FACULTY OF
BIOSCIENCE ENGINEERING

DEPARTMENT OF APPLIED BIOSCIENCES (BW15)

LABORATORY OF CEREAL TECHNOLOGY

MILLING TECHNOLOGY FOR CEREALS

Filip Van Bockstaele, 16-05-2017, QAQC training on flour fortification, Lusaka, Zambia

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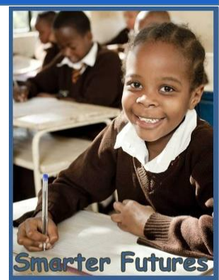

CEREALS

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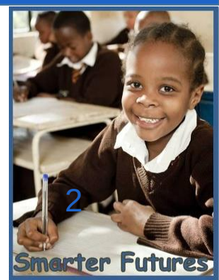

WHAT ARE CEREALS?

- Ceres
- Grass family (Gramineae)
  - One seeded fruits
    - Caryopsis = kernel = grain
      - Germ
      - Endosperm
      - Bran: seed coat and fruit coat
    - Developes in glume (chaff, husk)

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GENERAL ASPECTS

Easy to cultivate

High yield

Stable when not processed

Both in moderate as in dry climates

Storage in dry conditions

Insect and rodents cause major losses

Mycotoxins are a food safety issue

Spoilage is mostly caused by moulds

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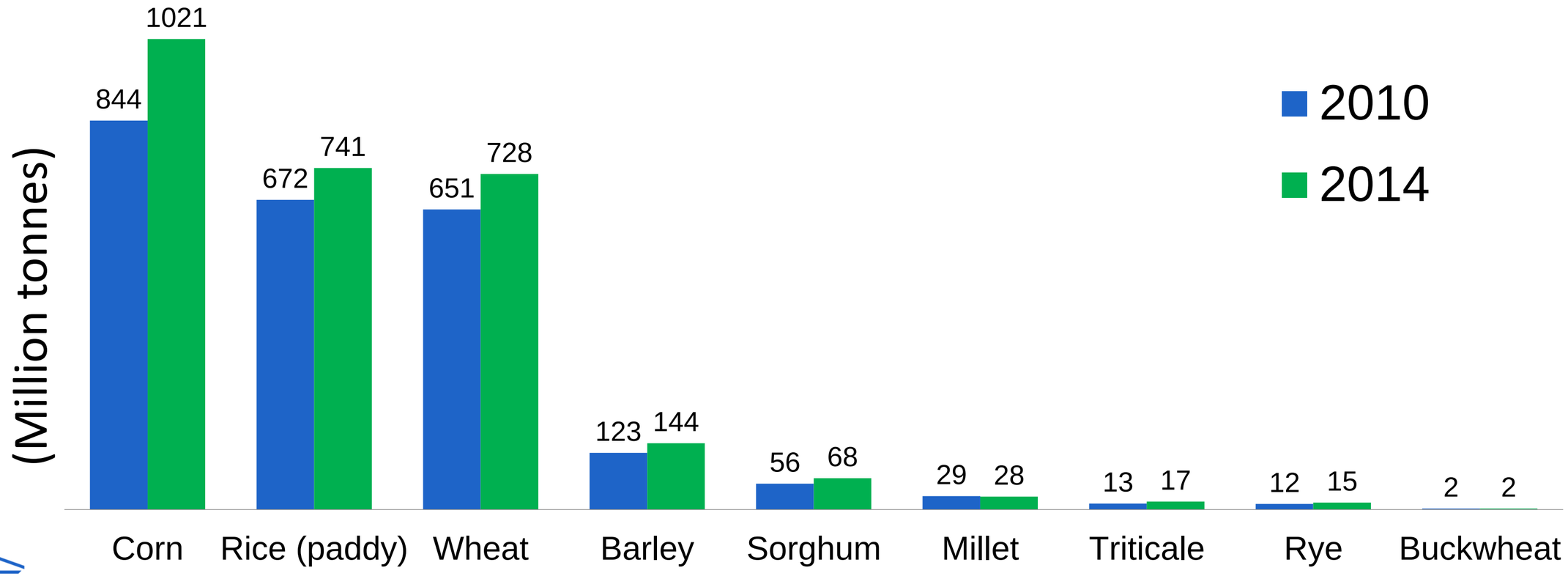
CEREALS IN THE WORLD

Annual production of major cereals in 2010/2014



(based on faostat.fao.org)

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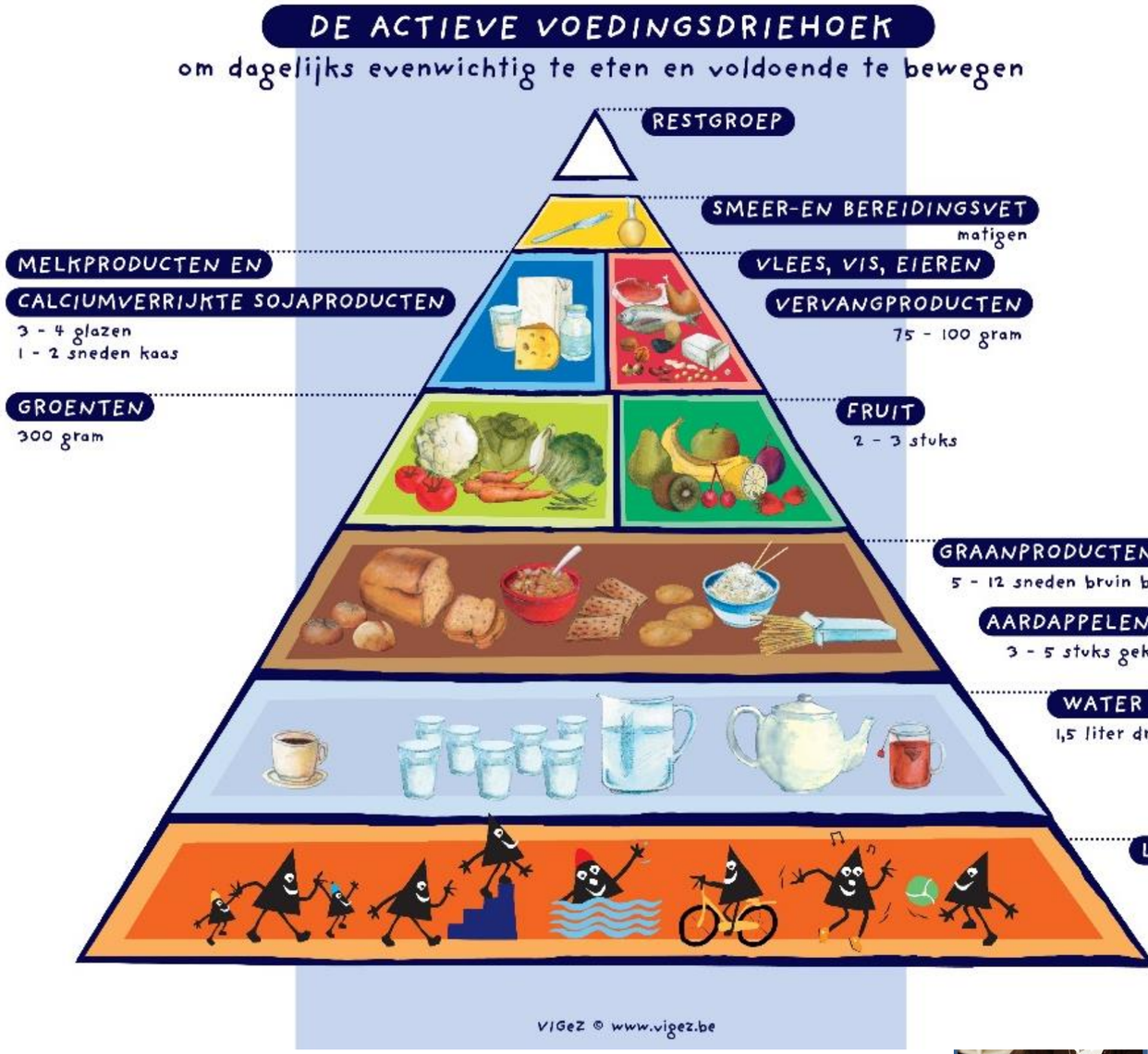
NUTRITIONAL IMPORTANCE OF CEREALS

- Macronutrients:
  - Carbohydrates (50-80%)
    - Staple food
    - Digestable: starch
    - Undigestable: dietary fiber
  - Proteins (8-15%)
  - Lipids (1.5-7%)

- Micronutrients:
  - Vitamins
  - Minerals (1-2.5%)



WHEAT

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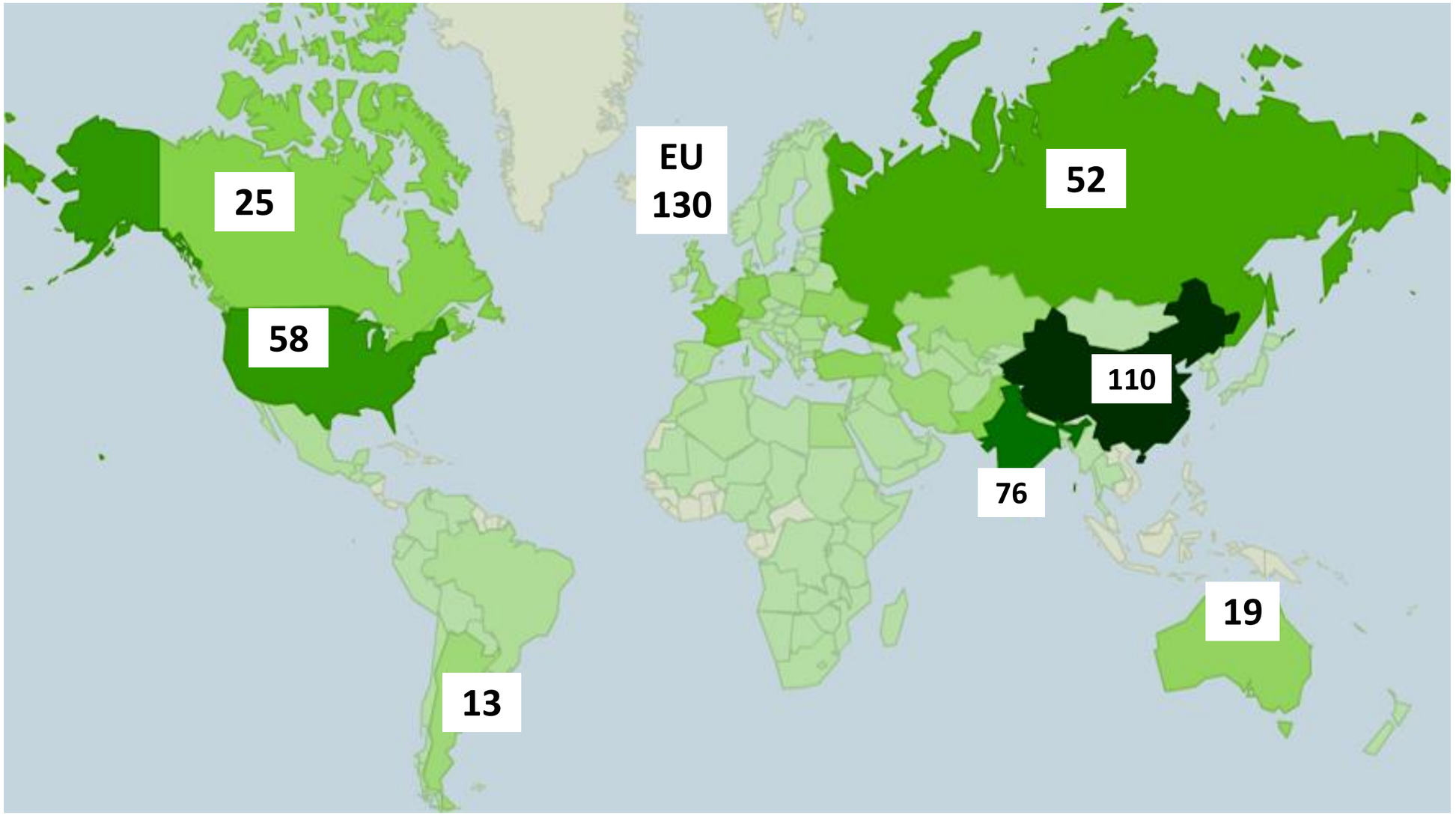
WHEAT PRODUCING COUNTRIES



