

# CEREALS AND MILLING TECHNOLOGY

Common milled cereal products and their alternatives



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# GLOBAL UTILISATION OF CEREALS



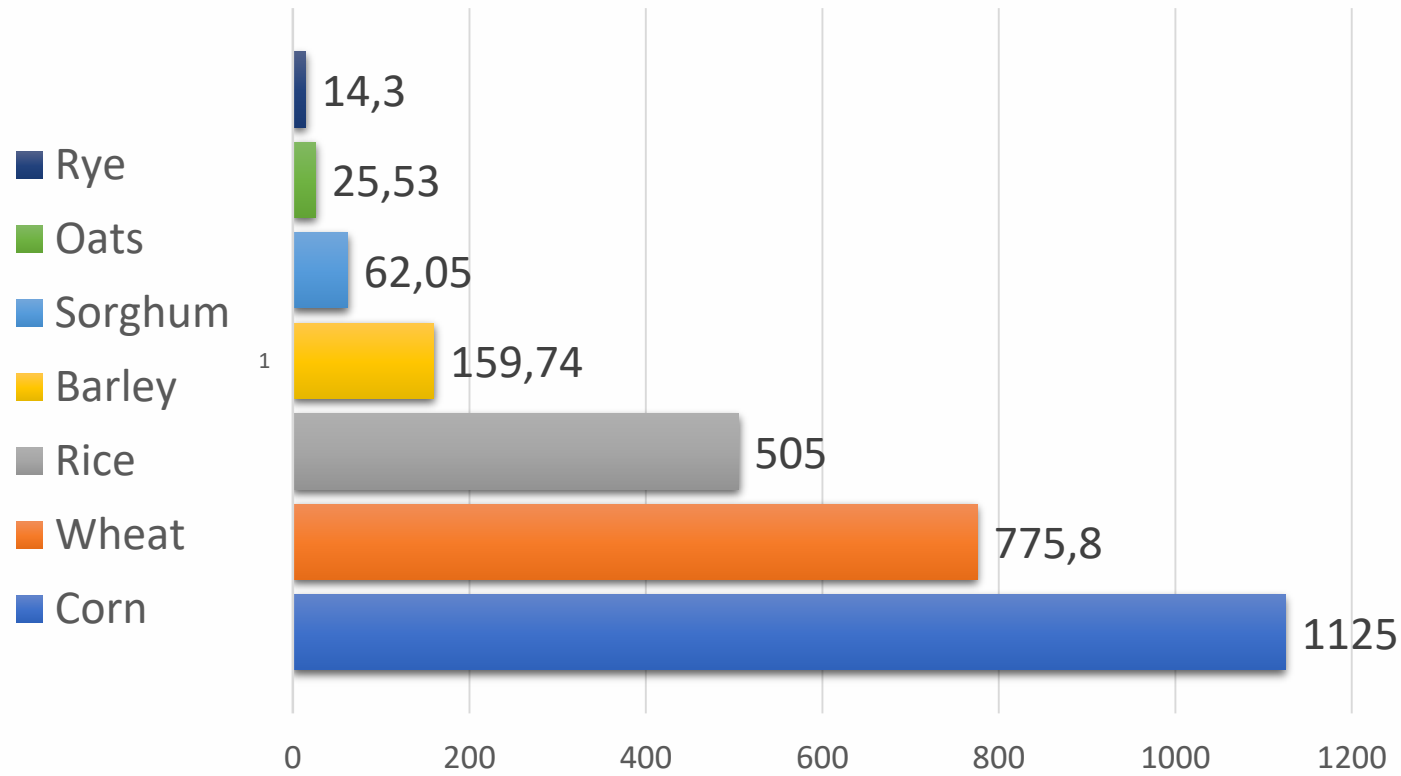
- Milled products for food purposes
- Feedstuff

Derived products:

- Sweeteners (e.g. corn syrup)
- Ethanol for biodiesel
- Starch



# WORLDWIDE PRODUCTION OF GRAIN IN 2020/21 *(in million metric tons)*



# CEREALS: family *Poaceae*

- Covering 20–40% of protein consumption and 30–45% of energy consumption (higher percentage in developing economies)

