- Genetic differences in uptake
- Genetic differences in partitioning and sequestration to economic parts

- Fermentation process/ polishing
- Blending

ECA/CAOBISCO/FCC (2014)
Bacterial contamination in cocoa and cocoa products

- Contamination in cocoa beans during the harvesting and drying stages

- Salmonella
  - Salmonellosis outbreaks: main focus of microbiological safety either in cocoa bean products, powder, or chocolate bar (ICMSF, 2005).
  - *Salmonella* contamination level in chocolate: 0.005 CFU/g - 23 CFU/g (Werber et al. 2005).
  - No specific risk assessment of *Salmonella* has been performed for cocoa products.

- Predominant microbiota in cocoa powder: *Bacillus* spore.
Critical Control Point (CCP) in chocolate production

- **Roasting** - eliminate *Salmonella* contamination
- Roasting with steam reduce bacteria in excess of 6 log of *Salmonella*
- **Elimination of > 6 logs of *Salmonella***

- Roasting – (105 -120 °C)
- 7 – 10 min

- **CCP1**

- **CCP2**
  - Reduce *Salmonella*

- **UNCLEAN AREA**
  - Elimination of > 6 logs of *Salmonella*

- **CLEAN AREA**
  - Cocoa beans
  - Inspection and cleaning
  - Roasting
  - Shelling
  - Winnowing
  - Nib grinding
  - Cocoa liquor
  - Pressing
  - Cocoa cake
  - Cocoa powder
  - Cocoa butter
  - Milling & Alkalization
  - Mixing
  - Conching
  - Tempering
  - Moulding
  - Chocolate bars

- **Raw materials and rework**

- **Control of a hazard**
- **Minimize the hazard**
Inactivation of *Salmonella* during cocoa roasting and chocolate conching

- **Roasting**: Thermal resistance of *Salmonella* greater in nibs compared to cocoa beans upon exposure at 110 to 130 °C.

- Reductions between 4 and 5-log for the roasting step [inline with reduction value set by National Confectioners Association Chocolate Council (NCACC, 2011)].

- **Conching of milk chocolate**: Rapid death in the first 180 min followed by a lower inactivation rate.

- Temperature and the initial count influenced the *Salmonella* resistance.

(Nascimento et al., 2012)
Mycotoxin contamination in cocoa and cocoa products

- Most important mycotoxin is ochratoxin A (OTA), produced mainly by *Aspergillus ochraceus*
- Carcinogenic, nephrotoxic, teratogenic, immunotoxic, and hepatotoxic
- Occurred during post-harvest: harvesting, pod-breaking, fermentation, drying, storage, and transportation.
- Currently no specific regulatory limits for OTA in cocoa in Codex and EU legislation
- Good practices is provided in Codex Code of Practice: prevention and reduction of OTA in cocoa (Codex Alimentarius Commission, 2013).
### Mycological evaluation of cocoa beans

<table>
<thead>
<tr>
<th>Stage</th>
<th>Fungi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvesting</td>
<td>No fungi was determined</td>
</tr>
<tr>
<td>Fermentation</td>
<td><strong>Monascus ruber</strong> (19.6%) , <strong>Penicillium paneum</strong> (23.5%) and <strong>Geotrichum candidum</strong> (25.5%)</td>
</tr>
<tr>
<td></td>
<td><strong>Aspergillus versicolor</strong>, <strong>A. wentii</strong> &amp; <strong>P. purpurogenum</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Aspergillus flavus</strong> &amp; <strong>A. Parasiticus</strong> (&lt; 5%)</td>
</tr>
<tr>
<td></td>
<td><strong>A. niger</strong> &amp; <strong>A. carbonarius</strong>, species producing OTA (&lt; 5%)</td>
</tr>
<tr>
<td>Drying</td>
<td><strong>Xerophilic</strong> spp. become dominant in earlier stage</td>
</tr>
<tr>
<td></td>
<td><strong>Aspergillus</strong> &amp; <strong>Penicillium</strong></td>
</tr>
<tr>
<td></td>
<td>Toxigenic species, including <strong>A. flavus</strong>, <strong>A. parasiticus</strong>, <strong>A. niger</strong> &amp; <strong>A. carbonarius</strong>, increase during the later stage</td>
</tr>
<tr>
<td>Storage</td>
<td><strong>A. flavus</strong> and <strong>A. niger</strong> (predominant species)</td>
</tr>
<tr>
<td></td>
<td>Xerophilic spp, especially <strong>Eurotium amstelodami</strong>, <strong>E. chevalieri</strong>, <strong>E. rubrum</strong> and <strong>A. penicillioides</strong> growth under poor storage conditions.</td>
</tr>
</tbody>
</table>

