

Grains

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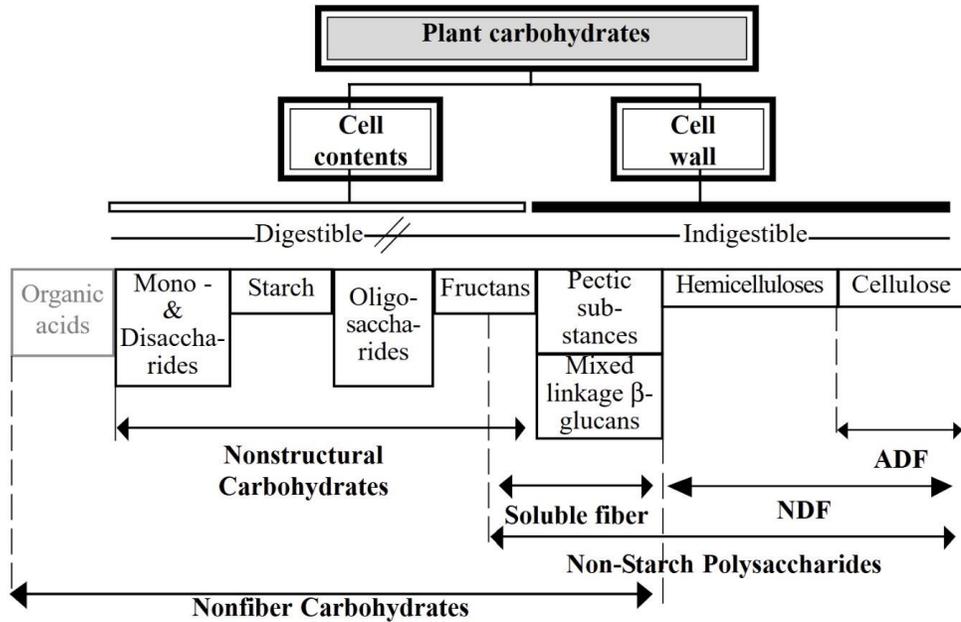


Figure 1 - Carbohydrates in plants. *Digestible or Indigestible* refer to potential for digestion by enzymes in the small intestine; all carbohydrates shown are potentially fermentable. Organic acids are not a carbohydrate, but their mass is included in the nonfiber carbohydrate value that is calculated by difference. As shown, soluble fiber includes only non-starch polysaccharides not in NDF. NDF = neutral detergent fiber, ADF = acid detergent fiber.

Total Carbohydrates = NFE + CF

NFE = Nitrogen Free Extract, as Percentage:

$$= 100 - (\% \text{Moisture} + \% \text{CP} + \% \text{EE} + \% \text{CA} + \% \text{CF})$$

or

$$= \% \text{DM} - (\% \text{CP} + \% \text{EE} + \% \text{CA} + \% \text{CF})$$

CP: Crude Protein, **EE:** Ether Extract, **CA:** Crude Ash, **CF:** Crude Fiber, **DM:** Dry Matter

Organic Matter (OM) % = DM % - CA %

Cell contents: (Neutral Detergent Solubles), **NDF**

Cell wall: (Neutral Detergent Unsolubles, Soluble in ADF)

ADF, Acid Detergent Fiber (Acid Detergent Unsolubles)

Cellulose: ADF - ADL

Hemicellulose: NDF - ADF

NFC % (Non-Fiber Carbohydrates) = 100 - (NDF + CP + EE + CA)