(source: faostat.fao.org) Million tons (average 2005-2010)

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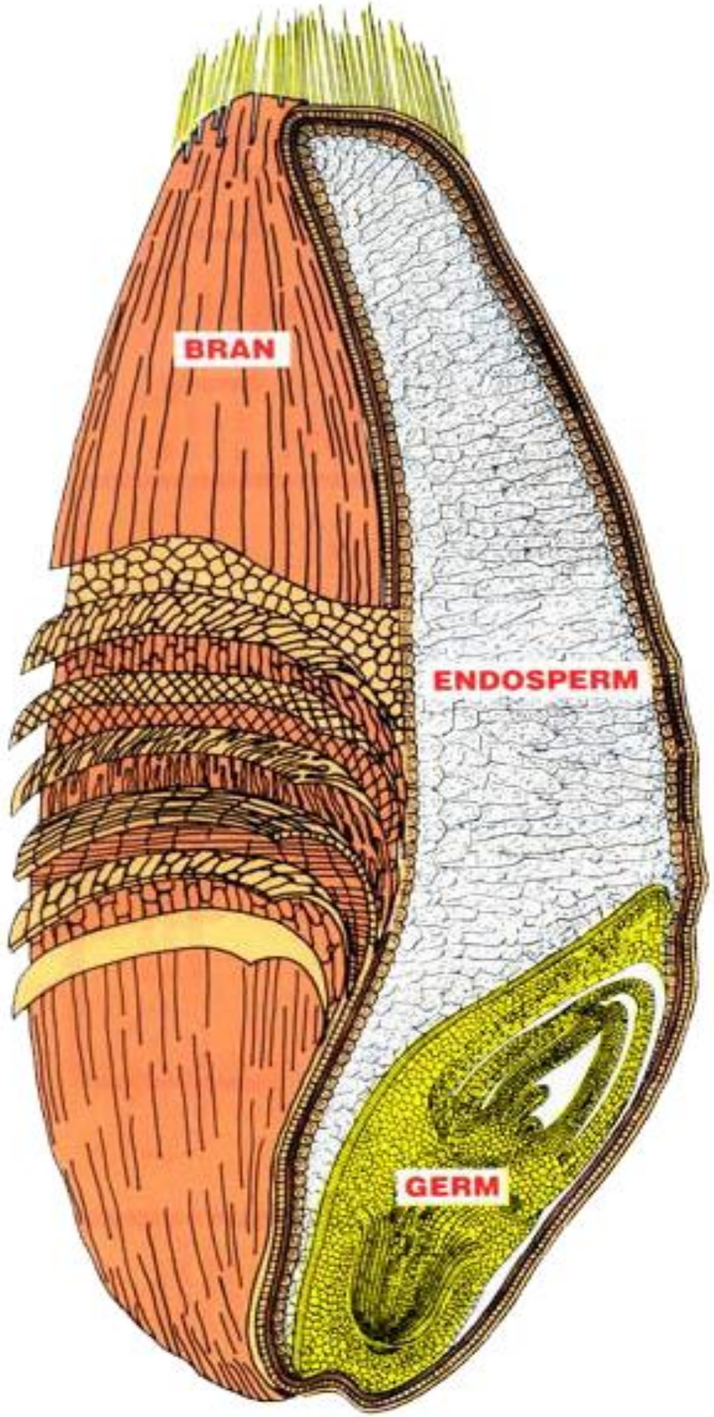
WHEAT KERNEL



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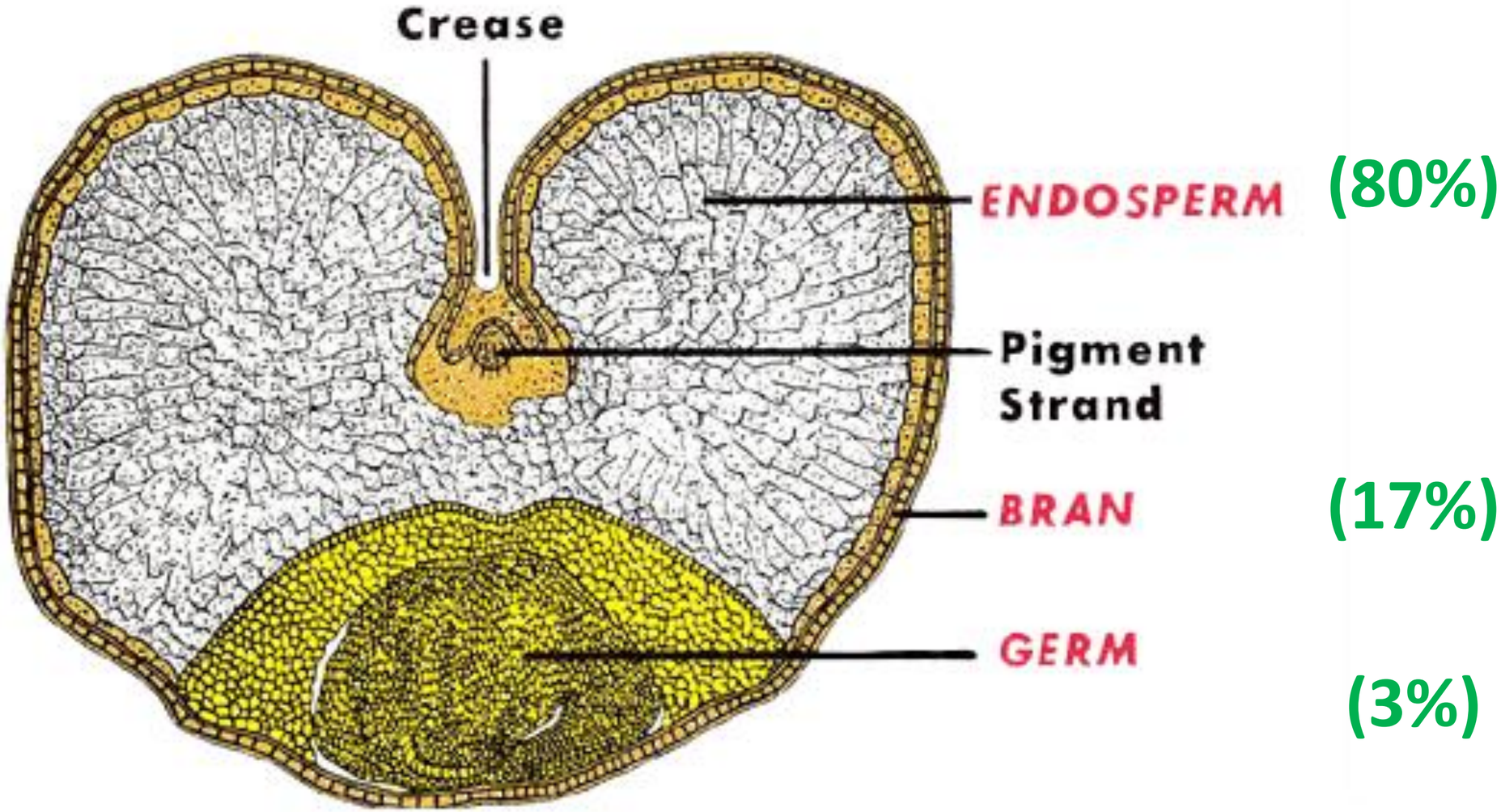
WHEAT KERNEL



(80%)

(17%)

(3%)

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WHEAT CLASSES

Hard Red Spring wheat

Durum wheat

Hard Red Winter wheat

Soft Red Winter wheat

Soft White Winter wheat

Mixed wheat

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http://www.css.msu.edu/

MILLING: ONE STEP?

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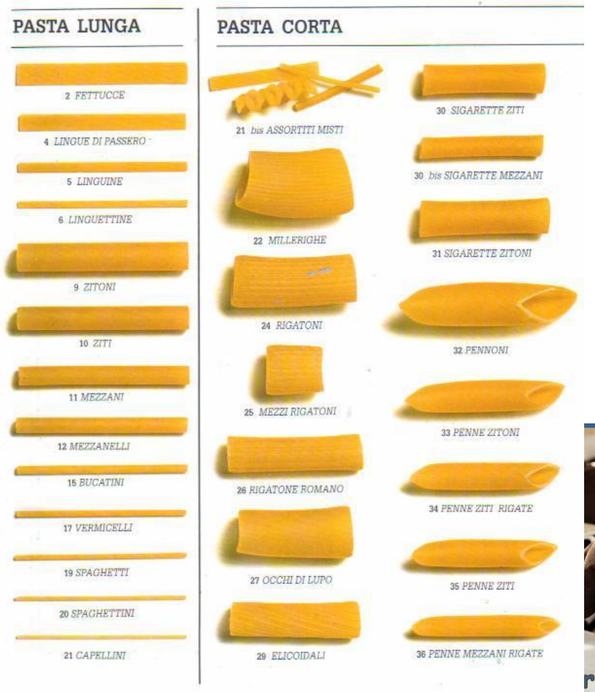
GOAL OF MILLING

Bran

Fine white flour

Bran

Semolina



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FROM CEREAL TO FLOUR

- Milling:
  - Separation of bran/germ from endosperm
  - Size reduction of endosperm -> flour
- Processing steps involved
  - Reception and pre-cleaning
  - Cleaning
  - Conditioning
  - Milling
  - Sieving
  - Blending

