- During **storage** and **distribution**, foods are exposed to a wide range of **environmental conditions**

- Environmental factors such as **pressure**, **temperature**, **humidity**, **oxygen**, and **light** can trigger several reactions that may lead to food degradation

- Then, foods may be altered to such an extent that they are either **rejected** by or **harmful** to the consumer

❑ **Condensation of moisture** on foods or a **damp atmosphere** favors **microbial** growth, occasionally promotes **insects** development, and may indirectly lead to deterioration, resulting in destructive **self-heating**

❖ **Mechanical damage** (e.g., bruises and wounds) results in spoilage, and it frequently causes further **chemical** and **microbial** deterioration ❶

- In case of frozen foods, **fluctuating temperatures** are often destructive

- **Freezer burn** is a major quality defect in **frozen foods** that is caused by **fluctuating** temperatures

Each microorganism has:

(i) an **optimum temperature** at which it grows best

(ii) a **minimum temperature** below which growth no longer takes place

(iii) a **maximum temperature** above which all development is suppressed

- Bacteria that grow particularly well at low temperatures are called ***psychrophilic*** **(*cryophilic*)**
- Bacteria with an optimum temperature of **20°C–45°C** are ***mesophilic***
- Bacteria with an optimum temperature **above 45°C** are ***thermophilic*** ❶

❖ **Prior to harvest**, fruits and vegetables generally have good **defense mechanisms** against microbial attack; however, after separation from the plant, they can easily succumb to microbial proliferation

❖ **Meat** upon slaughter is unable to resist rapidly growing microbes

- **Many enzymatic reactions change the quality of foods**

- Fruits when cut tend to brown rapidly at room temperature due to the reaction of **phenolase** with cell constituents released in the presence of oxygen

- **Lipooxygenase**, if not denatured during the blanching process, can influence food quality even at **subfreezing** temperatures

- In addition to **temperature**, other environmental factors such as **oxygen**, **water**, and **pH** induce deleterious changes in foods that are catalyzed by **enzymes**

- Some chemical reactions are induced by **light**, such as loss of **vitamins** and browning of **meats**

- **Nonenzymatic browning** is a major cause of quality change and degradation of the nutritional content of many foods

- Due to the interaction between **reducing sugars** and **amino acids**, resulting in the loss of **protein solubility**, **darkening** of lightly colored dried products, and development of **bitter flavors**

- Environmental factors such as **temperature**, **water activity**, and **pH** have an influence on nonenzymatic browning

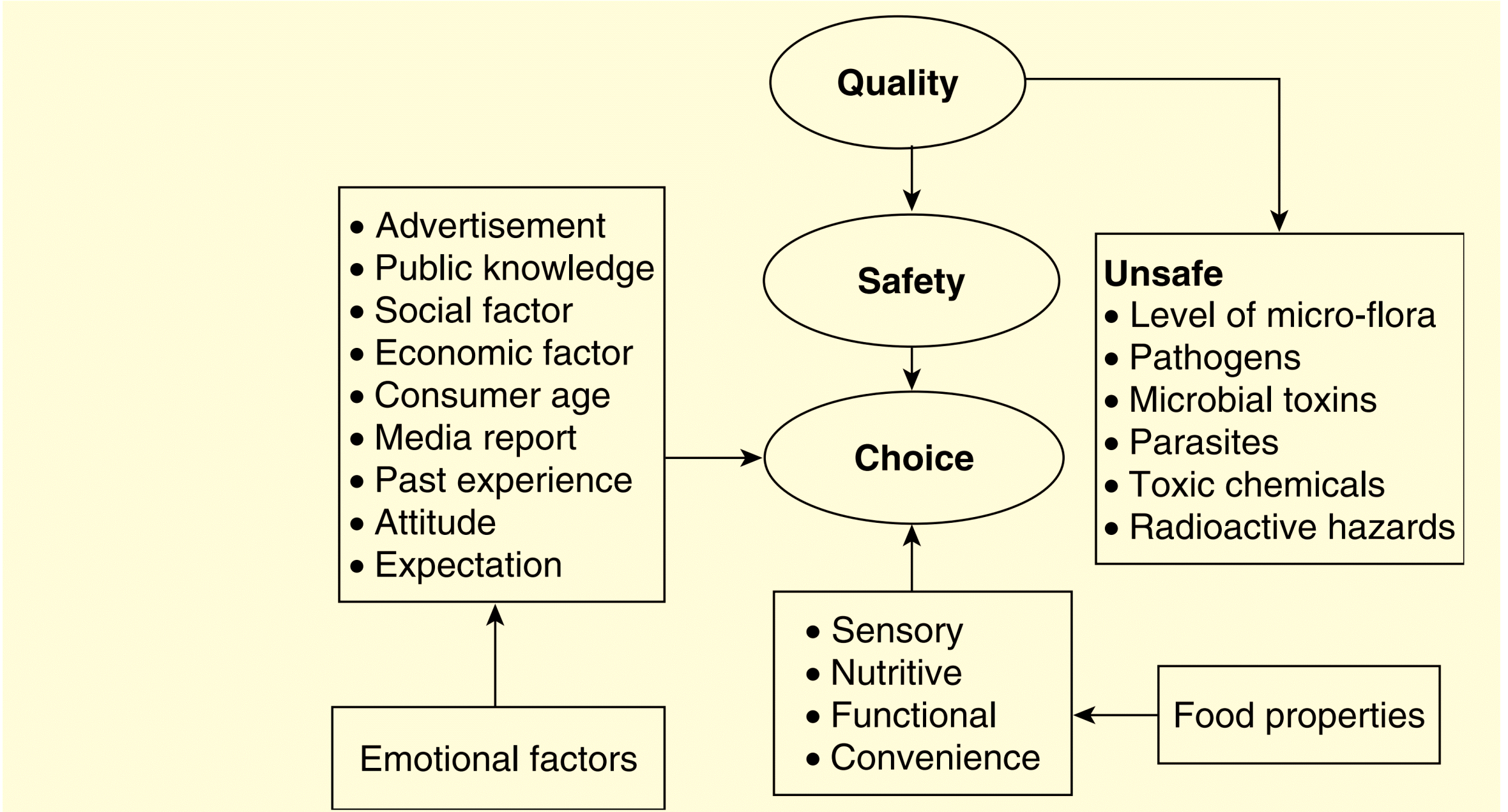
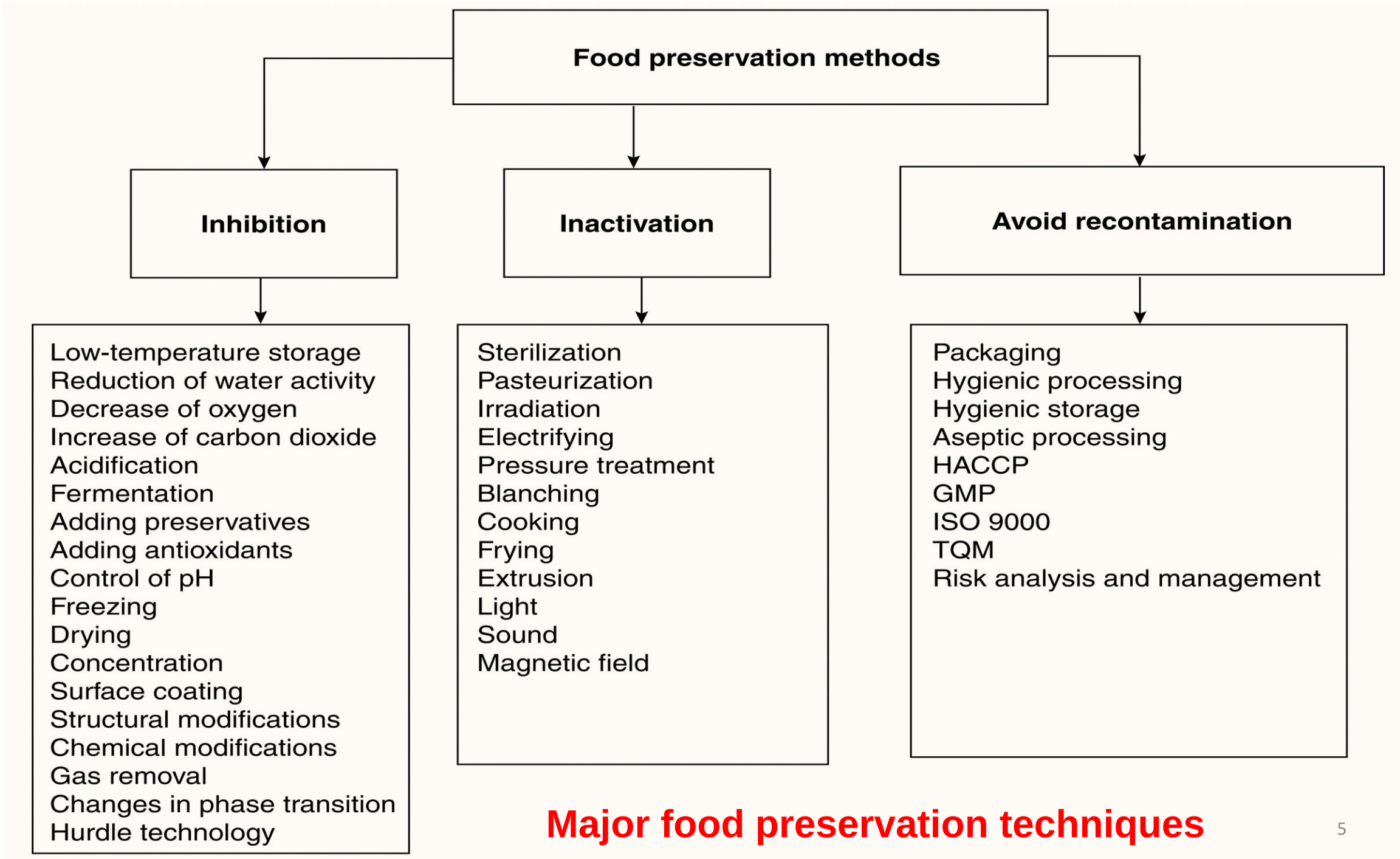