*For food use:*

- Wheat, rye, barley, oats
- Corn (southern Europe)
- Millet, sorghum (eastern Europe, Middle East)
- Rice (India, Far East)



# SPECIES OF WHEAT



- *Triticum aestivum*, **common wheat**
  - **hard** varieties – higher protein content (strong, flexible gluten)
  - **soft** varieties – inflexible, unstable gluten
- *T. turgidum* var. *durum*, **durum wheat** (pasta production)
- *T. aestivum* var. *spelta*, **spelt** (syn.: dinkel wheat)
- *T. monococcum* var. *monococcum*, **einkorn**



# ANATOMY OF GRAIN

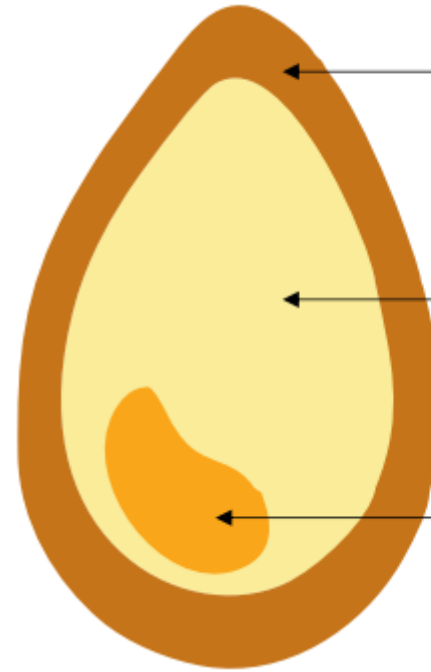


## Saccharides

- mainly starch granules
- fiber (bran)
- pentosanes,  $\beta$ -glucanes

## Proteins

- gluten-forming fraction
- Lipids (germ)
- Vitamins (germ)
- Minerals (bran)



BRAN

ENDOSPERM

GERM



- Biologicky aktivní látky (otruby)



# CHARACTERISTICS OF GLUTEN FORMING PROTEINS



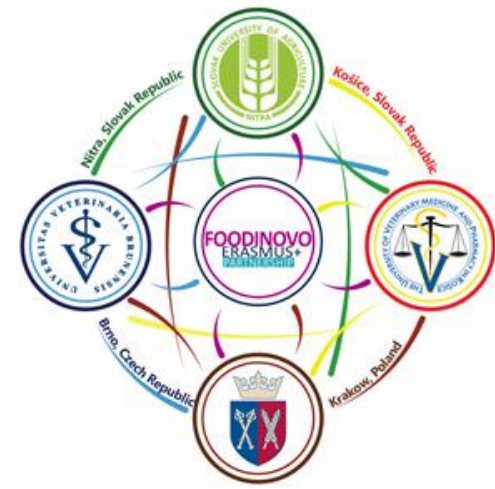
natural protein fraction insoluble in water

*gliadin* – simple high molecular protein

- Soluble in diluted ethylalcohol
- Syrupy consistency
- Gives elasticity

*glutenin* – soluble in 0,2% KOH (Potassium hydroxide)

- Fiber structure
- Responsible for dough strength and elasticity
- Evaluation of elasticity, extensibility and swelling index



# GLUTEN



main quality criterion of wheat flour bakery quality

**wet gluten** = flexible, extensible hydrated gel

- 80 – 95% proteins in dry matter
- 66% water
- dry gluten, ca. 1/3 wet gluten (after drying)



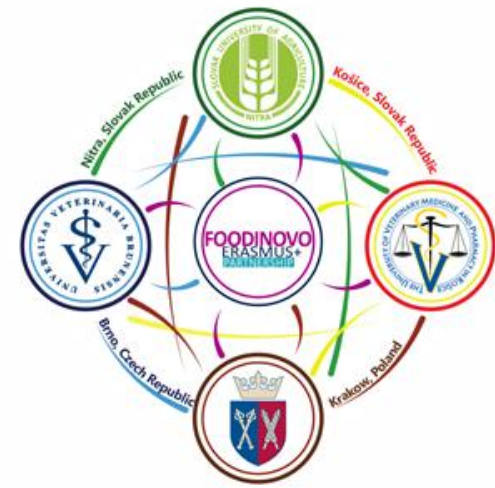


# GLUTEN & COELIAC DISEASE

**COELIAC DISEASE** = long-term autoimmune disorder that primarily affects the small intestine, gluten intolerance, especially gliadin fraction, causing damage of small intestine mucosa and consequently nutrient malabsorption