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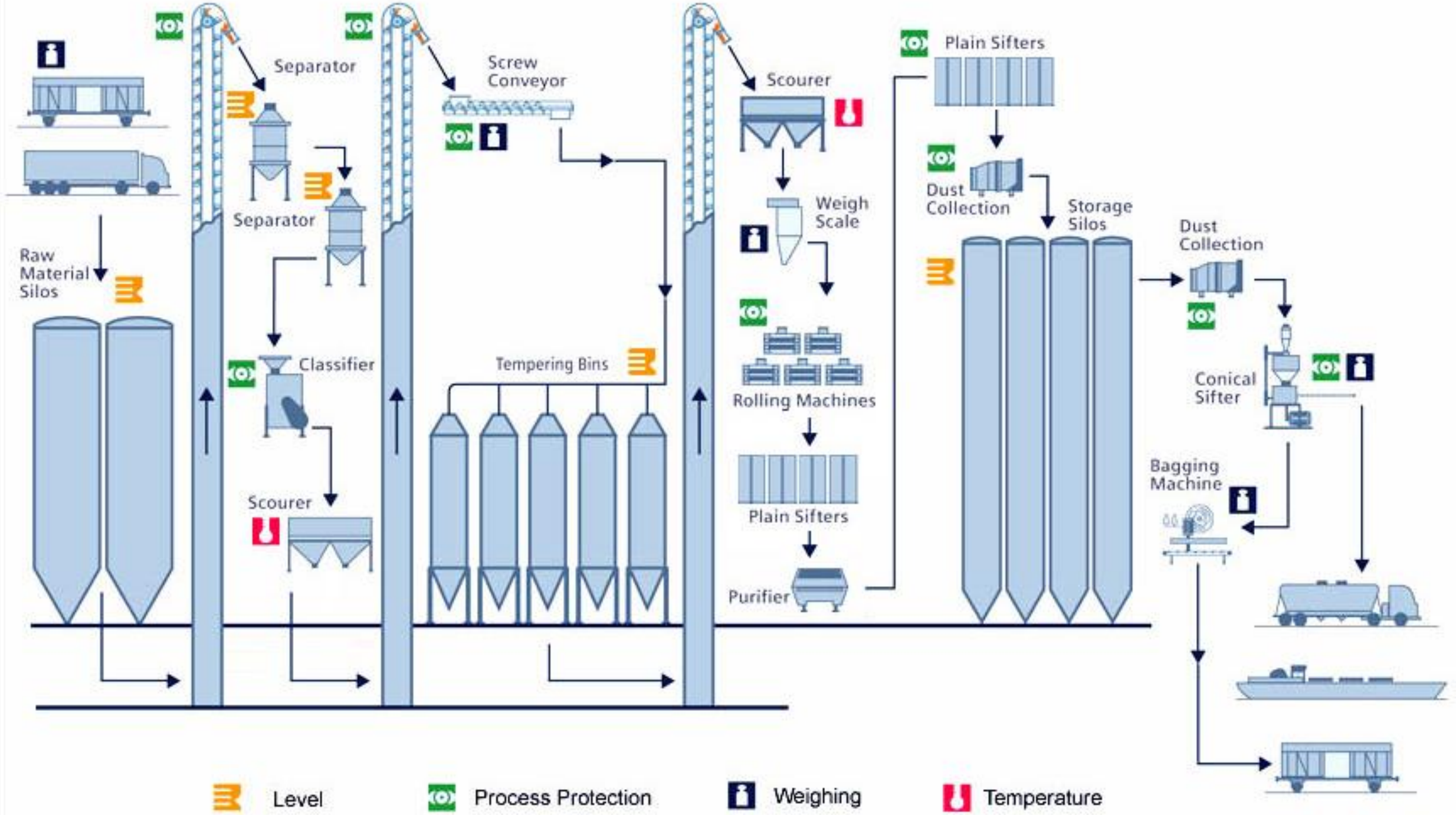
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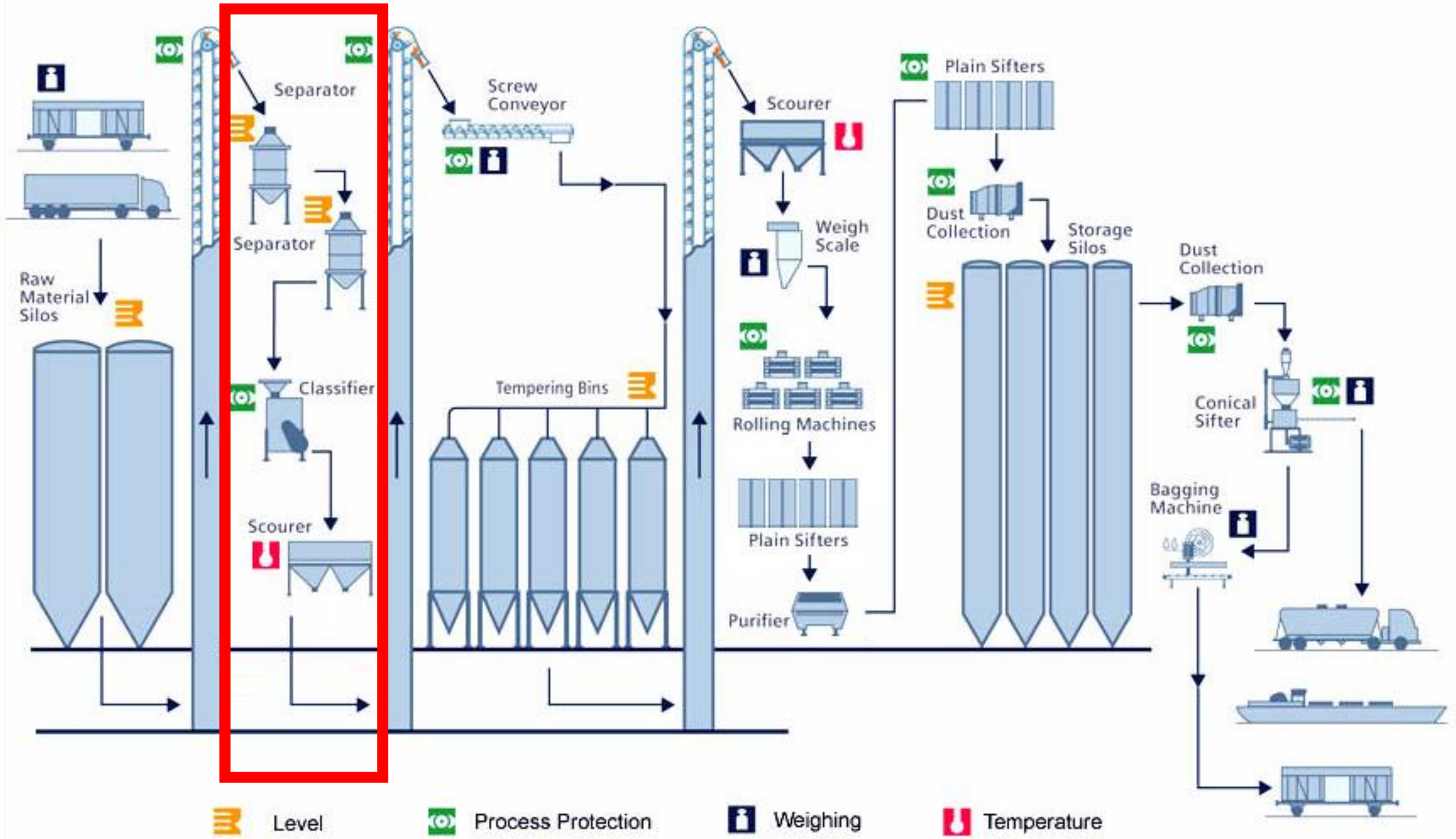
Screw Conveyor
Scourer
Plain Sifters
Weigh Scale
Dust Collection
Storage Silos
Dust Collection
Raw Material Silos
Classifier
Tempering Bins
Rolling Machines
Conical Sifter
Bagging Machine
Scourer
Plain Sifters
Purifier
Level
Process Protection
Weighing
Temperature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CLEANING

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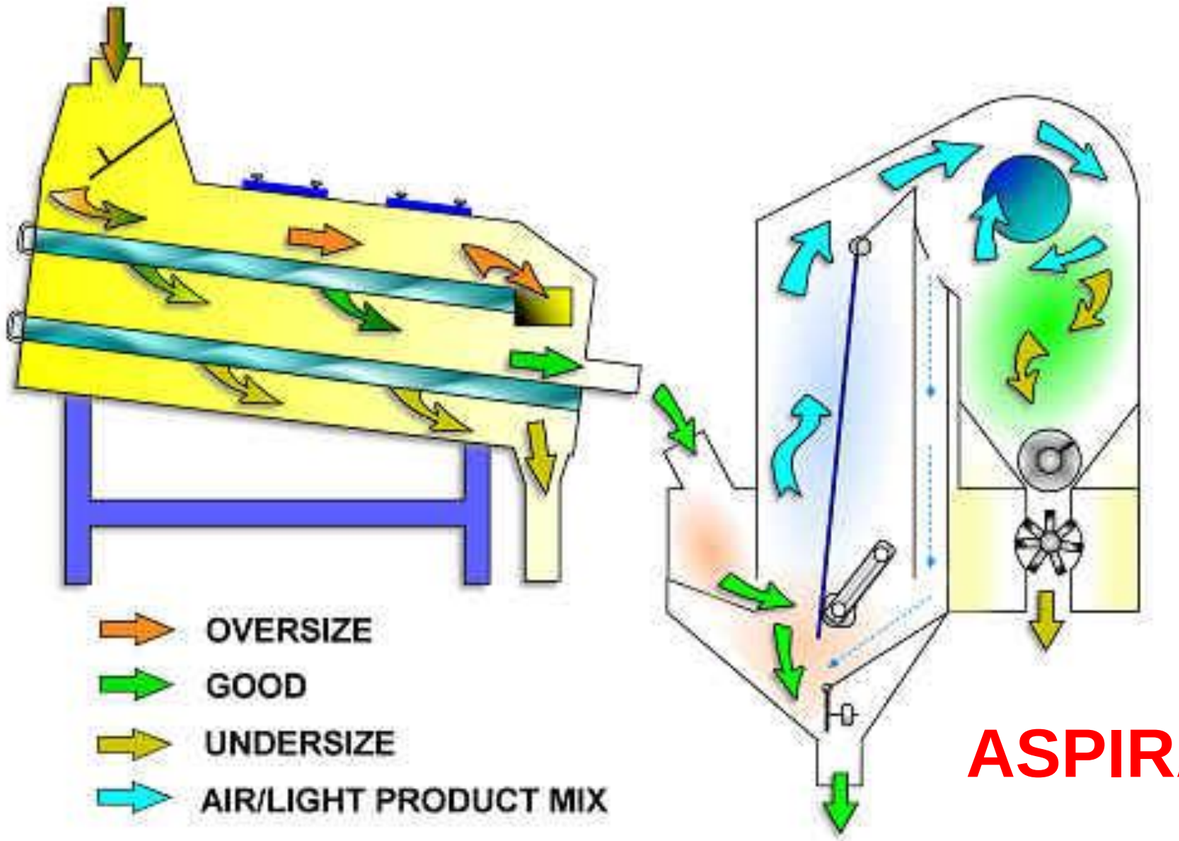
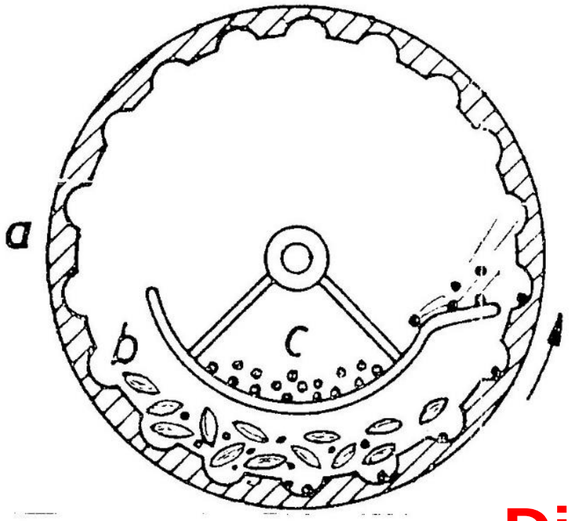
CLEANING TECHNOLOGY

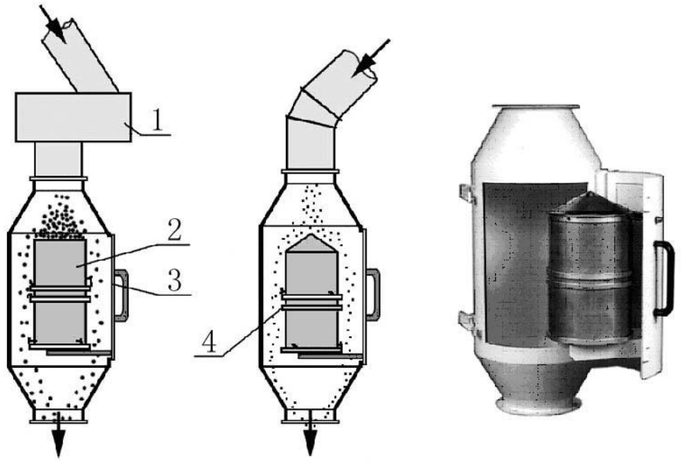


SIEVE SEPARATOR



Disk separator

ASPIRATOR



MAGNET

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CLEANING TECHNOLOGY

SCOURER

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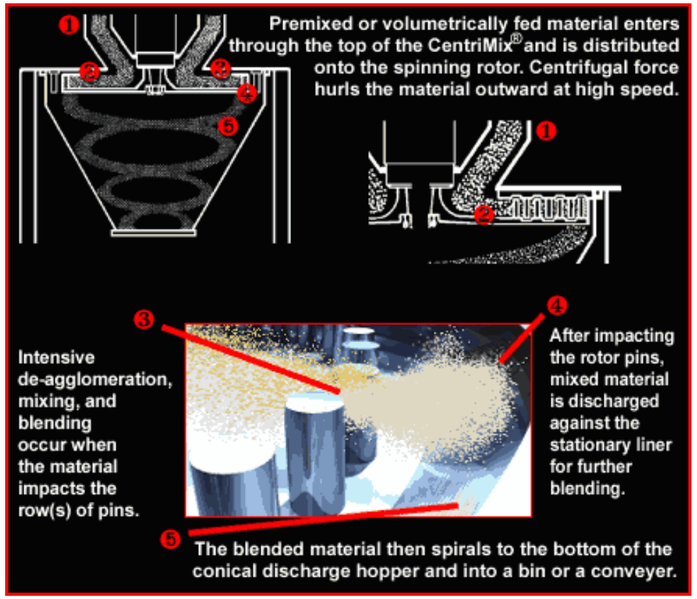