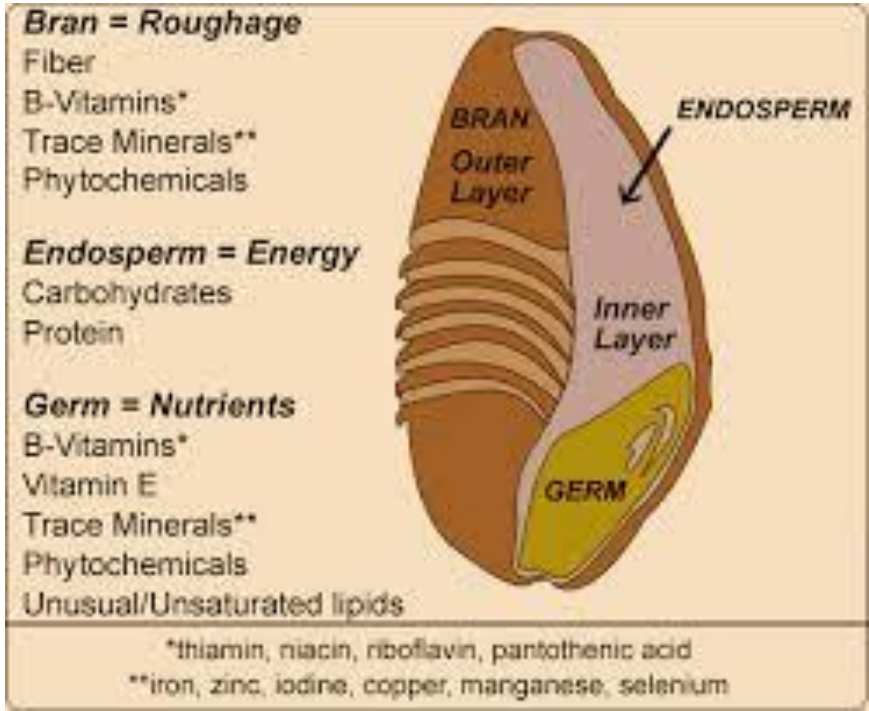
FIGURE 1.2 Factors affecting food quality, safety, and choice.



Major food preservation techniques

Structure and Composition of Cereal Grains and Legumes

- **Cereals** are **monocotyledonous** plants that belong to the grass family (**Gramineae**)(**Poaceae**)
- The cereal grains such as wheat, rice, corn, barley, oat, rye, sorghum, and millet (and triticale) provide 50% of the food energy and 50% of the protein consumed on earth
- **Wheat**, **rice**, and **corn** together make up **three-fourths** of the world's grain production
- Edible **fruit** are generally called ***grain***, but botanically referred to as ***caryopsis***
- The cereal grain consists of three major components:
  - ***Endosperm***
  - ***Embryo (germ)***
  - **Bran (fruit coats + seed coat)**

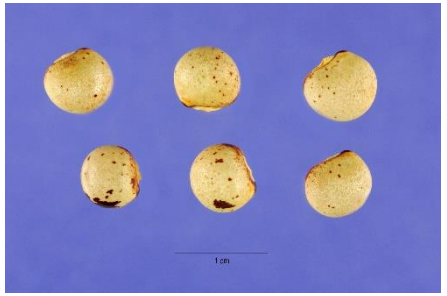


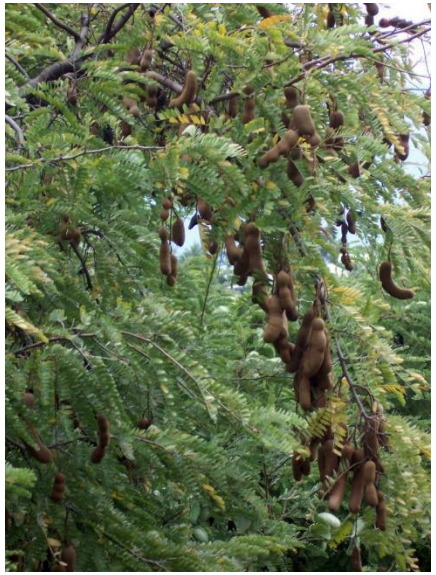
❖ **Legumes** are **dicotyledonous** plants in the family **Fabaceae** (**leguminaceae**)

❖ Well-known legumes include alfalfa, clover, chickpea, black gram, mung bean(green gram), and **pigeon pea**, **chickpea**, **pea** lentils, lupin bean, carob (lucost bean), **soybean**, **peanut** and **tamarind**