Preliminary Information

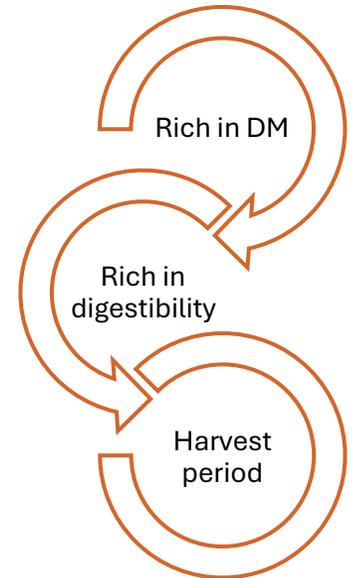
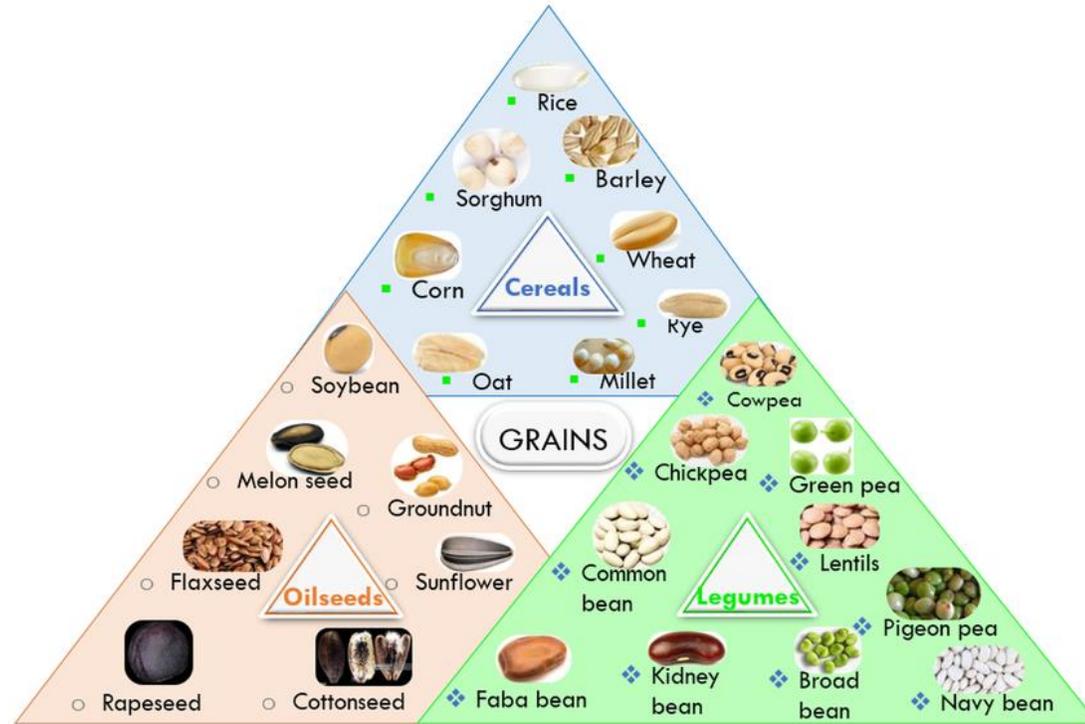
Grains

Cereal Grains

Legume Grains

Oilseeds

Jimoh, K. A., Hashim, N., Shamsudin, R., Man, H. C., Jahari, M., & Onwude, D. I. (2023). Recent advances in the drying process of grains. *Food Engineering Reviews*, 15(3), 548-576.



TYPES OF CEREAL GRAINS

ONLYFOODS

TRUE CEREAL GRAINS



PSEUDOCEREAL GRAINS



Cereal Grains

Rich in easily soluble carbohydrates

Major component is starch

Classified as energy feeds

70 – 95 % **NSP** (Non-Starch Polysaccharides) in their structure

What are NSPs?