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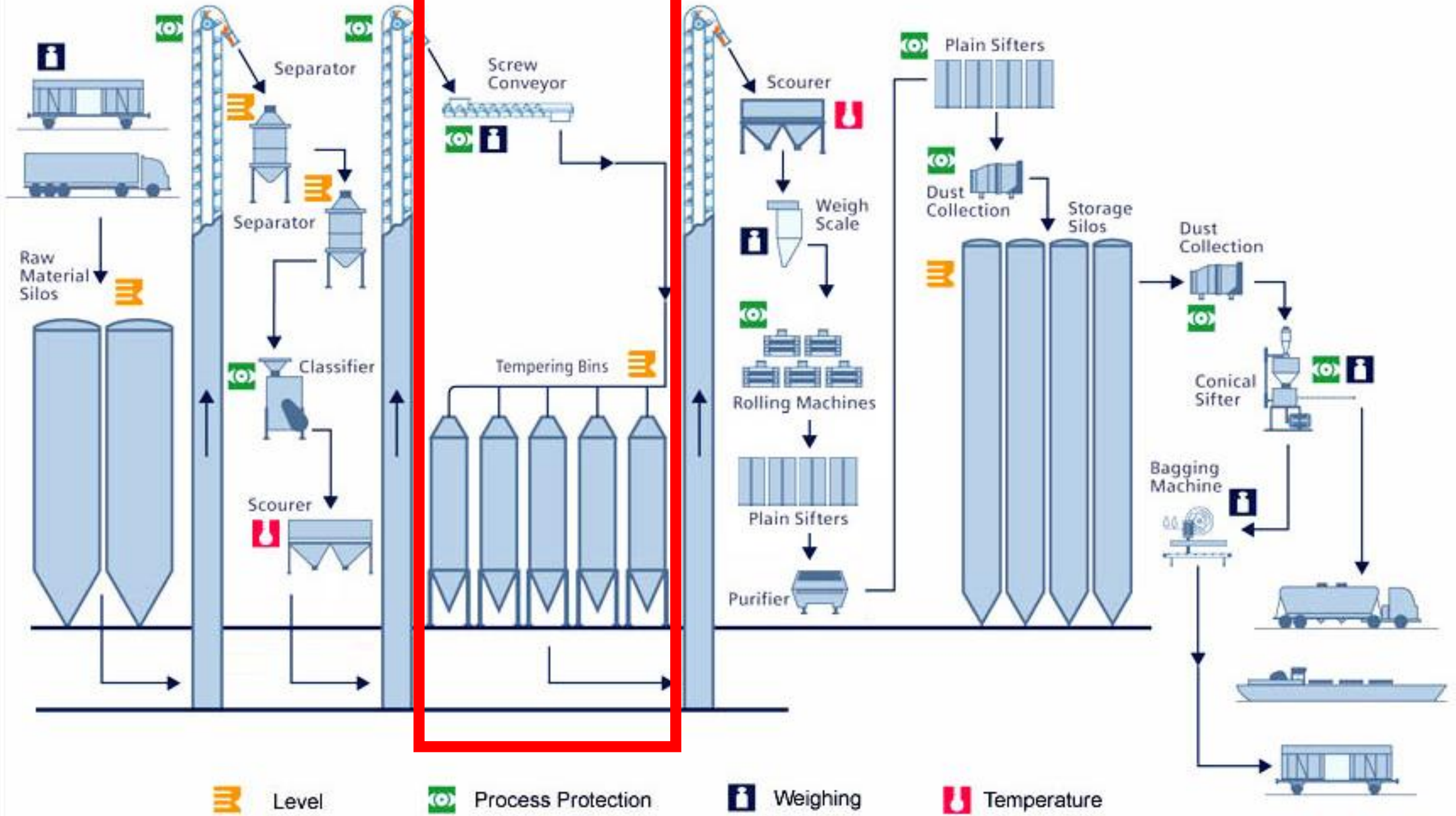
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TEMPERING

- controlled addition of water (and heat)
- intensive mixing to ensure uniform distribution
- resting for a period of time (3-36 h)
  - optimal distribution in different parts of kernel
  - reduce hydration differences
- 25°C
  - Soft wheat: 15 – 16.5%
  - Hard wheat: 17 - 18%

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TEMPERING

- **= adjustment of moisture content**
  - not too dry
    - bran should become elastic to avoid splintering and contamination of flour
    - better separation of endosperm-bran
    - less power required to grind to flour
  - not too wet
    - endosperm too soft, no creation of sharp particles
    - no efficient sieving

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TEMPERING

- Blending
  - Before
  - After
    - ⇒ goal: to produce a standard quality wheat flour
    - ⇒ eg. breadmaking quality

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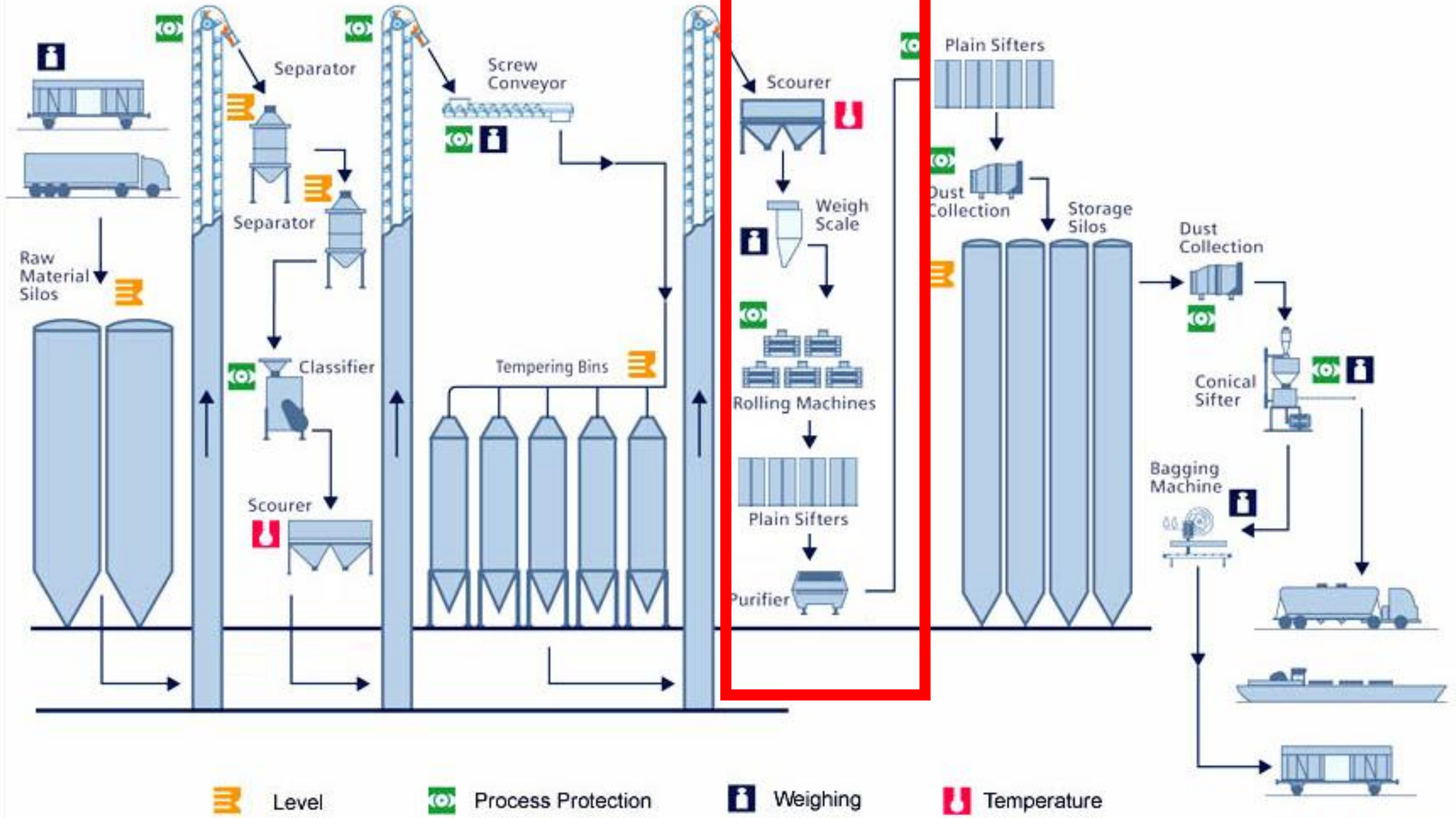
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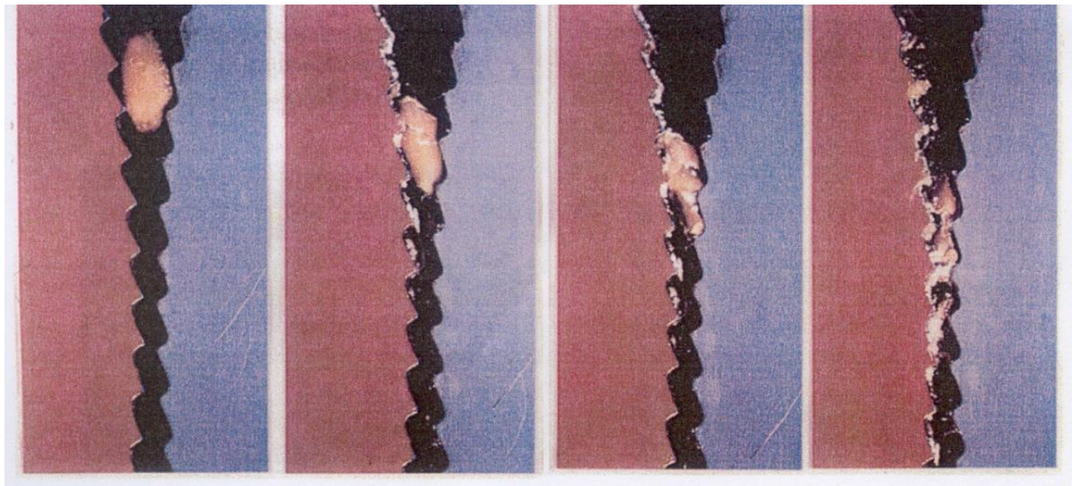
MILLING: BREAK ROLLS

- 4-5 breaks, corrugated rolls
  - first break opens kernel
  - subsequent breaks: scraping endosperm from the bran
  - gradually smaller but more corrugations
  - differential from 2.5 to 1