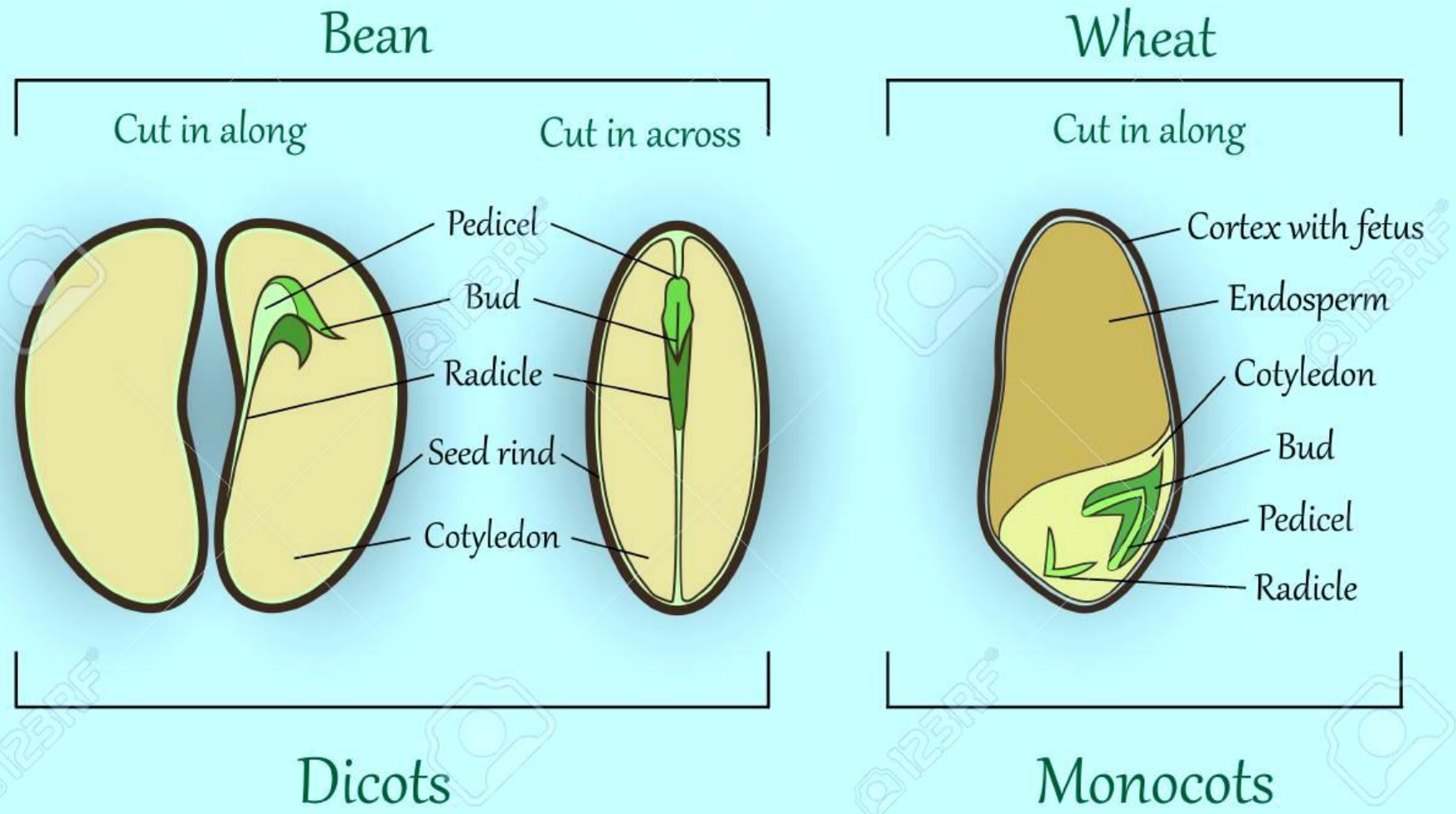
❑ Legumes that contain a small amount of fat are termed ***pulses*** (energy is stored as **starch**), and legumes that contain a higher amount of fat, such as **soybean** and **peanuts**, are termed ***leguminous oilseeds***

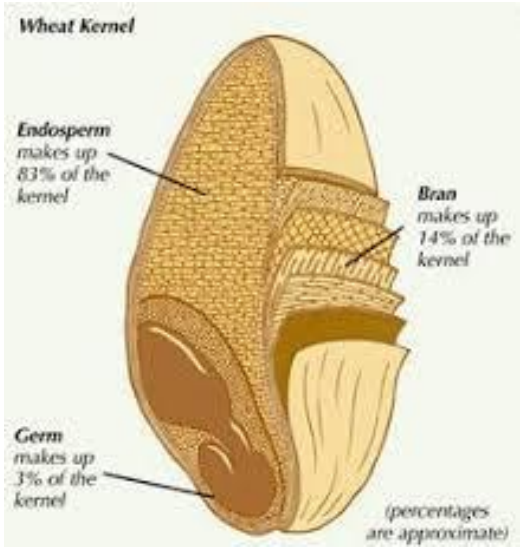
❑ Legumes are next to cereals in terms of their **economic** and **nutritional** importance as human food sources❶



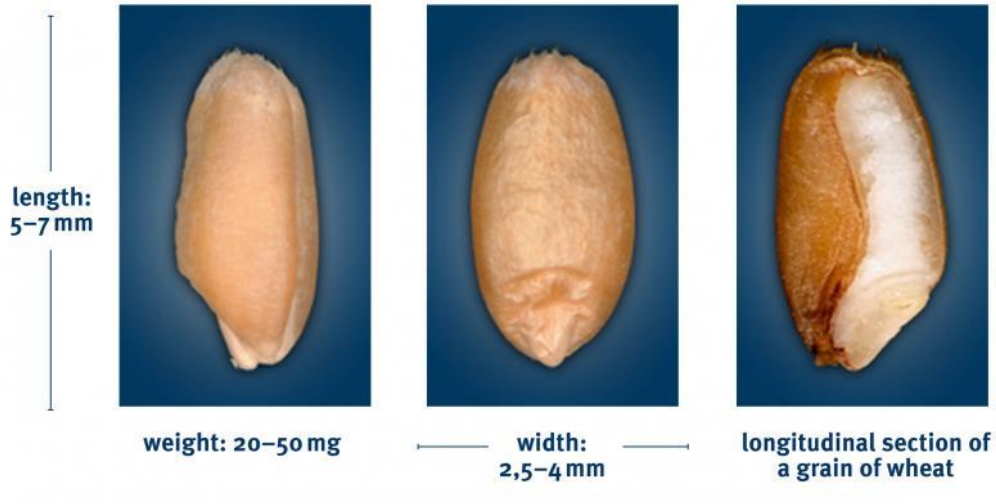


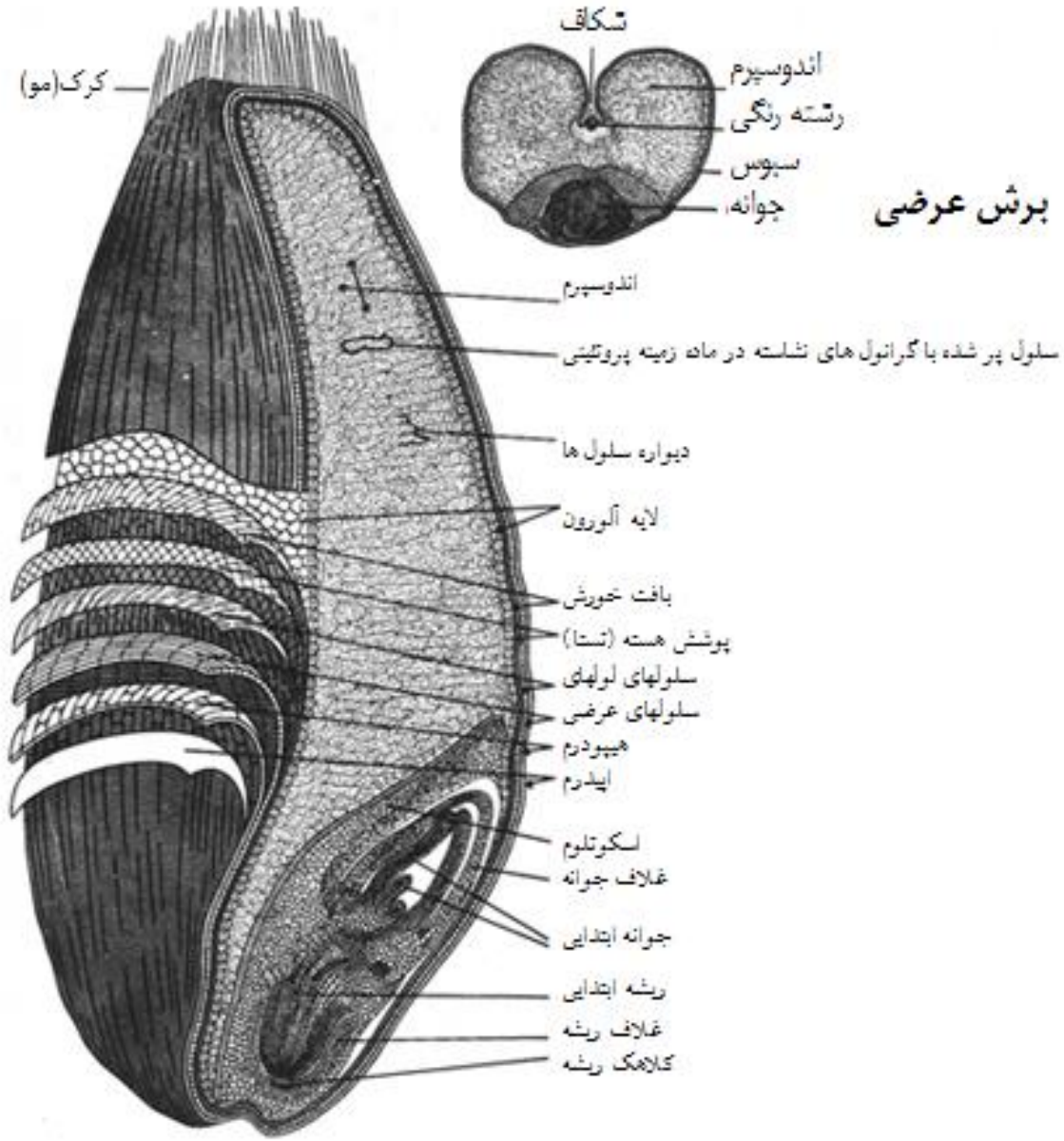
The structure of the seed in dicots and monocots