β -glucans, arabinoxylan, cellulose



Classified as water-soluble and water-insoluble NSPs



Water soluble NSPs has antinutritional affect on animals (mostly)



Negatively affect the utilization of nutrients

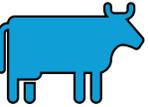


Sticky droppings

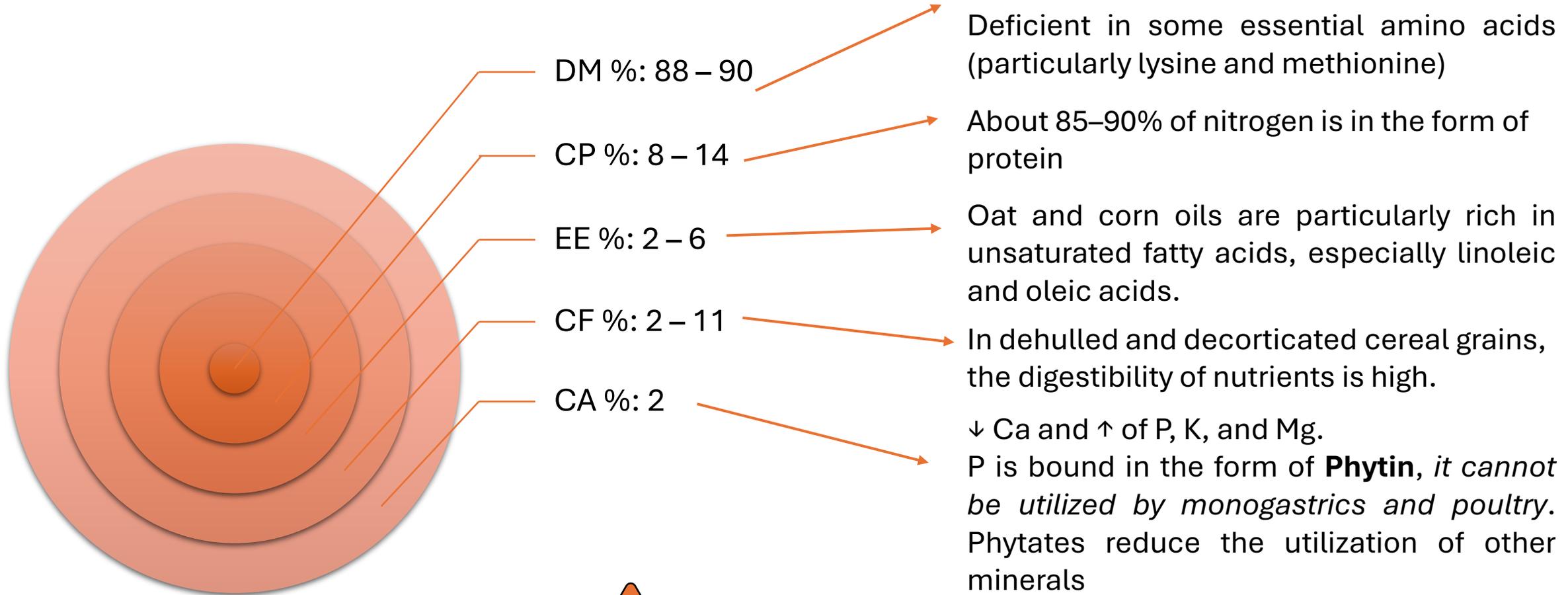


Management problems

Ruminants have the ability to digest NSPs through their rumen microbiota.



Cereal Grains



In ruminants, the starch digestibility of cereal grains from fastest to slowest is: Oat > Wheat > Barley > Corn > Millet⁶

Wheat (*Triticum vulgare*)