(Copetti et al., 2014)

27
## Mycotoxin level in processing stage of cocoa beans

<table>
<thead>
<tr>
<th>Process</th>
<th>Mycotoxin level</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvesting</td>
<td>- Mycotoxin not detected.</td>
<td>-</td>
</tr>
<tr>
<td>Fermentation</td>
<td>- Ochratoxin A (&lt; 50 ng/g)</td>
<td>(Gilmour and Lindblom, 2008; Mounjouenpou et al., 2008; Copetti et al., 2010, 2011)</td>
</tr>
<tr>
<td></td>
<td>- Aflatoxins (&lt; 20 ng/g)</td>
<td></td>
</tr>
<tr>
<td>Drying</td>
<td>- Aflatoxins low (mean 130 ng/g)</td>
<td>(Copetti et al., 2010, 2011)</td>
</tr>
<tr>
<td></td>
<td>- OTA low (&lt; 130 ng/g)</td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td>- OTA &gt; 2 ppm (2000 ng/g)</td>
<td>(Dembele et al., 2009; Copetti et al., 2010; de Magalhaes et al., 2011)</td>
</tr>
</tbody>
</table>
Key Reduction Points of Mycotoxin: Cocoa bean industrial processing

Reduce OTA by mechanical shelling (27–72%) and shelling by hand (50–100%)

More effective in reducing aflatoxin than OTA

Reduce OTA by 24–40% (Manda et al., 2009)

Sourced: M.V. Copetti et al. 2014
Formation & reduction in aflatoxin & OTA during stages of production of cocoa powder % chocolate from cocoa beans

- Highest mycotoxin contamination occurred during storage.
- Shelling and winnowing lead 90% reduction in OTA concentrations

Sourced: M.V. Copetti et al. 2014
Cocoa GAP - Mitigation of OTA residues

✓ Discard insect damaged/rotten/mummified pods.
✓ Avoid wounding pods with machete.
✓ Do not store harvested pods longer than 7 days.
✓ Follow guidelines for fermentation, sun drying.
✓ Dry cocoa down to ≤ 8% moisture.
✓ Careful handling of beans.
✓ Effective de-shelling of beans.
Mycotoxin regulation in cocoa and cocoa products

✓ Few countries set regulatory limits for OTA and/or aflatoxins in cocoa beans & cocoa products.

✓ Max limit for OTA in cocoa does not appear necessary (European Commission, 2010).

✓ Brazilian Sanitary Surveillance Agency (ANVISA) set limits for both OTA & aflatoxins (2011):
  o 10,000 ng/g for cocoa beans
  o 5,000 ng/g for cocoa products & chocolate
Polycyclic Aromatic Hydrocarbons (PAH) in cocoa beans

- PAH from incomplete combustion (burning) of organic substances (e.g. wood, gas, diesel) and geochemical processes.
- Genotoxic and carcinogenic → food safety authorities recommend
- Contamination of PAH in cocoa: smoke during artificial drying

Smoke from a fire below a drying table can contaminate beans with PAH.
Mitigation of PAH residues

✓ Sun-dry where possible (protect beans from rain).
✓ Use indirect drying if sun drying not possible.
✓ Direct drying with wood or diesel fires are not to be used.
✓ Avoid smoke contamination
  - Well maintained, functional exhaust/chimney
  - Regular maintenance of dryers required.
✓ Handle beans carefully to avoid broken beans
✓ Effective de-shelling of beans
Effect of cocoa bean drying methods on polycyclic aromatic hydrocarbons (PAHs) contamination in cocoa butter (Misnawi, 2012)

- PAHs higher in whole cocoa bean than peeled cocoa beans.
- Indicating, contaminant moved from cocoa shell into the bean cotyledon.
- Artificial dryer with wood showed a higher risk of contamination than kerosene and industrial diesel oil.
- Leak of gas separator facilitating a contact of firing gas with cocoa beans.
- PAHs level below the max limit set by EU (2ng/g.)
**EU Maximum Limits for PAH in Cocoa Products**