Wheat Kernel
Endosperm
makes up
83% of the
kernel
Bran
makes up
14% of the
kernel
Germ
makes up
3% of the
kernel
(percentages
are approximate)

Wheat


length:
5–7 mm
weight: 20–50 mg
width:
2,5–4 mm
longitudinal section of
a grain of wheat



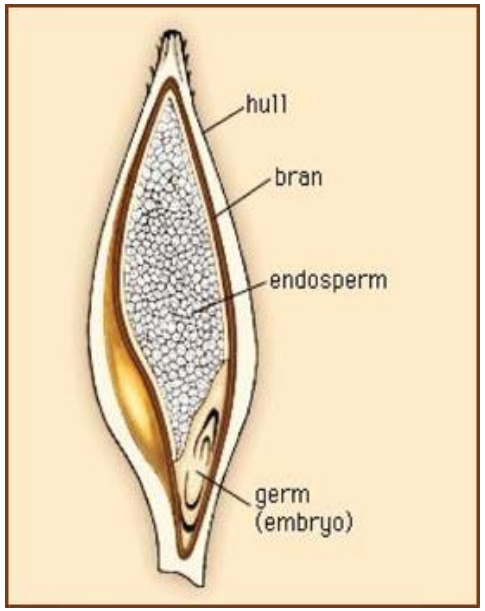
- دانه گندم (کاریوپسیس)
  - پریکارپ (پوشش میوه)
    - پریکارپ خارجی
      - ۱- اپیدرم (اپی کارپ)
      - ۲- هایپودرم
      - ۳- بقایای سلول های با دیواره نازک
    - پریکارپ داخلی
      - ۴- سلول های حدواسط
      - ۵-سلول های عرضی
      - ۶- سلول های لوله ای
  - سبوس
  - هسته
    - پوشش هسته (تستا، اسپرمودرم، تگمن) و رشته رنگی
    - اپیدرم خورش (لایه هیالین، پریسپرم)
    - اندوسپرم
      - ۱- لایه آلورون
      - ۲- اندوسپرم نشاسته ای
  - جوانه (جنین)
    - اسکوتلوم (کوتیلدون)
      - ۱- اپی تلیوم
      - ۲- پارانشیم
      - ۳- بافت های پرووواسکولار
    - محور جنینی
      - ساقه چه و کولئوپتیل
      - ریشه اولیه، به وسیله کولئوریز پوشیده شده
      - ریشه چه جانبی ثانویه
    - اپی بلاست

Barley

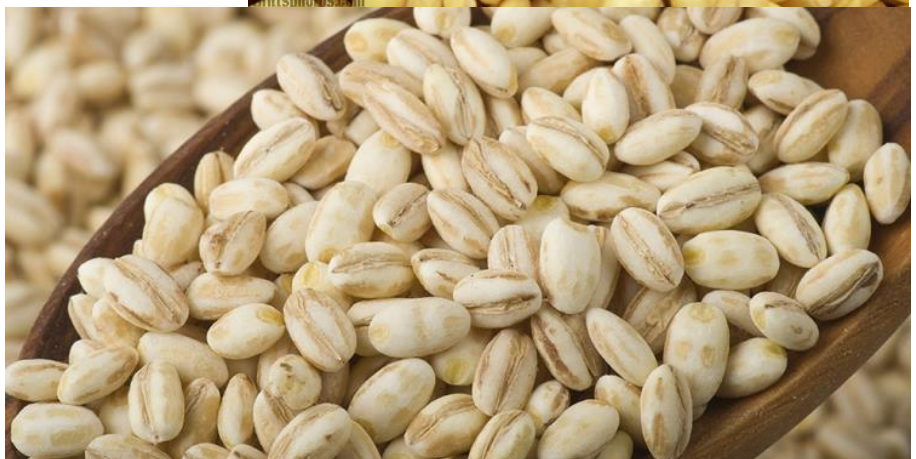
Wheat

Covered barley

Hull-less barley

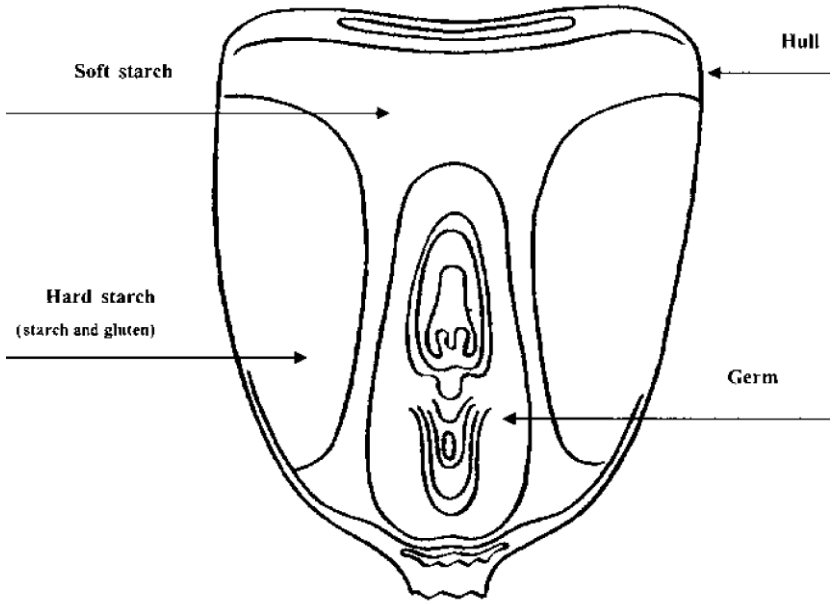


Pearled barley




Barley
Wheat
Oats
Rye

Corn or **maize**
(*Zea mays* L.)



Rice *(Oryza sativa* L.)