Parameter	Value / Description	Nutritional / Physiological Effect
Use	Human food and animal feed	Widely consumed
DM	~90%	High nutrient density
CP	~12% (13–15%)	Moderate protein source
Protein Distribution	~70% in endosperm	Mainly gluten proteins (gliadin + glutenin)
Gluten	High content	In fine form and excess amount → forms pasty mass
Essential Amino Acids	Deficient (especially lysine, methionine)	Limits protein quality
EE	~2%	Low fat content
CF	~2%	Low fiber
CA	~2%	Low mineral content
Calcium (Ca)	Low	Poor Ca source
Phosphorus (P)	High, mostly as phytate	Low availability in monogastrics and poultry
Phytates	Bind P, Ca, Mg, Zn + some protein & starch	Decreases nutrient utilization
Non-Starch Polysaccharides (NSP)	Mainly arabinoxylans, some β-glucans	May increase digesta viscosity
Starch	~60–65%	More rapidly fermented than corn starch
Digestibility	High when dehulled	Increased feed efficiency
Risks (in ruminants, high inclusion)	Fast fermentation lowers rumen pH	Digestive disorders, reduced fiber digestibility, diarrhea, acidosis, bloat, laminitis, reduced feedintake

Maize (Corn, *Zea mays*)



Parameter	Value / Description	Nutritional / Physiological Effect
Use	Excellent feed and energy source for all animal species	Used directly as grain and via by-products: wheat flour industry (bran, germ, meal), starch industry (corn gluten feed, corn gluten meal), alcohol/biofuel industry (DDGS)
DM	~88–90% (can drop to 82–85%); high-moisture corn: 22–28% moisture	High energy density; storage stability depends on DM
CP	~8%	Protein mainly zein and glutelin; low biological value
Amino Acid Profile	Deficient in essential amino acids, especially lysine and tryptophan	Limits growth when used as sole protein source
EE	~4% (range 3–6%)	Rich in unsaturated fatty acids, especially linoleic acid
CF	~2%	Highly digestible
CA	~2%	Low mineral content
Calcium (Ca)	Low	Poor source of Ca
Phosphorus (P)	High, ~75% bound as phytate	Limited availability in monogastrics
Vitamins	Yellow corn rich in carotene (Vitamin A precursor) and xanthophylls; low in niacin	Enhances yolk pigmentation in poultry; risk of pellagra if niacin not supplemented
Starch	~65%	Slower fermentation compared to other cereal starches
Starch Digestibility in Ruminants	~30% escapes rumen fermentation (bypass starch)	Provides glucose absorption in the small intestine; lowers acidogenic effect
Metabolizable Energy (ME)	~3300–3400 kcal/kg	High energy value
By-products	Corn bran, corn germ meal, corn gluten feed/meal, DDGS	Valuable protein and energy supplements

Barley (*Hordeum vulgare*)



Parameter	Value / Description	Nutritional / Physiological Effect
Use	Widely used in ruminant and non-ruminant feeding	Particularly palatable and valuable energy feed for ruminants
DM	~88–90%	High nutrient concentration
CP	~11–12%	Moderate protein source
EE	~2%	Low fat content
CF	~6% (higher than wheat and corn)	Contributes to bulk and rumen health
NSP	Soluble type, mainly β -glucans	Increases digesta viscosity; causes sticky droppings in poultry
Starch	~55%	Main energy source; highly fermentable in the rumen
ME	Poultry: ~2650 kcal/kg	Lower than wheat and corn; limits use in high-energy poultry diets
CA	~2%	Low mineral content
Phosphorus (P)	Variable; low-phytate barley varieties exist	Improved mineral availability in new cultivars
Hull / Dehulled Grain	Dehulled barley: lower fiber, higher digestibility	Improves energy utilization
Processing	Rolled or coarsely ground preferred; fine grinding forms a doughy mass	Prevents undigested grains in feces; improves intake and digestibility
Fermentation Rate	Faster rumen degradation than corn	Excess intake \rightarrow higher risk of acidosis, laminitis, liver abscess, reduced feed intake
In Poultry Rations	Limited use due to lower ME and high β -glucan content	Causes sticky droppings, wet litter, increased digesta viscosity, and reduced nutrient digestibility

Oat (*Avena sativa*)