Gluten-free cereals: maize, rice, millet  
Safe for majority of CD patients: oat

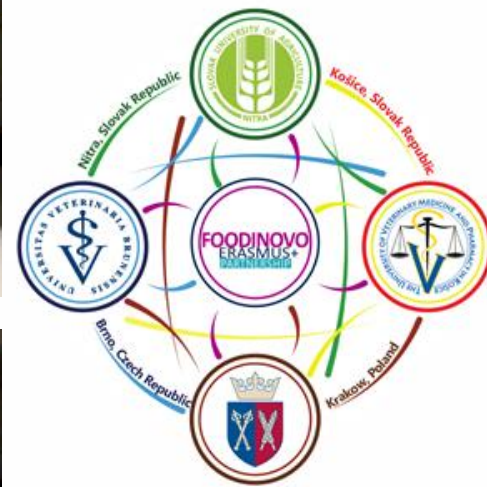
Alternative = pseudocereals



# WHEAT FLOUR

cream colour –  $\beta$ -carotene

- **coarse flour:** dumplings, gnocci, pasta
- **semi-coarse flour:** cakes, leavened pastries
  - semi-coarse flour **extra:** similar usage, finer and lighter in colour
- **smooth/fine:** for thickening soups and sauces, light sponge cakes and pie crusts, coating of meat
  - **smooth/fine 00 Extra:** lower content of minerals, higher in gluten proteins
- **whole-wheat flour:** grinding the full wheat kernel
  - **graham flour:** coarsely ground bran flakes
- **spelt flour**
- **flour for starch production**



# RYE

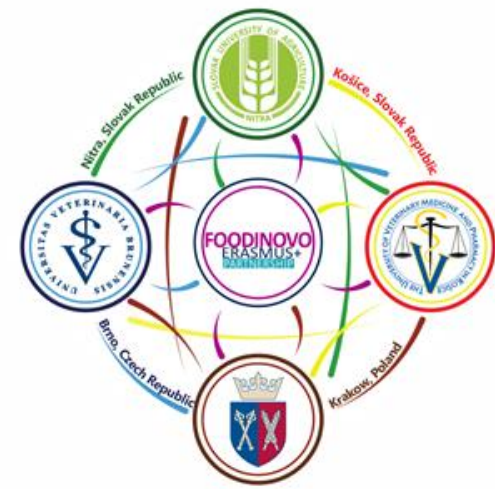


## *Agronomic properties:*

- tolerance for worse ecological conditions
- frost resistance, drought resistance
- tolerance to acidic soils

## *Nutritional value:*

- quality nutrient source (minerals and vitamins)
- lowest calorie value among cereals
- highest content of lysine amino acid among cereals
- more fiber than wheat
- less gluten than wheat



# RYE PROTEINS:



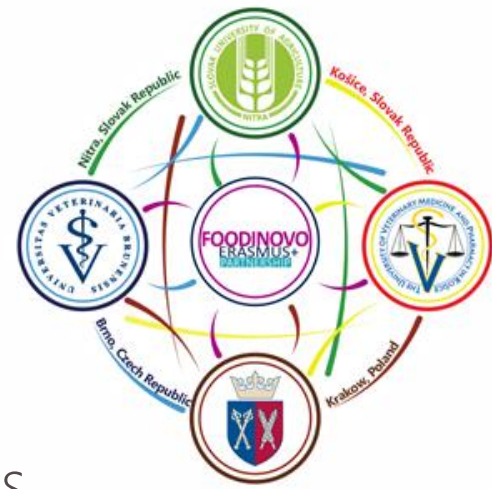
Do not form flexible gluten - gluten content in rye is not a significant dough-making factor.

- Still contain gliadin fraction – not safe for coeliac consumers

Starch is more important for bread making in rye flour than in wheat flour.

polysaccharides pentosans - the pentosan level in rye flour is higher and more important for bread making.