Brown Rice

White Rice

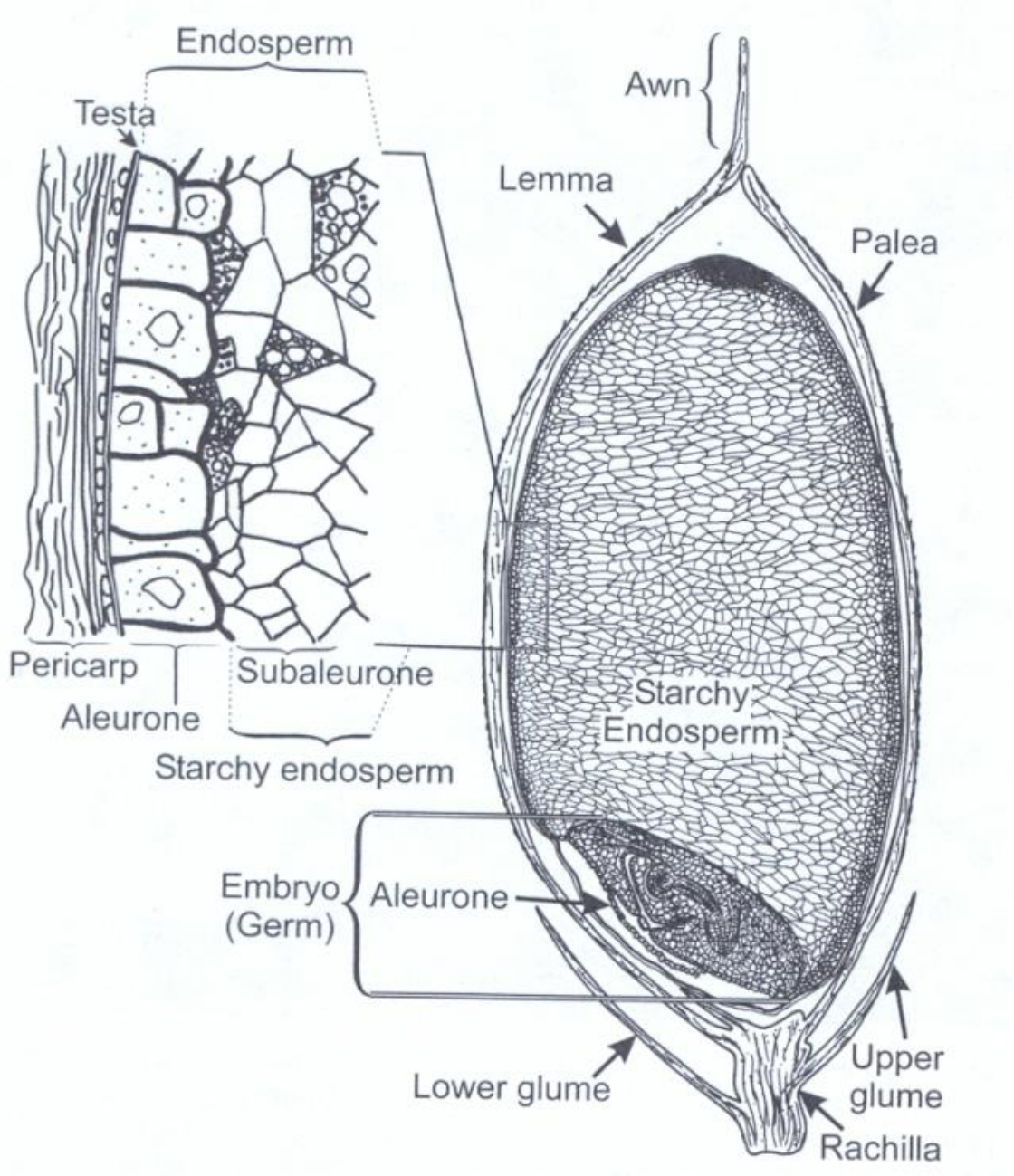
Paddy

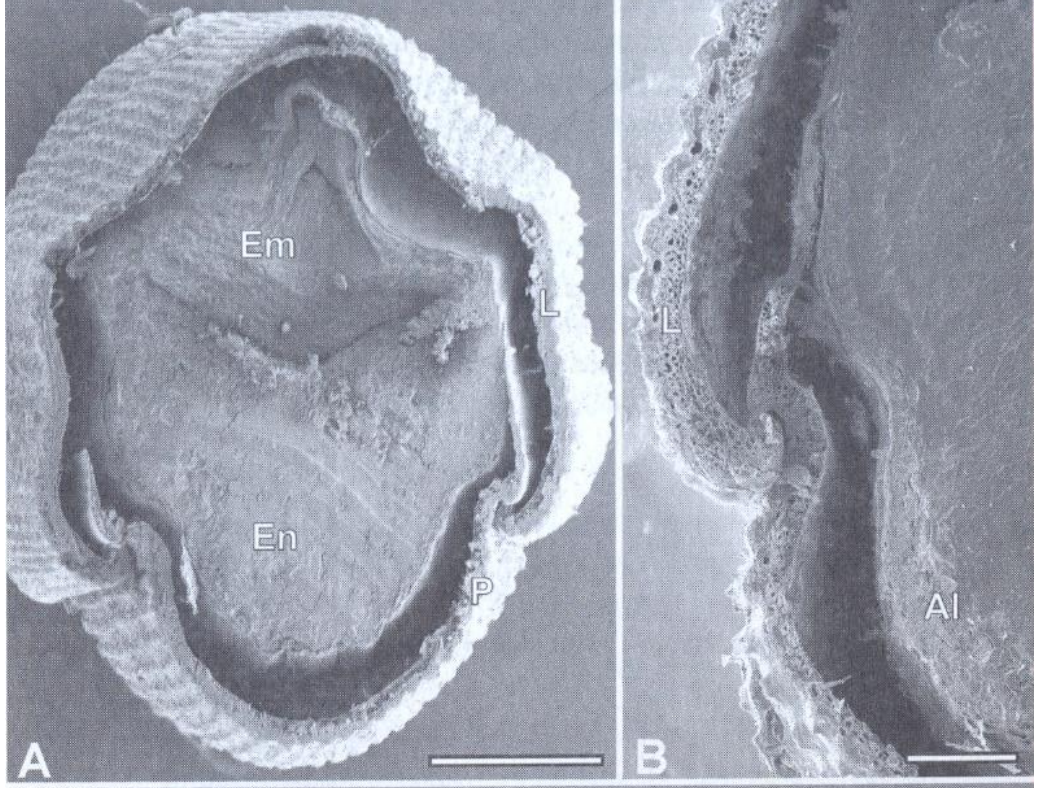
- The **hull** also protects the grain from **insect** infestation and **fungal** damage

- Two modified leaves:

Palea

Larger **lemma**





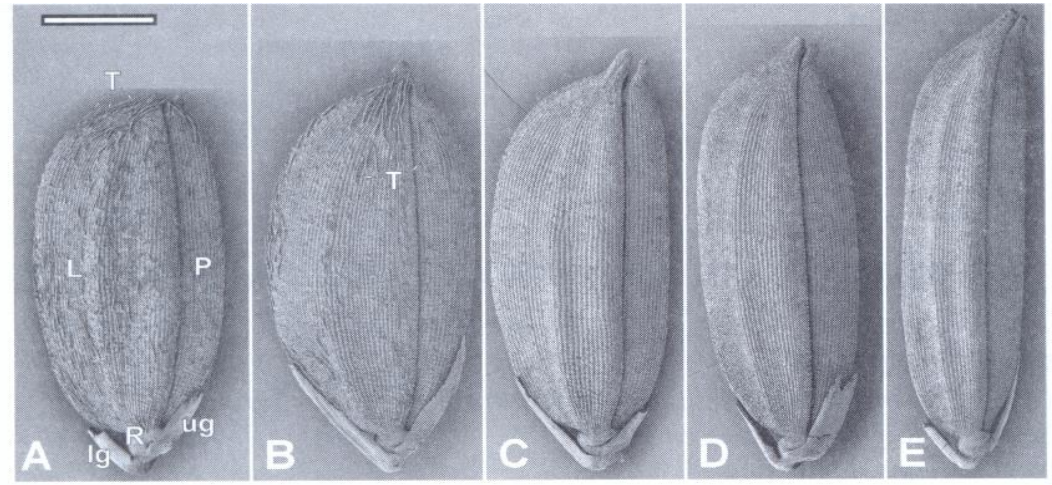
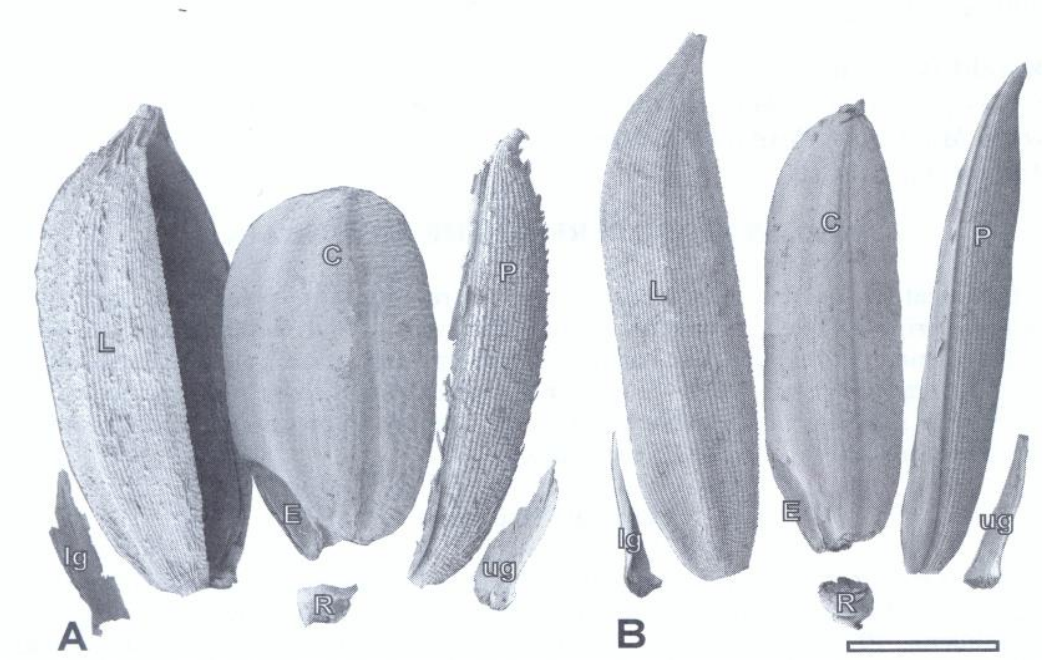


Fig. 1. Scanning electron micrographs of mature, intact paddy rice (spikelets). A, Calmochi-101, waxy; B, S-102, short grain; C, M-202, medium grain; D, Bengal, medium grain; and E, Cypress, long grain. Note the multitude of hairlike structures (trichromes) on the outer surfaces of the palea and lemma, especially toward the top of the micrographs in A and B, and the lack of trichromes on the surfaces of C–E (which are therefore described as "glabrous"). L = lemma, lg = lower glume, P = palea, R = rachilla, T = trichomes, ug = upper glume. Scale bar = 2 mm.



Rye (*Secale cereale* L.)

Rye Bread

OATS *(Avena sativa)*

sorghum (*Sorghum bicolor* L.)

Foxtail Millet

Pearl

Proso

Finger (Ragi)

Triticale

Pseudocereals

Table 2.5 Composition of some cereal grains (%).

	Endosperm	Germ	Bran and aleurone layers	Husk
Maize	82	13	5	
Wheat	82	3	15	
Rice	73	10	5	20
Sorghum	82	2	8	

Table 1 Proximate, Vitamin, and Mineral Composition of Different Cereal Grains

		Wheat	Rye	Corn	Barley	Oats	Rice	Sorghum
Proximate composition	Moisture[a]	10	10.5	15	10.6	9.8	11.4	10.6
	Protein[a]	14.3	13.4	10.2	13	12	9.2	12.5
	Fat[a]	1.9	1.8	4.3	2.1	5.1	1.3	3.4
	Fiber[a]	3.4	2.2	2.3	5.6	12.4	2.2	2.2
	Ash[a]	1.8	1.9	1.2	2.7	3.6	1.6	2
Vitamin composition	Retinol	—	—	2.5[d]	—	—	0.0–0.08[b]	—
	Thiamine	9.9[b]	1.45[d]	3.8[d]	—	0.67[d]	2.6–3.3[b]	4.62[b]
	Riboflavin	3.1[b]	2.90[d]	1.4[d]	—	0.11[d]	0.6–1.1[b]	1.54[b]
	Niacine	48.3[b]	—	28[d]	—	0.80[d]	29–56[b]	48.4[b]
	Pyridoxin	4.7[b]	—	5.3[d]	—	0.21[d]	4–7[b]	5.94[b]
	Pantothenic acid	9.1[b]	—	6.6[d]	—	—	7–12[b]	12.54[b]
	Biotin	0.056[b]	—	0.08[d]	—	13[d]	0.04–0.08[b]	2.9[b]
	Folic acid	—	—	0.3[d]	—	104[d]	—	0.20[b]
Mineral composition	Calcium	—	31.5[f]	0.01–0.1[g]	406[b]	50[g]	0.1–0.8[g]	0.05[a]
	Magnesium	3740[a]	92[f]	0.09–1[g]	410[b]	141[g]	0.6–1.5[g]	0.19[a]
	Phosphorus	—	—	0.26–0.75[g]	5630[b]	450[g]	1.7–3.9[g]	0.35[a]
	Potassium	—	412[f]	0.32–0.72[g]	5070[b]	370[g]	1.5–3.7[g]	0.38[a]
	Sulfur	—	—	0.01–0.02[g]		—	0.4–1.6[g]	—
	Sodium	—	—	0–0.01	254[b]	4[g]	—	0.05[a]
	Chlorine	—	—	0.05[b]	—	—	500–800[b]	—
	Cobalt	4.4[e]	—	0.003–0.34[b]	—	—	—	3.10[a]
	Iodine	—	—	73–810[b]	—	4[g]	—	—
	Manganese	—	—	0.7–54[b]	18.9[b]	—	17–94[b]	10.80[a]
	Selenium	28.1[a]	—	0.01–1[b]	—	—	53–810[b]	—
	Zinc	2610[e]	—	12–30[b]	23.6[b]	3[g]	1.7–31[b]	15.4[a]
	Iron	5410[a]	2.7[f]	1–100[b]	36.7[b]	3.81[g]	—	50[a]

[a]Percentage.
[b]Range mean content (μg/g).
[c]U/g.
[d]mg/kg (dry basis).
[e]μg/100 g.
[f]mg/100 g.
[g]mg/g at 14% moisture.

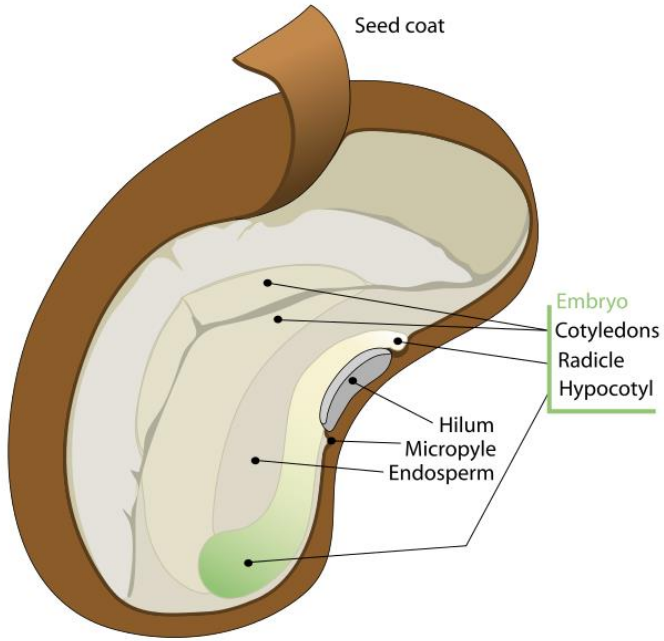
Table 2.2 A summary of the main functions of carbohydrates, lipids and proteins in plants and humans.