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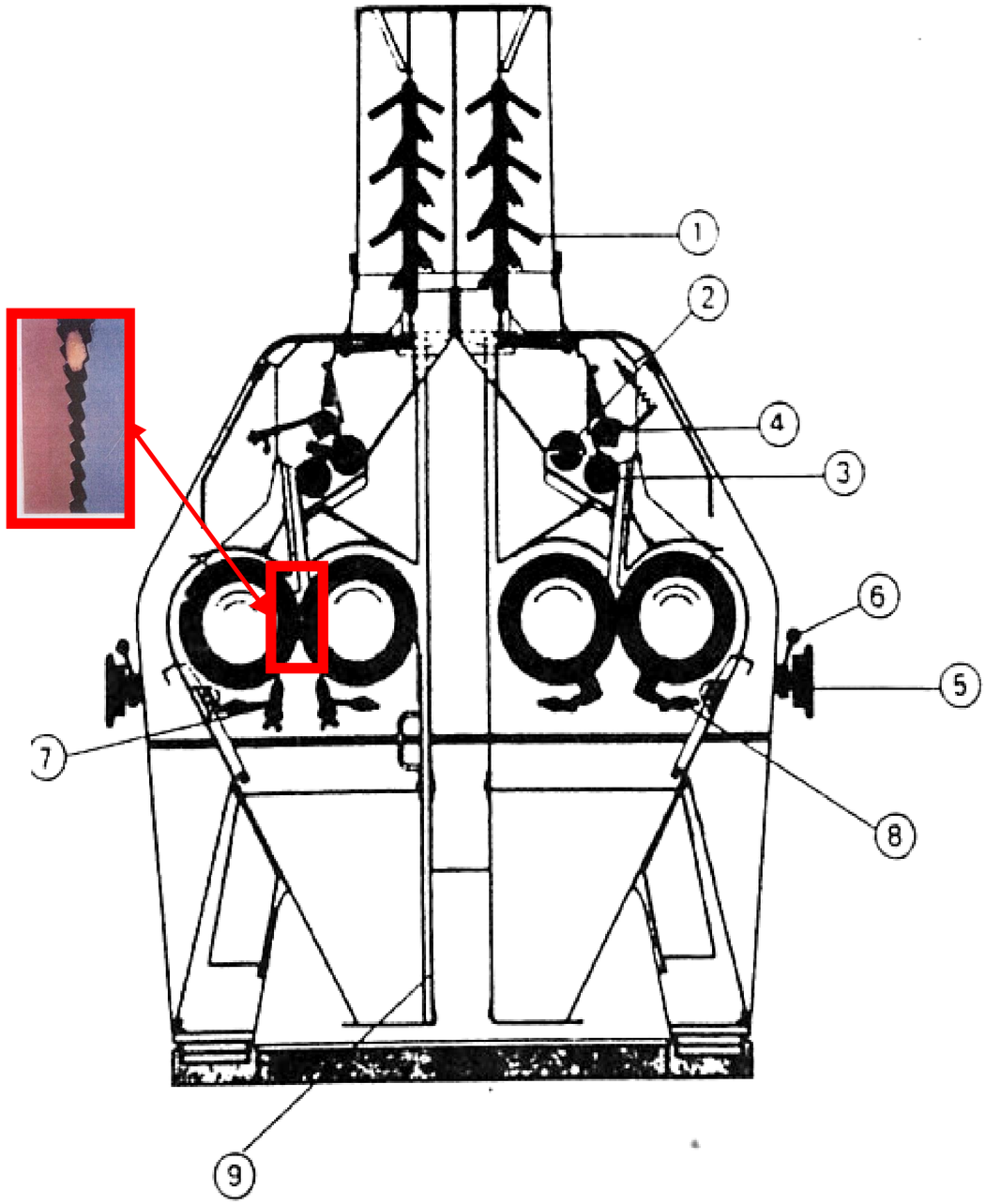
ROLLER MILLING



PLANSIFTER

PLANSIFTER

FLOUR

To reduction rolls

To break rolls

To purifier

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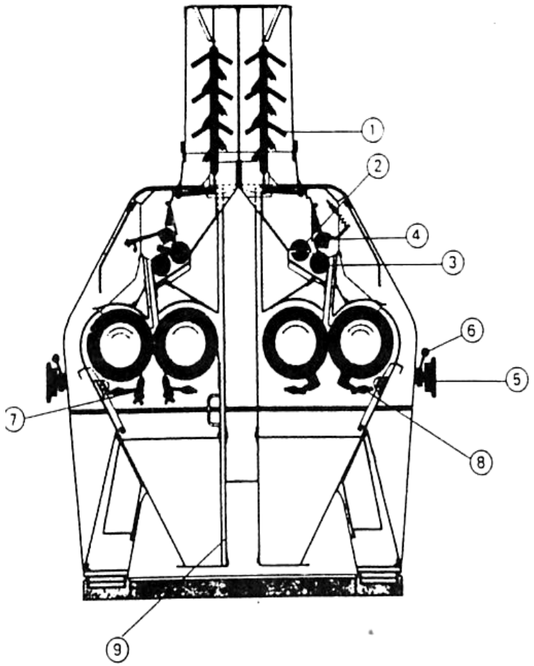
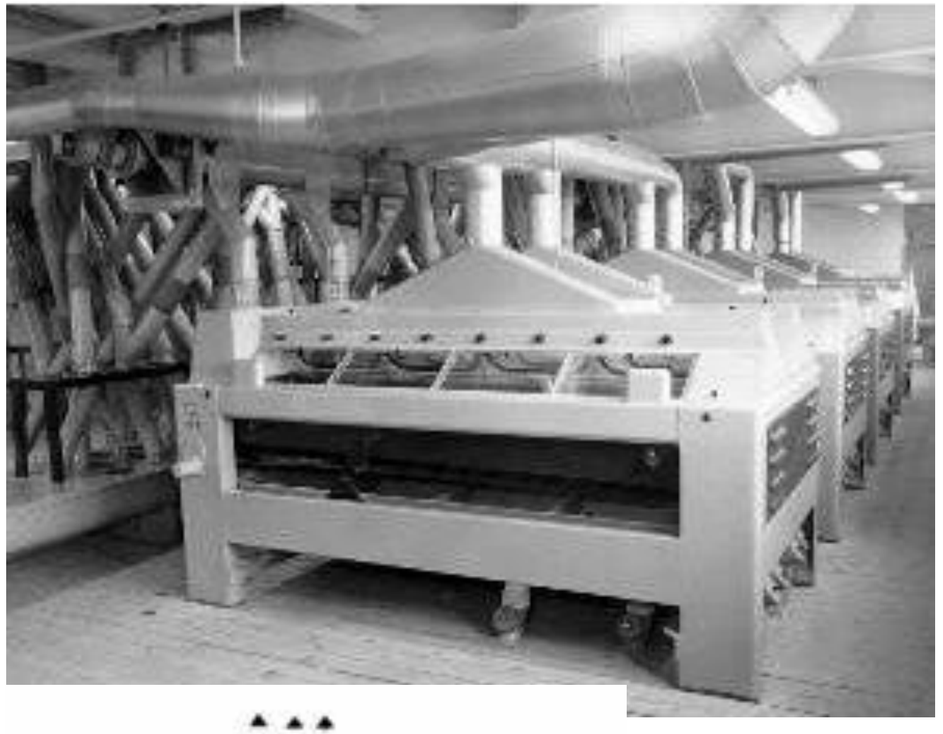
REDUCTION ROLLS

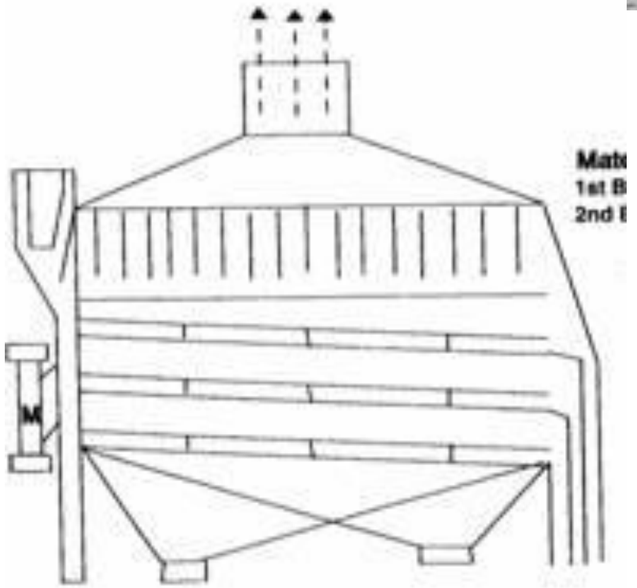
- Smooth rolls
- coarse reduction (scratching or sizing)
  - removing small pieces of bran and germ from endosperm
  - smaller particles endosperm
- fine reduction
  - grinding endosperm into flour
  - minimum in crushed germ and bran powder
  - **optimum** in damaged starch granules



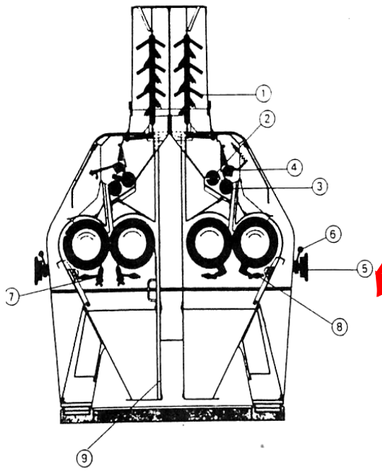
PURIFIER

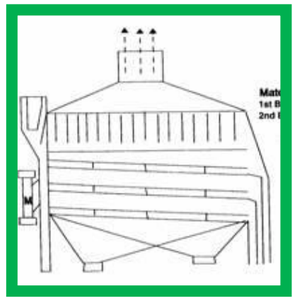
- Separating bran and endosperm particles of similar size
- Combinations of sieving and aspiration