- Formation of concentrated gel
- Rye flour has greater water binding capability than wheat flour, due to its starch and pentosan content.



# RYE FLOUR

greenish-gray colour – chlorophyll



Typical slightly darker colour of bakery products

- first-grade („výražková“) flour
- bread flour
- whole-grain flour



# OATS



- superior grain quality over other cereals
- abundant amount of protein (11–15%)
- higher content of essential amino acids
- high fiber content (oat  $\beta$ -glucans)
- wide range of phytochemicals
  - high in vitamins B, iron, zinc, magnesium content – oats for strong nerves
- higher antioxidant capacity
- whole grains: flakes or flour
- **good source of gluten-free products**



# GLUTEN-FREE CEREAL FLOURS

- **rice flour** (fine/semi-coarse/semolina)
- **corn flour** (fine/semi-coarse/semolina)
- **millet flour**
  - thickening, pasta production
  - common and instant version
  - often used in combination with other flours



# PSEUDOCEREALS

species other than *Poaceae*, which are processed and used in a similar manner to cereals

„grains of the twenty-first century“

superior nutritional value compared to cereals:

- higher protein levels
- proteins of high quality with a balanced essential amino acid composition

**development of different gluten-free foods** from quinoa, amaranth and buckwheat, mainly bakery products, snacks, pasta, and beverages





# PSEUDOCEREALS: BUCKWHEAT



- rich source of fiber, vitamins and minerals
- high content of complex proteins
- significant source of antioxidants
  - rutin
  - resveratrol (cardioprotective polyphenolic compound)
  - lecithin (regeneration of brain cells)
- slightly bitter taste



# PSEUDOCEREALS: AMARANTH

„third-millennium grain“

- superior protein quality with high lysine and methionine content
  - high content of crude fiber
  - antioxidant squalene – coenzyme Q 10 precursor
  - flavonoids and chlorophyll – regeneration of intestine cells
  - good source of iron, calcium, magnesium, zinc, vitamins A, B, K and C.
- 
- highly tolerant to pests, diseases and environmental stress



# PSEUDOCEREALS: QUINOA

- 2013: International Year of Quinoa (FAO)
- high quality proteins = alternative protein source
- high fiber content
- better source of minerals (Ca a Fe) than cereals
- high antioxidant capacity
- low glycemic index





# POST HARVEST PROCESSING OF GRAIN



# POST HARVEST PROCESSING OF GRAIN

= preparation of harvested grain for storage in silos



## AIM

- **MOISTURE CONTROL:** storage humidity max. 14%
  - **CONTAMINATION CONTROL:** clean and free from foreign or extraneous matter
- 
- Treshing, winnowing
  - Cleaning
  - Drying
  - (Chemical conservation)/Antifungal treatment
  - Storage
  - Regular inspection for signs of spoilage and the moisture content



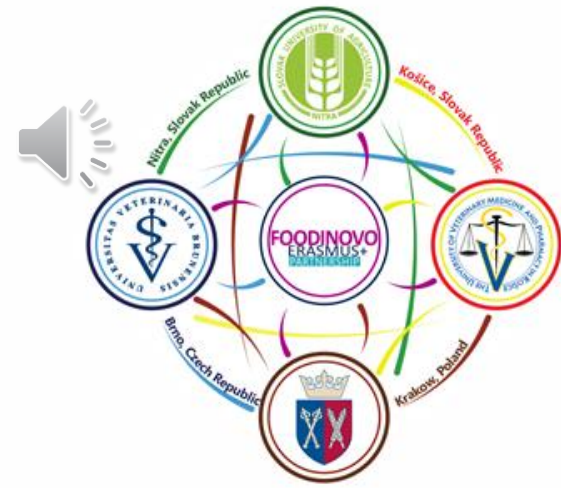


# TECHNOLOGY OF MILLING



# PROCESSING STEPS AT FLOUR MILL

- grain receiving and storage
- cleaning
- gristing (blending)
- tempering/conditioning
- grinding
- sifting
- storage
- packaging



# GRAIN RECEIVING AND TESTING



- **Each load sampled and quality tested:**

- moisture
- foreign material
- insect infestation
- sprout damage, etc...