	Main function in plants	Main function in humans
Carbohydrates (composed of carbon, hydrogen and oxygen)		
Simple sugars (monosaccharides, disaccharides)	Energy to drive metabolism	Energy to drive metabolism (Calories)
Polysaccharides (large carbohydrates made from simple sugars)	Storage, e.g. starch Structure, e.g. cellulose, lignin	Storage, e.g. glycogen Not very important for structure
Lipids (composed of carbon, hydrogen and oxygen)	Constituents of cell membranes Storage of energy (but less important than carbohydrates)	Constituents of cell membranes Storage of energy (more important than carbohydrates) Cushioning of organs Heat insulation
Proteins (composed of carbon, hydrogen, oxygen, nitrogen, sulphur and some phosphorus)	Enzymes control metabolic processes Important functional component of cell membranes	Enzymes control metabolic processes Important functional component of cell membranes Important in structural tissues such as bones, cartilage and tendons

❖ The **structure** of the food leguminous plants is generally **similar**

❖ Mature legume seeds have 3 major components:

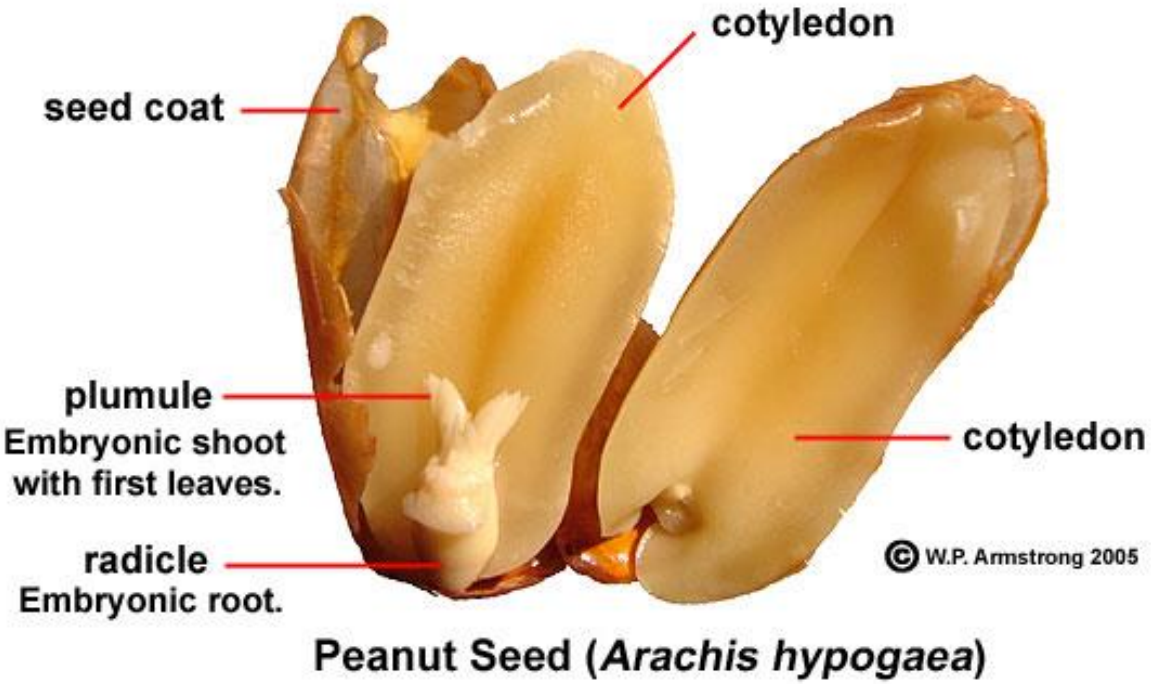
1. **Seed coat (Testa)**(8%): *The outer layer of the seed*
2. **Cotyledons**(90%)
3. **Embryo axis** (2%)



❖ In most legumes, the ***endosperm*** is **short-lived** and, at maturity, it is reduced to a **thin layer** surrounding the cotyledons or embryo ❶

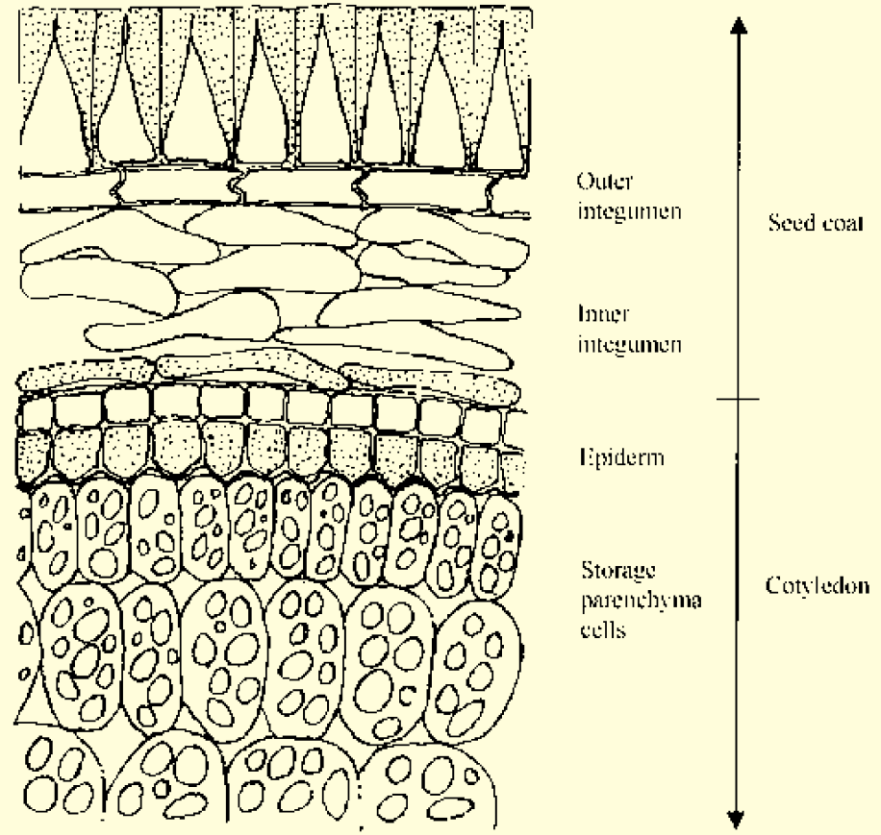
❖ After **soaking** and removing the seed coat of a bean, the endosperm comes off, and the reminder is composed of embryonic structure

❖ The embryonic stem and plumule are fairly **well developed** in the resting seed and lie between two cotyledons or seed leaves