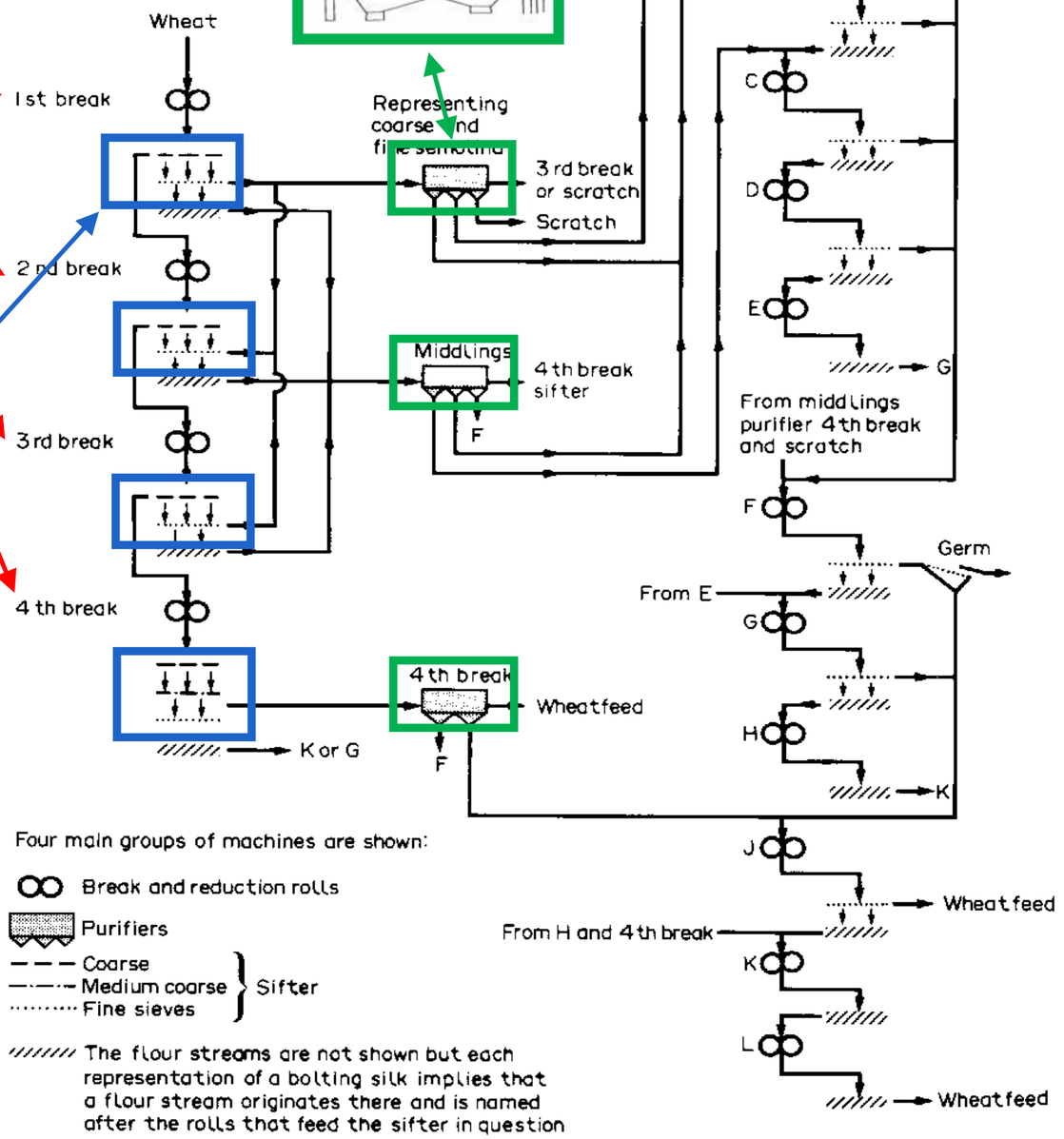




MILLING SCHEME







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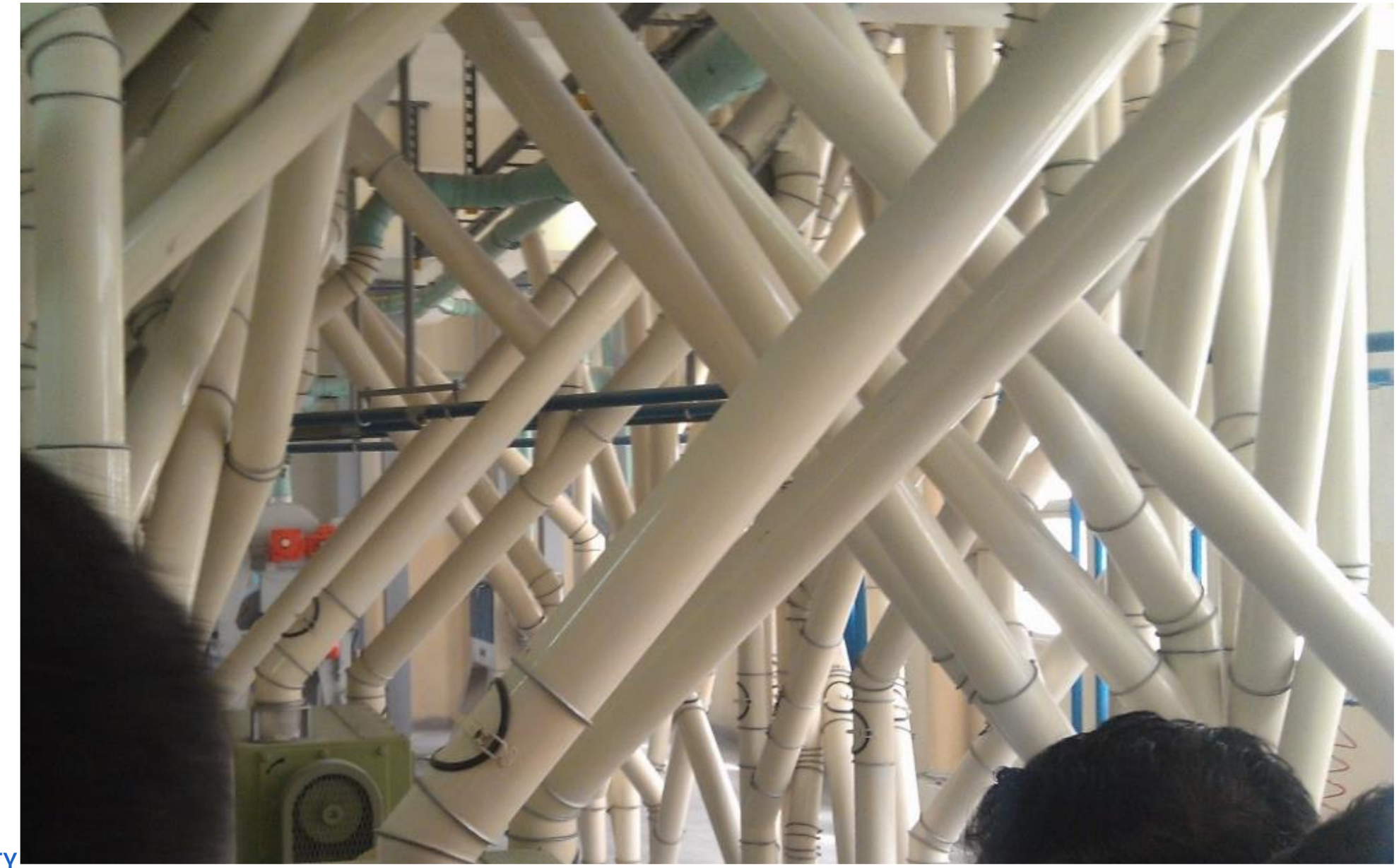

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MILLING: CONCLUSION

- Milling process
  - multi-stage process
  - size reduction, separation (sieving) and purification operations
  - different materials at different stages BUT no fraction completely pure

- Milling efficiency
  - flour extraction degree
  - pureness of the fractions

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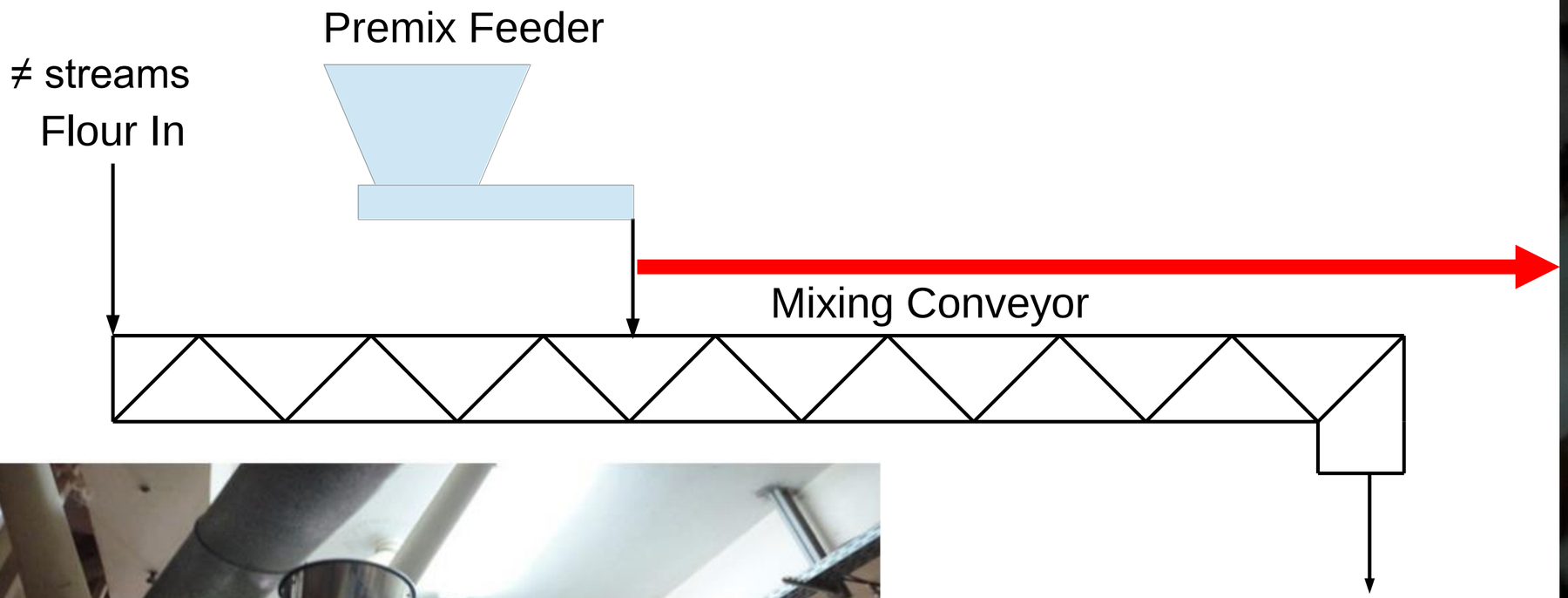
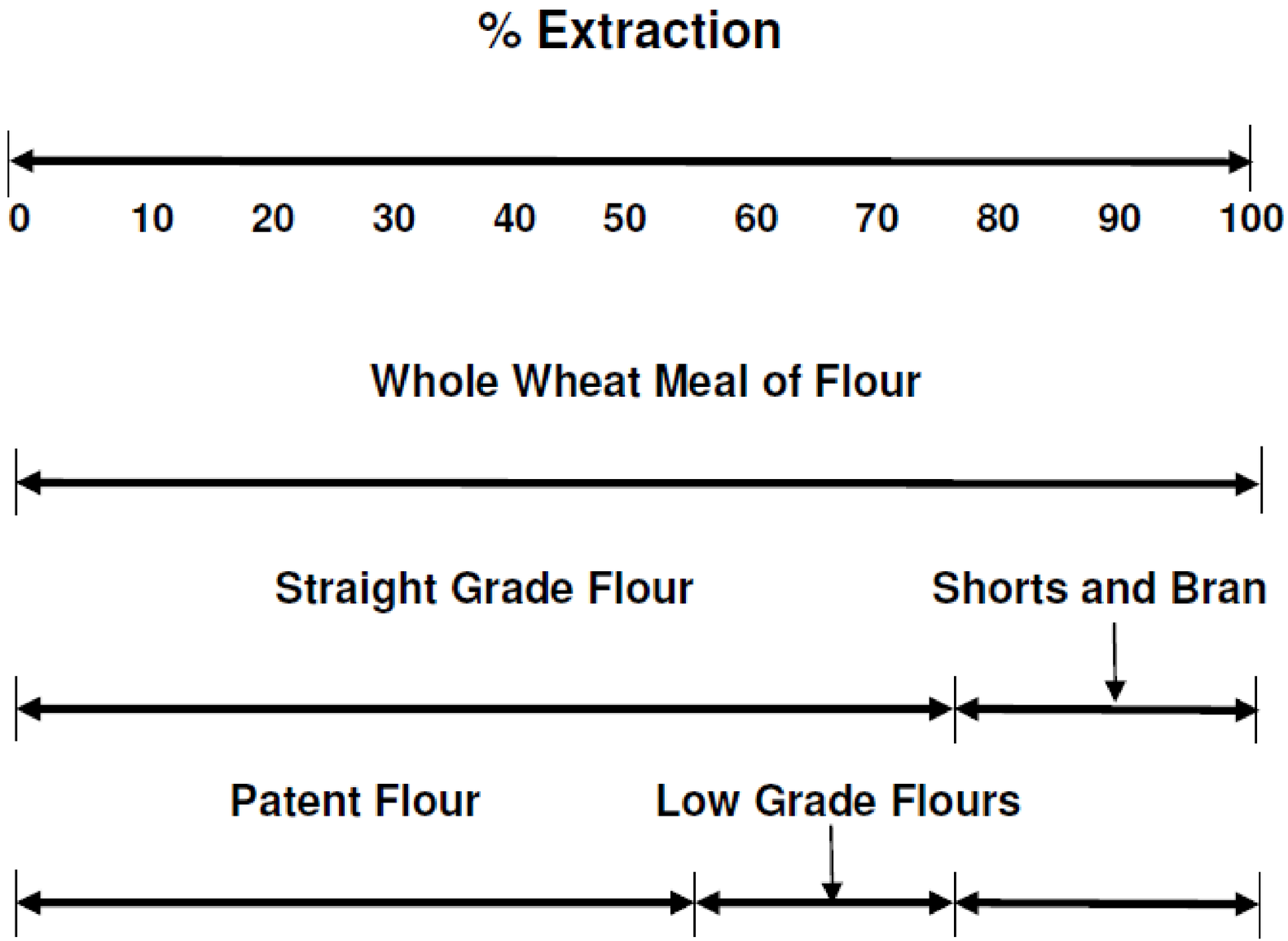
MILLING: FINAL STAGE

– Wheat flour: blending all flour streams



EXTRACTION RATE



Source: principles of cereal science and technology, Hoseney

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Table 1
Chemical composition (dry basis) of wheat flour in function of the extraction rate (Pederson et al., 1989)

	Extraction rate (%)						
	100	95	91	87	80	75	66
Starch + sugar (%)	69.9	73.2	75.3	77.2	80.8	82.9	84.0
Protein ($n \times 6.25$) (%)	14.2	13.9	13.8	13.8	13.4	13.5	12.7
Fat (%)	2.7	2.4	2.3	2.0	1.6	1.4	1.1
Dietary fiber (%)	12.1	9.4	7.9	5.5	3.0	2.8	2.8
Ash (%)	1.8	1.5	1.3	1.0	0.7	0.6	0.5
Energy (kJ/g)	18.5	18.5	18.5	18.5	18.5	18.4	18.3
Phosphorus (mg/g)	3.8	3.3	2.8	2.1	1.5	1.3	1.2
Calcium (mg/g)	0.44	0.43	0.38	0.33	0.27	0.25	0.23
Zinc (ppm)	29	25	21	18	12	8	8
Copper (ppm)	4.0	3.7	3.4	2.8	2.4	1.6	1.3
Iron (ppm)	35	33	28	23	15	13	10
Thiamine (μg/g)	5.8	5.4	–	4.8	3.4	2.2	1.4
Riboflavin (μg/g)	0.95	0.79	–	0.69	0.46	0.39	0.37
Niacin (μg/g)	25.2	19.3	–	10.1	5.9	5.2	3.4
Pyridoxine (μg/g)	7.5	6.6	–	3.4	1.7	1.4	1.3
Biotin (μg/g)	116	108	–	106	76	46	25
Folic acid (μg/g)	0.57	0.53	–	0.45	0.11	0.11	0.06