- **Rejection/unloading**

- grain unloading pits

- (Wet wheat transferred to a drier)

- **Storage in individual silos**





# GRAIN CLEANING

- Grain scalper/screener
  - removes large material
  - consists of series of perforated plates/wire screens
- Aspirator
  - removes light material
  - draws air across a flowing grain stream
- Destoner machine
  - removes stones
- Magnetic separator
  - removes any metal
- Optical color sorter
  - high resolution camera
  - removes material with different color
- Disc/spiral/cylinder separators
  - sorting by shape



# GRAIN GRISTING

- grain blending
- **Purpose:** maintain the same degree of flour quality
- Systematic combining of two or more lots or kinds of grains to obtain a **uniform mixture of a desired specification.**



# TEMPERING/CONDITIONING

- Purpose: easy separation of bran from endosperm
  - toughens outer bran with water
  - humidity max. 13,5–14% during receiving increases to 15–16%
  - short period of tempering – water penetrates to outer layers only
  - application of heat during tempering: **CONDITIONING**



# GRAIN MILLING

- Flour is obtained from a whole series of processing operations
  - Basic technological stages / the product flow of a mill = passages
  - 1st passage result:  
grain is torn open  
small amount of flour, fair amount of semolina and large pieces of endosperm still adhering to the branny outsides.  
These are fed to the next set of rolls or 2nd passage:
  - „reduction rolls“: reducing the size of semolina particles to fine flour
- 2 basic ways of milling
- *Semolina milling* – for wheat
  - *Flour milling* – for rye



# ROLLER MILL

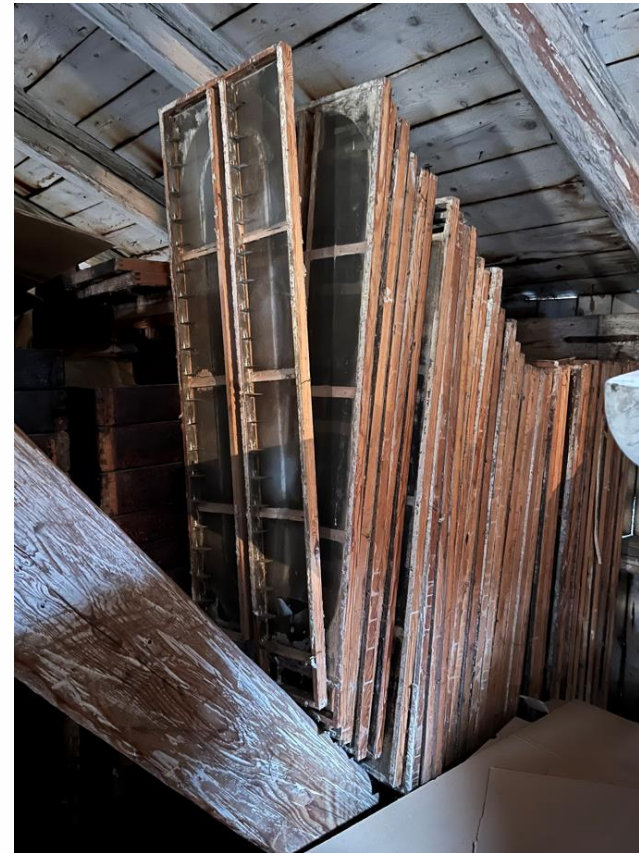
- grains are ground between two rotating rollers
- differential speed, cylinder surface and distance between rollers