<table>
<thead>
<tr>
<th></th>
<th>Benzo(a)pyrene</th>
<th>benzo(a)pyrene + benz(a) Anthracene + benzo(b) fluoranthene + chrysene</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cocoa beans and derived products with the exception of the products below</strong></td>
<td>5 ppm fat from 1/4/2013</td>
<td>35 ppm fat from 1/4/2013 - 31/3/2015</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30 ppm ng/g fat from 1/4/2015</td>
</tr>
<tr>
<td><strong>Cocoa fibre and products derived from cocoa fibre, intended for use as an ingredient in food.</strong></td>
<td>3 ppm From 27/10/2015</td>
<td>15 ppm from 27/10/2015</td>
</tr>
</tbody>
</table>
Breakdown of undeclared allergen recalls by food type, between 1 Jan 2007 and 31 Dec 2016 – Aus-NZ

Number of recalls by year and classification, 1 Jan 2007 - 31 Dec 2016.
Allergens in Cocoa products & regulations

- Allergens in cocoa products: peanuts, tree nuts, milk, soya

- In chocolate, it's a legal requirement for it to be clearly labelled in the ingredients list

- Components of an Allergen Policy (Plant)
  - Regulations and Laws
  - Identifying and minimising allergen hazards in the plant
  - How to avoiding cross-contact in the plant
  - Policy on labelling and precautionary statements
  - Training and education for staff, suppliers, contractors and vendors
Climate Change and Mycotoxins

Climate change and food safety: An emerging issue with special focus on Europe


Abstract

According to general consensus, livestock production, the potential investigator issue. Nonetheless, remain a less studied topic. This to be affected by changes in climate linked to plant products in the by changes in pest pressure; traces in their abundance and availability in long-range atmospheric transport following production of mycotoxins in foods following more frequent topics that are amenable to further

Additional Images

How will climate change affect mycotoxins in food?

R. Russell M. Paterson, Nelson Lima

Additional Images
Effects of Climate Change on Food Safety

- Alter chemical and pathogen inputs to food
- Increase use of pesticides & insecticide
- Impact on global cocoa cultivation

- Flood - mechanism for transporting pathogens & chemicals onto agricultural land
- Elevate temperatures increase food borne pathogens & mycotoxins
- Increase the irrigation water to crop, elevating pathogen risks

Source: Dr. Iain Lake et al., 2011, Food and climate change report
Climate change affects heavy metal concentrations in soil through various mechanisms:

- **Increase occurrence of hydrology & leaching of heavy metal**: Evapotranspiration & heavy precipitation affect transport rates and pathways of heavy metals.
- **Floods, increases in heavy metal concentrations due to desorption or re-suspension**: Droughts increase in eutrophication and heavy metal concentrations due to a decrease in dilution.

These changes are due to increased evapotranspiration and heavy precipitation, and decreased dilution due to droughts.

*Source: Wijngaardet al., 2017,*
Climate change can affect infection of crops by toxigenic fungi, the growth of these fungi and the production of mycotoxins.

Climate change

More mutagen mycotoxins

Fungal mutation

Precursors

More, new Mycotoxins

2003, hot and dry summer in Italy have resulted in increases occurrence of A. flavus, with consequent the serious outbreak of aflatoxin contamination.
Climate change

High tolerate to stress condition including extremes pH, temperature (heat), oxygen, pressure and osmotic stress

Bacterial stress response (*Salmonella*)

Increase growth & survival rate of *Salmonella* in dry environment of raw ingredients used in manufacture of chocolate

Enhance their competitiveness (FAO, 2008a)

Exposure to a range of antimicrobial, preservative and sanitizing agents
Cocoa Safety

• Concern in cocoa and cocoa products safety is mainly due to chemical hazards, Salmonella

• Control measures:
  – Proper management of farm to fork - soil, post-harvest of cocoa and product handling and processing reduce safety risk.
  – “Good” Practices (ex GAP, GMP, GWP), HACCP
  – Knowledge, awareness, practices

• Traceability of hazards along the supply chain

• Climate change enhances hazard risks
  – Lack in data, research in food safety with climate change
Terima kasih

jinap@upm.edu.my; sjinap@gmail.com
### Pesticide residues and maximum residue levels (ng/g), set by EU (Regulation (EC) No 396/2005)

<table>
<thead>
<tr>
<th>Products</th>
<th>Type of pesticide</th>
<th>Maximum level (ng/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocoa</td>
<td>Ethephon</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Methomyl &amp; Thiodicarb</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Profenofos</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Triadimefon &amp; triadimenol</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Trifloxystrobin</td>
<td>50</td>
</tr>
<tr>
<td>Cocoa (fermented beans)</td>
<td>Cypermethrin</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Ethephon</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Fenitrothion</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Indoxacarb</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Lambda-Cyhalothrin</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Methomyl &amp; Thiodicarb</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Profenofos</td>
<td>200</td>
</tr>
</tbody>
</table>

*MPL of pesticide residues in cocoa not available in codex*