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MAIZE

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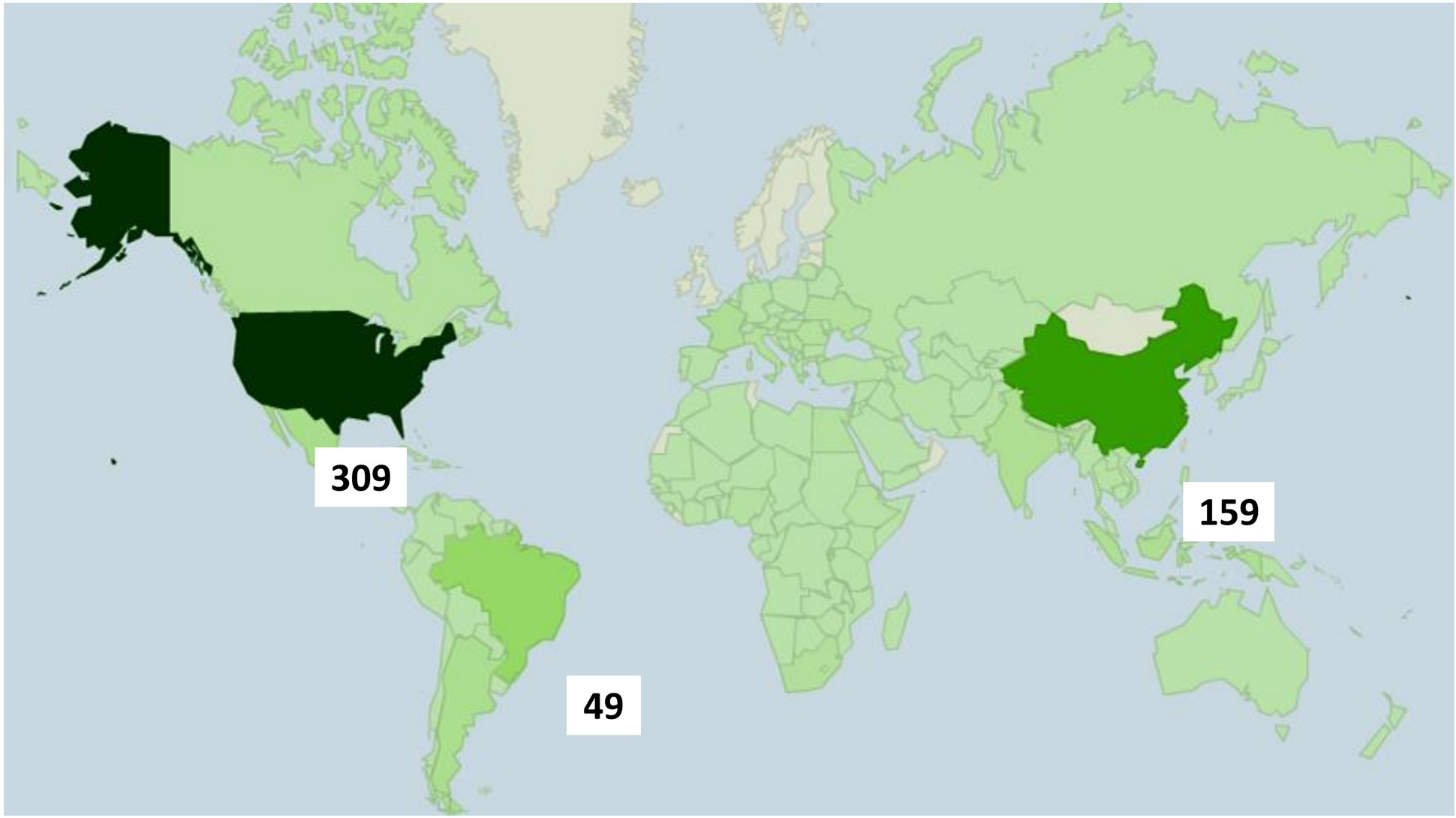
CORN PRODUCING COUNTRIES



(source: faostat.fao.org) Million tons (average 2005-2010)

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CORN/MAIZE

- Most produced grain
- Highest yielding cereal (world average)
  - Maize: 4.3 tonnes/hectare
  - Paddy rice: 3.8 tonnes/hectare
  - Wheat: 2.7 tonnes/hectare
- Animal feed
- Human food: tortillas, porridge
- Starch production: wet milling

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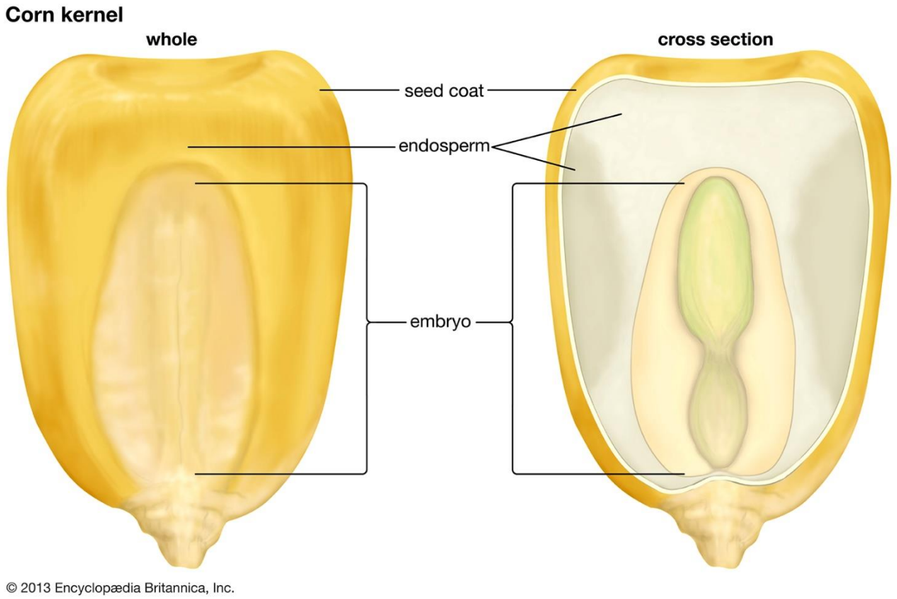
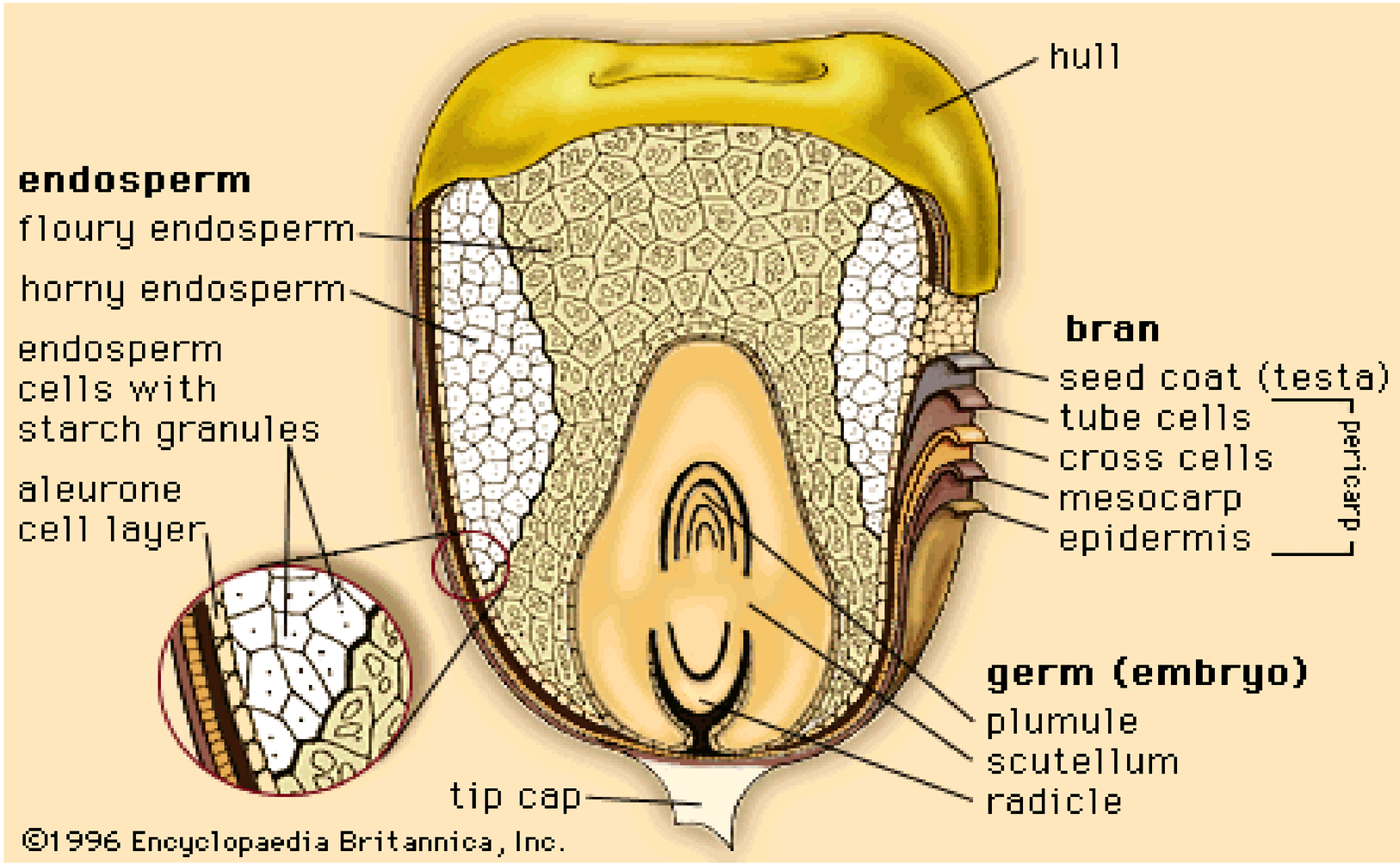
MAIZE GRAIN





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MAIZE TYPES

TYPES

Dent

Soft

Waxy

Popcorn

Sweet

White

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MAIZE PROCESSING: TANZANIA

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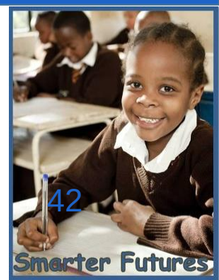