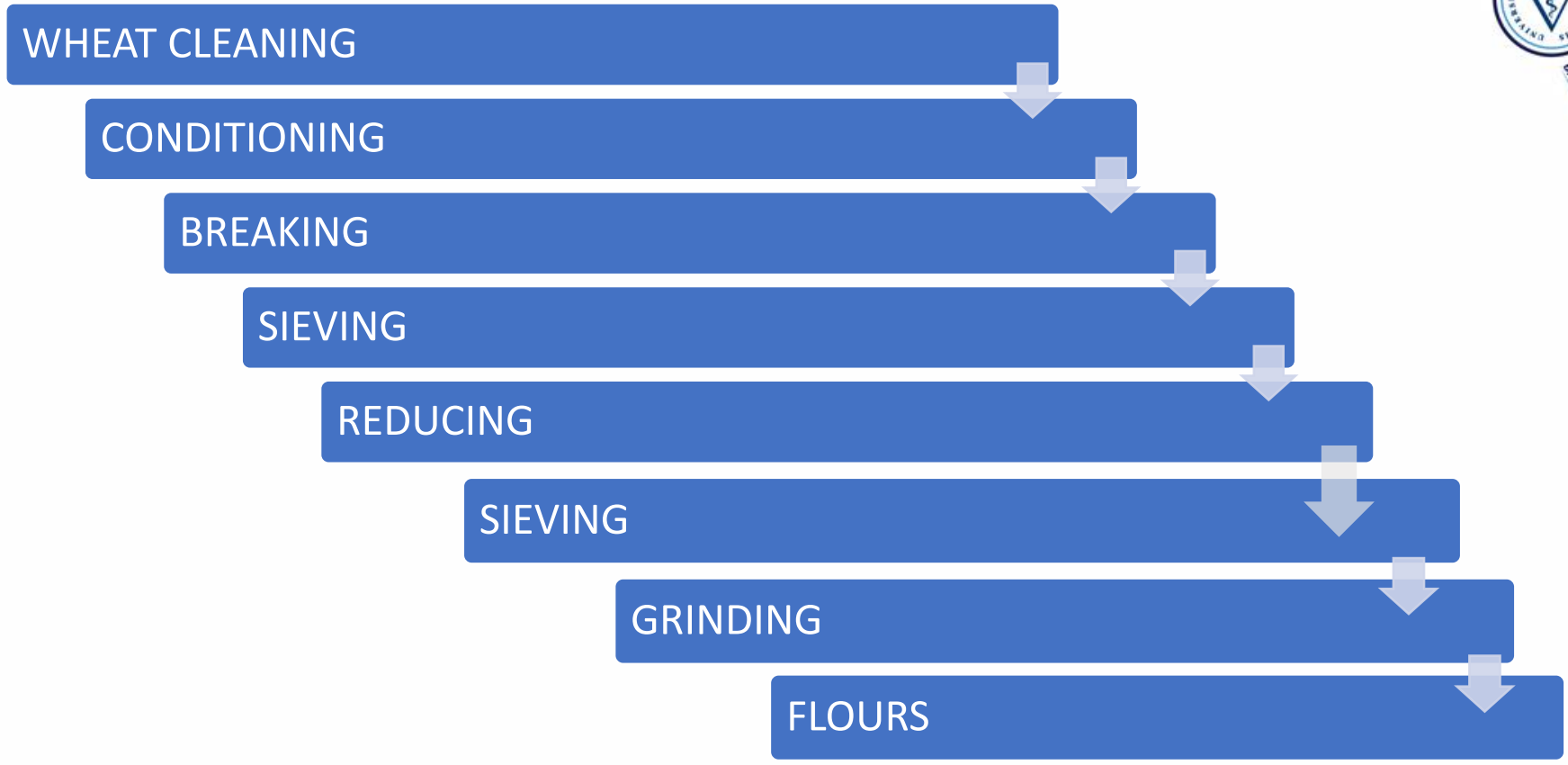
# PLAN SIFTER



- rotating sieves with differently sized apertures separate particles of similar size



# FLOW CHART OF WHEAT MILLING PROCESS



# FLOUR AGING

- needed to improve flour properties
- **1–3 months** optimum for wheat
- oxidizing agents: **ascorbic acid**
- flour quality totally destroyed after 4 years





# TYPES OF MILLED CEREAL PRODUCTS



Decree No. 18/2020 Sb. on requirements for flour-milling cereal products, pasta, bakery products and confectionary products and doughs

= products obtained by processing of one or more botanical species of cereals, buckwheat or other pseudocereals or rice using a multi-stage milling process.