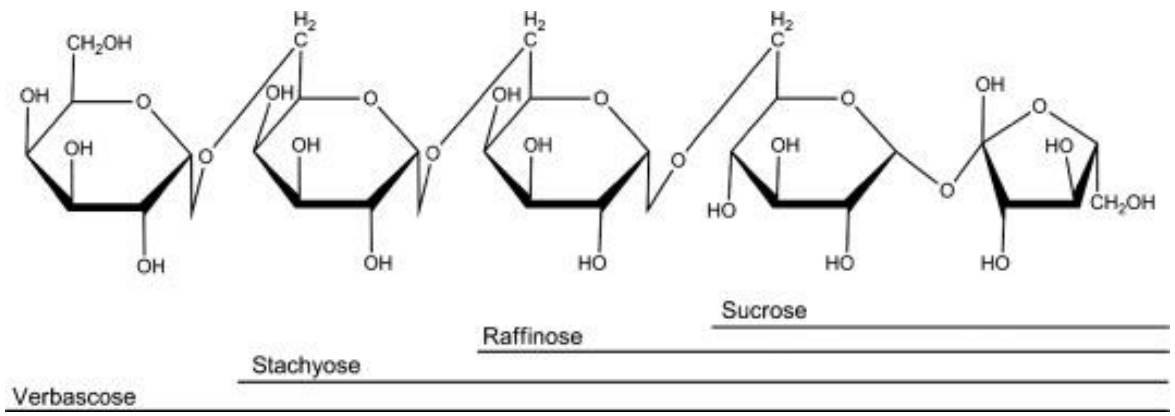


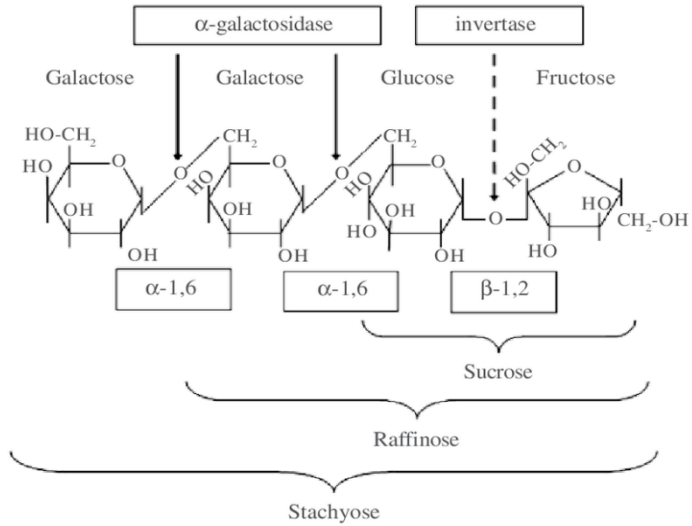
Peanut Seed (*Arachis hypogaea*)

- The **radicle** or **embryonic root** has almost no protection except that provided by the seed coat
- Therefore, the seed is unusually **breakable**, especially when it is **dried** and **roughly treated**
- Usually, legumes have a moderately **thick seed coat**
- Legume seeds having **thick seed coats** have higher amounts of **lipids**
- The size of the **parenchymatous cells** ranges from 70 to 100 µm, and the most abundant structures in this region are **starch**
- Major portion of **protein**, phosphorus, and iron is present in cotyledons, whereas 80–90% of **crude fiber** and 32–50% of **calcium** are present in **seed coat**



- Legumes usually contain a large amount of **carbohydrates** ranging from 24 to 68%
- The carbohydrates include mono- and oilgosaccharides.
- In **soybean** and **lupine** seeds **starch** content ranges from 0.2 to 3.5%
- The oligo saccharides, such as those of the **raffinose** family (raffinose, stachyose, and verbascose), are the most predominant in legumes and are 31.1–76% of total soluble sugars
- Consumption of large amount of beans causes **flatulence** in humans and animals
- Legumes also contain large amounts of **crude fiber**, ranging from 1.2–13.5%
- **Chickpeas** have one of the highest nutritional compositions of any dry edible legumes. The average nutritional content of chickpea is 22 % protein, 67 % total carbohydrates, **47 %** starch, 5 % fat, 8 % crude fiber, and 3.6 % ash





- ❖ Legumes contain an appreciable amount of **protein**
- ❖ The protein content depends on the species of legume and ranges from **15 to 45%**
- ❖ **Globulins** constitute most of the storage proteins in most legume seeds
- ❖ The **biological value** of legume proteins is **low** owing to their content of sulfur amino acids

- ❑ Some legumes, such as peanuts (50%) and soybean (21%) have a considerable amount of **lipid**
- ❑ Lipid content of other species varies from 1 to 7.2%
- ❑ The major fatty acid contents of the legume are **oleic**, **linoleic**, and **linolenic** acid
- ❑ Lipids are highly sensitive to enzymatic and nonenzymatic oxidation, which results in the aldehydes, ketones, esters, and acids

- ➢ Legumes are a good source of **minerals**, such as calcium, iron, copper, zinc, potassium, and magnesium
- ➢ **Potassium** is the main mineral of the legume and comprises about **25–30% of the total mineral** content of the food legumes❶
- ➢ **Drying and storage** diminish most of the vitamins

Table 3 Proximate, Vitamin, and Mineral Composition of Different Raw Legumes

		Peanut	Pigeon	Chickpea	Soybean	Lentils	Large	Black	Green	Fava	Mug	Cowpea
Proximate composition (%)	Moisture	5.6	10.6	10.7	8.6	10.5	10.9	10.6	10.7	10.6	9.7	11.7
	Protein	22.7	19.8	19.5	34.3	24.7	21.2	21.8	23.9	24.8	23.6	22
	Fat	44.5	1.3	5.7	18.7	1	1.1	1.4	1.3	1.4	1.4	1.3
	Carbohydrate	25.5	65.2	61.7	31.6	61.2	62.7	63.5	62.4	60.4	61.6	63.4
	Crude fiber	2.9	5.5	4	3.8	4.1	5.3	—	3.4	7	4.4	4.5
	Neutral fiber	5.5	13.6	6.1	12	10.4	11.3	13.3	5.7	14.9	9.2	7.7
	Ash	2.2	3.7	2.7	5.1	2.6	4.2	3.4	2.5	3.3	3.3	3.3
Vitamin composition (mg, %)	Thiamine	0.90	0.60	0.51	0.87	0.54	0.64	0.99	0.79	0.52	0.61	0.94
	Riboflavin	0.183	0.166	0.228	0.330	0.238	0.180	0.201	0.254	0.286	0.245	0.227
	Niacin	15.44	2.94	1.72	2.35	2.3	1.61	1.93	2.94	2.52	2.46	2.36
	Vitamin B_6	0.582	0.264	0.560	0.627	0.549	0.601	0.285	0.153	0.374	0.410	0.440
	Total folacin	0.401	0.343	0.481	0.250	0.432	0.308	0.47	0.322	0.431	0.490	0.545
	Pantothenic acid	2.92	1.35	1.32	1.73	1.78	1.32	0.99	1.91	1	1.71	1.39
	β-Carotene	—	36.2	29.1	46.3	34.9	—	—	160.2	47.4	54.1	28.0
Mineral composition (mg, %)	Phosphorus	460.4	317.4	365.7	477	408.5	366.5	380.3	332.9	373.3	348.8	426.5
	Potassium	786.6	1200.4	1044.2	1820	970	2017.3	1424.3	1049.5	1503.1	1192.2	1450.3
	Sodium	34.4	26.1	22.7	6.9	16.6	6.6	5.2	18.4	11.6	5.6	23
	Calcium	66.0	129.1	165	223.1	59.3	98.6	92.3	49.1	97.8	124.8	80.3
	Magnesium	268.3	171	202.7	284.5	180.7	236.2	195.6	157.2	214.7	243.6	250.2
	Zinc	5.28	2.87	3.54	4.48	3.51	2.97	3.96	2.73	3.35	2.62	3.77
	Manganese	2.99	1.79	2.14	5.43	1.31	1.67	1.17	1.13	4.59	1.06	1.28
	Copper	3.15	1.09	0.81	1.43	0.77	0.96	0.77	0.76	0.82	1.05	0.94
	Iron	5.92	8.26	6.23	8.66	8.07	7.43	4.82	5.02	6.66	8.80	7.54