MAIZE CLEANING AND TEMPERING

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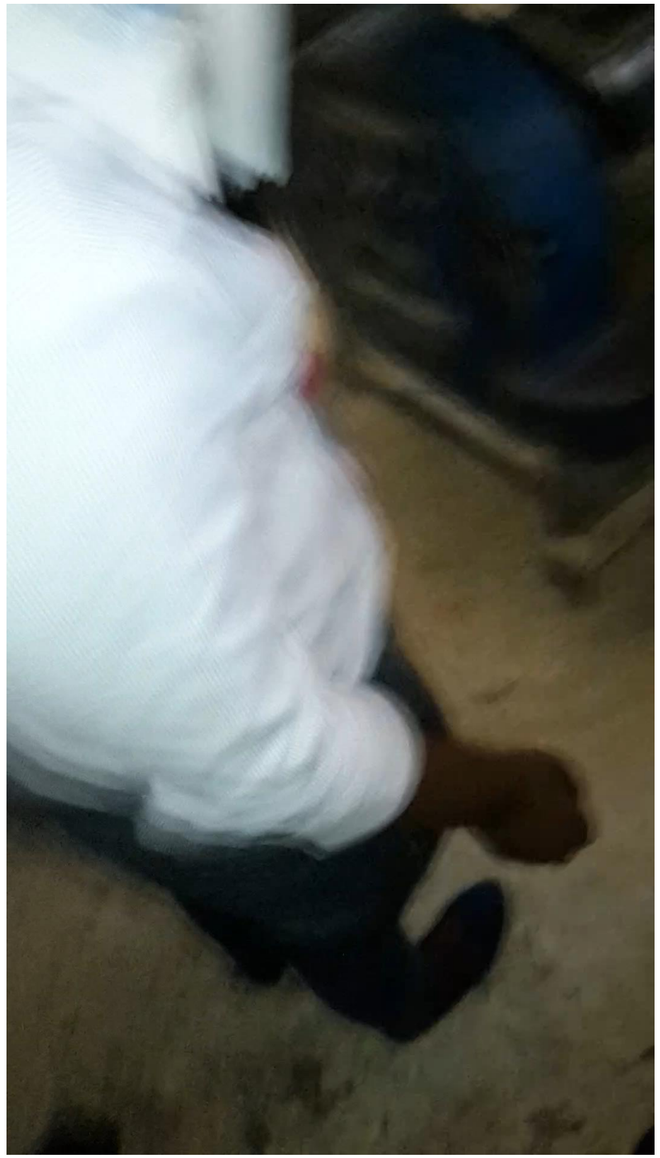
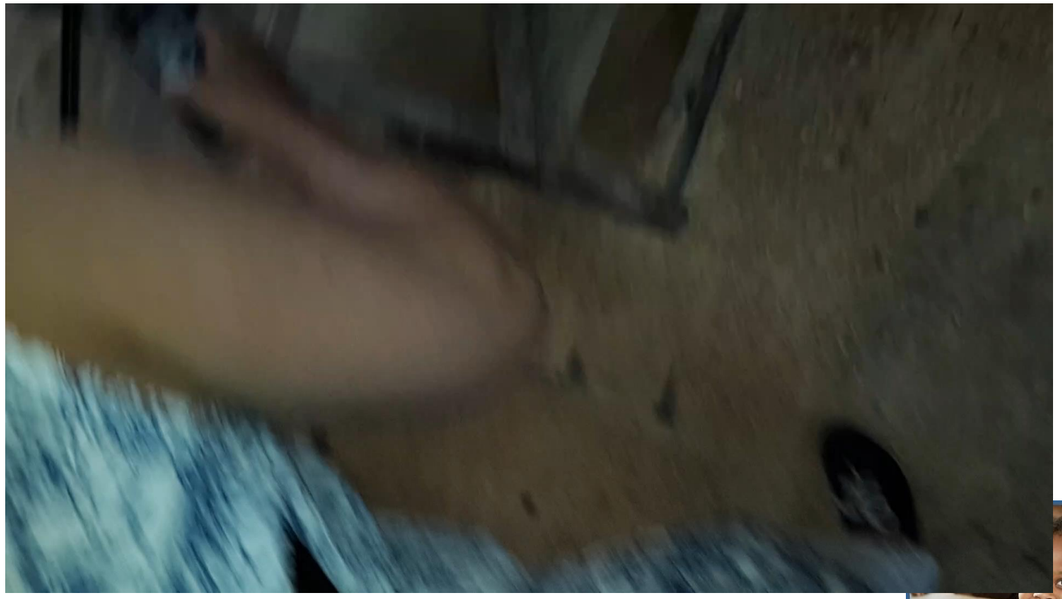
DEHULLING





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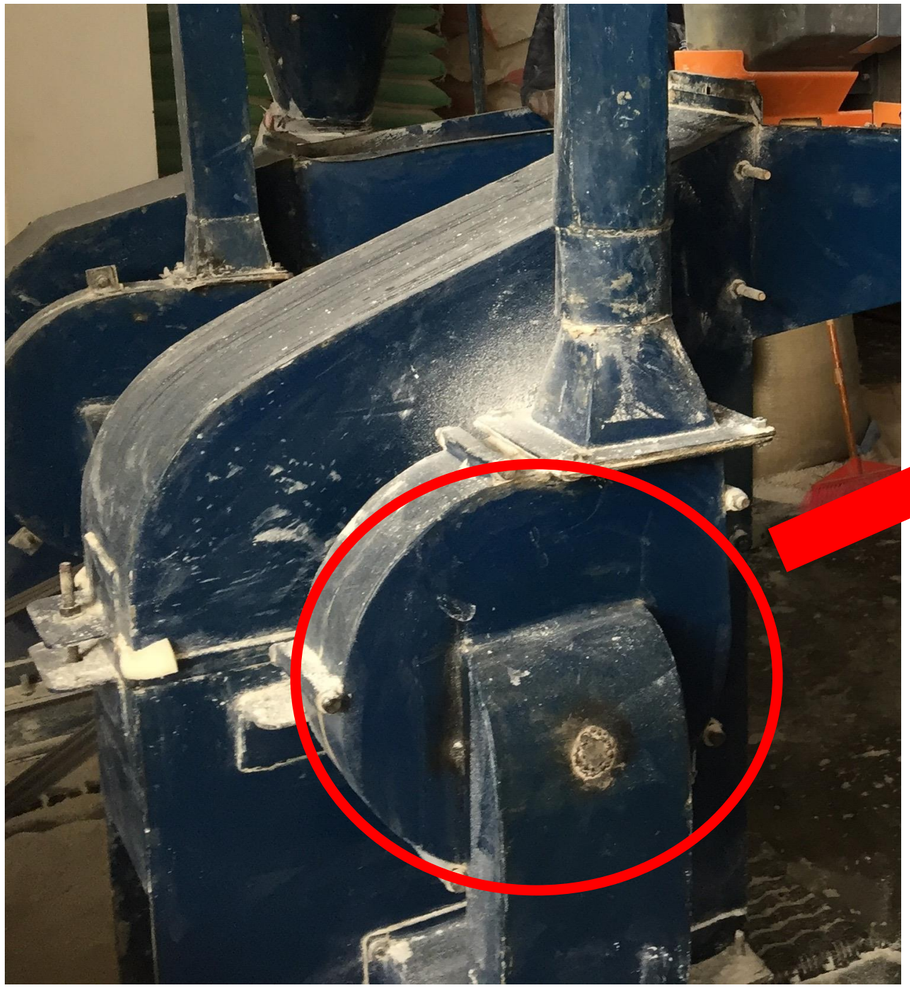
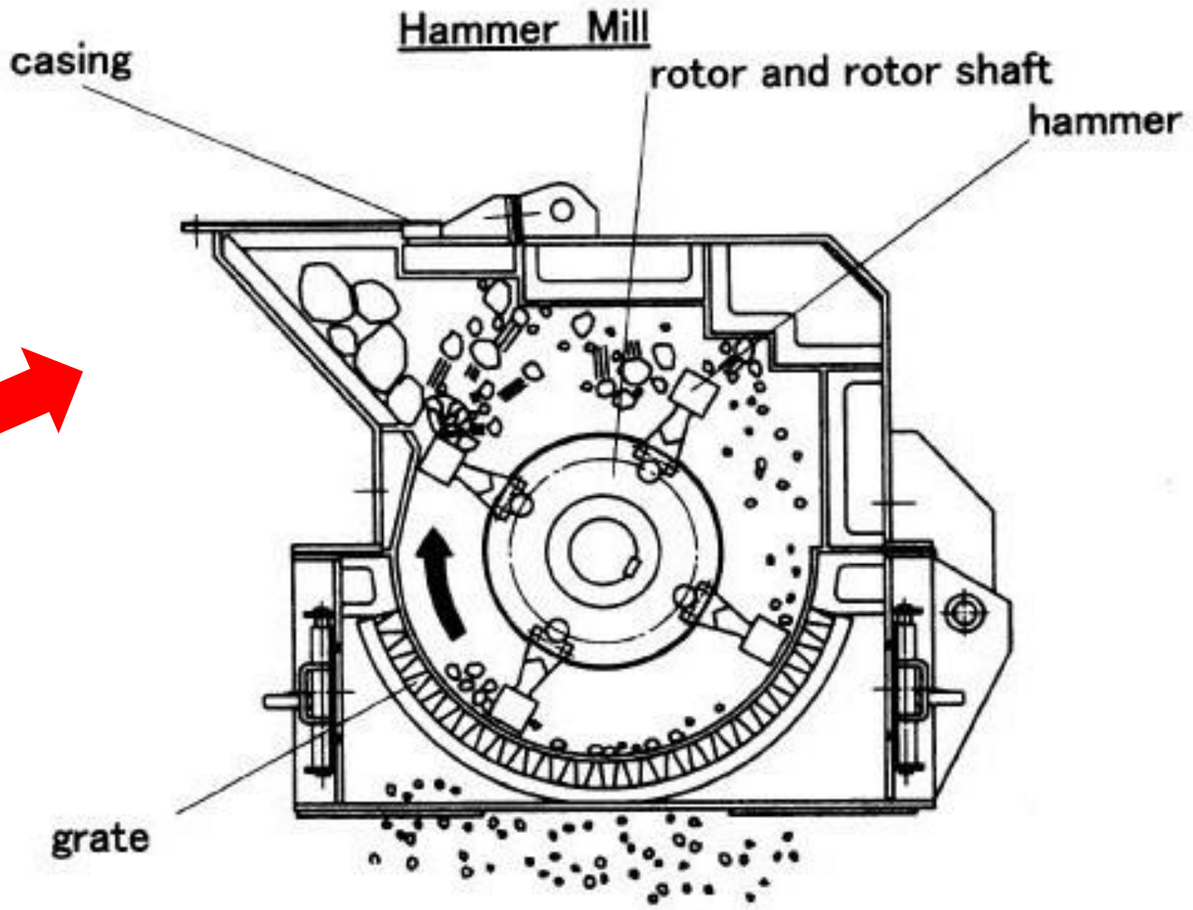
DEHULLING

HAMMER MILL: SMALL SCALE MILLING





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HAMMER MILL: FORTIFICATION

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ROLLER MILL: LARGE SCALE OPERATIONS

- Gradual size reduction
- Sieving + roller milling
- Flour streams are blended in mixing conveyer

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MAIZE MEAL COMPOSITION

- Maize variety / type of milling / extraction rate

Typical Extraction Rates for Maize meal

Mill size	Maize meal Extraction Rate %	Kernel Components for conversion to maize flour
Large	70 - 75	Endosperm with some pericarp and germ
Medium	65 - 70	Endosperm, pericarp and germ
Small	60 - 65	Endosperm little or no pericarp and germ

NOTE:

Pericarp and germ components can influence the taste of the cooked porridge

Bitterness is one of the characteristic tastes from the pericarp and germ

The purer the endosperm used to mill into flour the lower the bitterness taste

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MAIZE MEAL QUALITY

Composition of Maize Product

Class of Maize Product	Fat Content by Mass (%)		Fiber Content by Mass (%)		Fineness by Mass
	Minimum	Maximum	Minimum	Maximum	
1. Super Maize Meal	-	Less than 2.0	-	0.8	At least 90% shall pass through a 1.4mm sieve, and less than 90% shall pass through a 300micrometer sieve.
2. Special Maize Meal	2.0	Less than 3.0	-	1.2	At least 90% shall pass through a 1.4mm sieve.
3. Sifted Maize Meal	3.0	Less than 4.0	-	1.2	At least 90% shall pass through a 1.4mm sieve.
4. Unsifted Maize Meal	3.5	Less than 4.5	More than 1.2	2.5	At least 90% shall pass through a 1.4mm sieve
5. Samp	-	1.5	-	0.8	Not more than 5% shall be whole grain and not more than 5% shall pass through a 2.36mm sieve
6. Maize Rice	-	1.5	-	0.8	At least 90% shall pass through a 4.0mm sieve, and not more than 5% shall pass through a 1.18mm sieve
7. Maize Grit	-	1.5	-	0.8	At least 90% shall pass through a 2.0mm sieve, and not more than 5% shall pass through a 850micrometer sieve
8. Maize Flour	-	Less than 2.0	-	0.8	At least 90% shall pass through a 300micrometer sieve
9. No. 1 Straightrun Maize Meal	3.7	-	1.8	2.5	At least 90% shall pass through a 2.36mm sieve
10. No. 2 Straightrun	3.7	-	More	6.5	At least 90% shall pass through a

Courtesy: Philip Randall

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CONCLUSIONS

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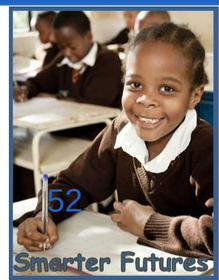

- Different wheat and maize types
- Processing of wheat and maize is different
- Milling in large scale operations is multistep process which includes consecutive milling, sieving and purifying
- Extraction rate is important and also determines flour or meal quality

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