flour, semolina

flakes

stone-ground flour („trhanka“)

millet, groats

pseudocereals

germs, brans

cereals for direct consumption, mixtures based on cereals

rice



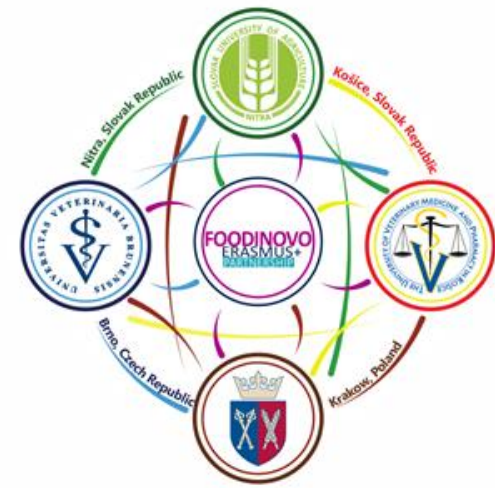
# FLOUR CLASSIFICATION AND LABELING IN CZECH REPUBLIC



- ***fine wheat flour***
  - Light (ash content max. 0,60 % DM)
  - Semi-light (ash content max. 0,75 % DM)
  - bread flour (ash content max. 1,15 % DM)
- ***fine rye flour***
  - ***light*** („vyrážková“) (ash content max. 0,65 % DM)
  - ***fine rye flour – dark/bread*** (ash content max. 1,10 % DM)
- ***semi-coarse wheat flour*** (ash content max. 0,50 % DM)
- ***coarse wheat flour*** (ash content max. 0,50 % DM)
- ***whole-wheat flour*** (ash content max. 1,90 % DM)



# ASH CONTENT IN FLOURS



- **flours with high ash content – more bran** → darker, lower digestibility and shelf-life, slightly bitter/acrid taste, higher nutritional value
- **flours with low ash content – without bran** → lighter, higher digestibility and shelf-life, neutral taste, lower nutritional value, higher energy value, contain mostly starch, without fat and vitamins



# FLOUR TYPE NUMBERS

- **number = ash content expressed as milligrams of dry matter**
- e.g. T 930: 100 g of rye flour = 930 mg of ash after burning
- **Numbers replaced by verbal specification** – e.g. fine wheat flour (= T 650)

\* higher number: darker, higher ash content, less gluten, worse leavening power

\* lower number: less fiber, lighter in colour



# CEREAL MILLING BY-PRODUCTS



*Principal by-products:*

- *Feed flour* (ca. 5,5%)
- *Bran* (ca. 15%)
- *Germ* (ca. 2–3%).
  - feedstuff ingredient
  - functional food ingredient
  - pharmaceutical industry
- *Grain screenings* for feeding wild game
- *Grain dust* – substrate for composting and biogasification



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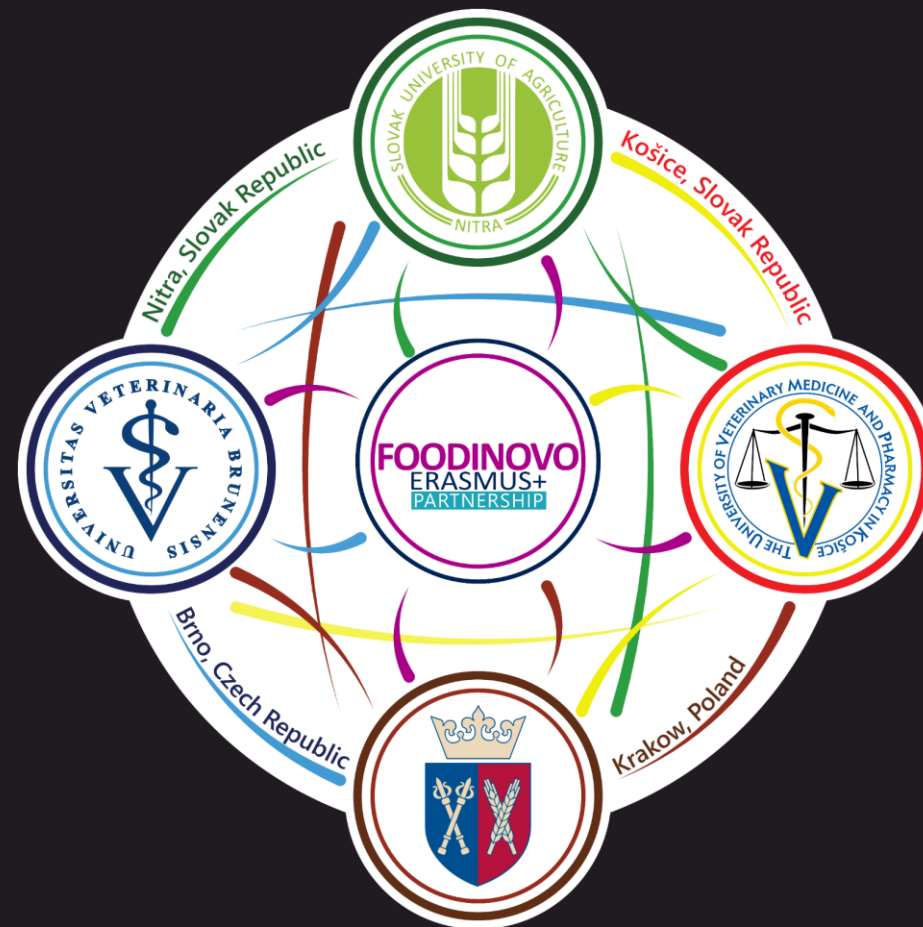
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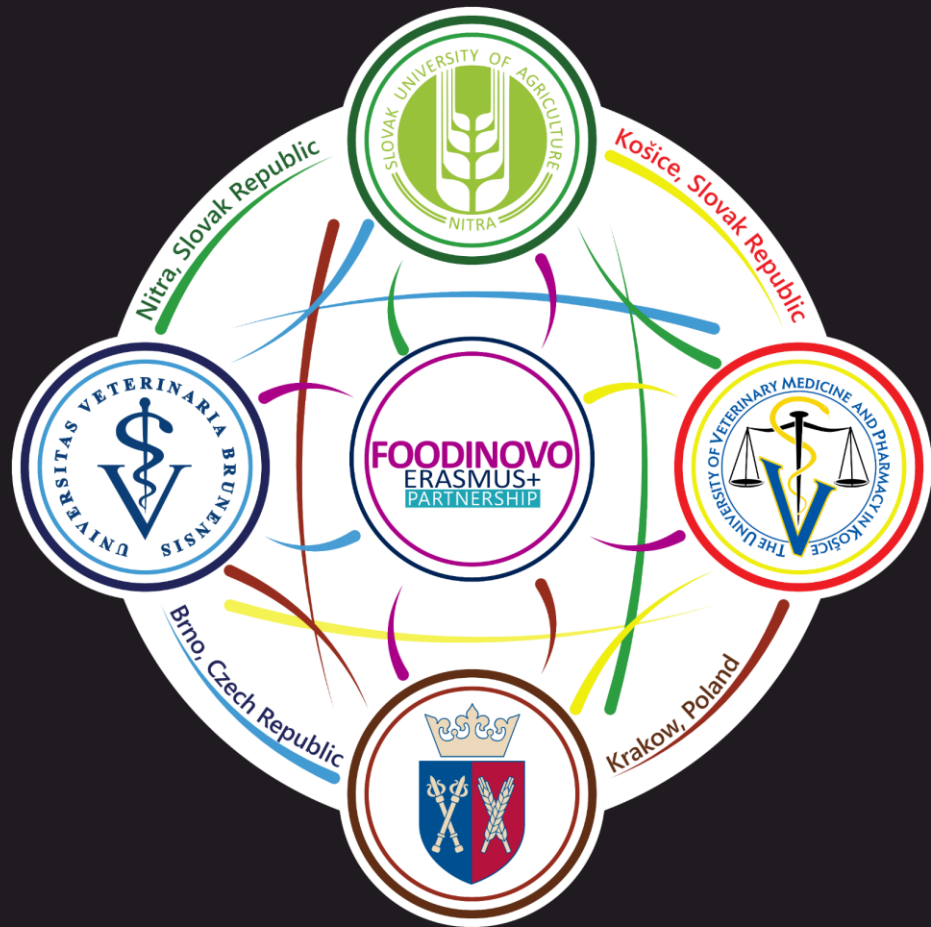
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