Parameter	Value / Description	Nutritional / Physiological Effect
Use	Feed grain for ruminants, horses, and limited use in poultry diets	Especially suitable for breeding ruminants and horses
DM	~88–90%	High nutrient concentration
CP	~11–12%	Higher lysine content compared to other cereals
EE	~4–6%	High in unsaturated fatty acids (mainly linoleic and oleic acids)
CF	~11% (ADF: ~16%)	Contains 20–30% hulls; reduces overall digestibility
Hull Content	20–30%	Lowers energy density and nutrient digestibility
Starch	~40%	Lower starch content than other cereals; slower energy release
Fatty Acid Profile	Rich in unsaturated fatty acids	Improves milk yield and milk fat content in dairy cows; excessive use may soften butter consistency
Vitamins	Very low in Vitamins A, D, and niacin	May require supplementation in monogastric diets
Fiber Type	Contains soluble arabinoxylans and β -glucans	Increases digesta viscosity; limits use in poultry diets
Digestibility	Lower than other cereals due to hulls	Dehulled oats have improved digestibility but are costlier
In Ruminants	Provides good palatability; moderate energy source, improves milk fat percentage	Suitable for maintenance and breeding animals; inadequate for high-gain beef cattle when used alone, excessive feeding softens butter texture
In Poultry	Limited inclusion due to high fiber and soluble NSPs	Can help reduce feather pecking and cannibalism
Processing	Dehulling improves energy availability	Dehulled oats can substitute for corn, but cost limits use



Rye (*Secale cereale*) & Triticale (\times *Triticosecale*)

Parameter	Rye	Triticale
Use	Limited use in animal feeding due to palatability and anti-nutritional factors	Hybrid grain obtained by crossing wheat and rye; developed to combine high yield and quality
DM	~88–90%	~88–90%
CP	~12%	~12–14% (higher than corn)
EE	~2%	~2%
CF	~2%	~2–3%
Palatability	Lowest among cereal grains	Better palatability than rye; similar to wheat
Anti-nutritional Factors	Contains ergot alkaloids (ergotamine)	Lacks ergot contamination risk under proper cultivation
Toxic / Physiological Effects	Ergotamine causes contraction of arterial muscles \rightarrow \uparrow blood pressure; may induce uterine contractions and abortions in pregnant cows; laxative at high levels	Safe alternative; improved amino acid balance reduces nutritional risks
Amino Acid Profile	Deficient in lysine and methionine	Higher in lysine and methionine than wheat; rich in essential amino acids
Fiber Type / NSPs	Contains arabinoxylans (soluble NSPs)	Contains arabinoxylans; effects mitigated by enzyme supplementation
Digestibility	Moderate; may decrease feed intake due to low palatability	Comparable to wheat; good digestibility
ME	Slightly lower than wheat and corn	Similar to corn and wheat; high energy value
P	Moderate	Higher than in wheat and rye; better mineral contribution
Vitamins / Minerals	Limited vitamin content	Improved nutrient balance; higher mineral concentration
In Ruminants	Limited use due to potential for ergot contamination; risk of digestive disorders	Suitable for cattle, sheep, and pigs as a balanced grain feed
In Poultry	Not recommended due to sticky droppings and digestive issues	Can replace part of corn or wheat when supplemented with suitable enzymes
Special Notes	Should not be fed in high quantities; risk of abortion in pregnant cows	Combines wheat's grain quality and rye's hardiness; good feed grain with safe inclusion levels

Sorghum (*Sorghum vulgare*)



Parameter	Value / Description	Nutritional / Physiological Effect
Use	Commonly used in poultry diets and as a substitute for corn in all animal feeds	Suitable for all livestock species; widely used in regions where corn is expensive or scarce
Grain Characteristics	Smaller kernel size than corn	Requires grinding or cracking before feeding to improve digestibility
DM	~88–90%	Similar to other cereal grains
CP	~10–15%	Slightly higher than corn; provides moderate-quality protein
Limiting Amino Acids	Lysine and threonine	Deficiency limits protein quality; requires supplementation in monogastric diets
EE	Lower than corn	Lower fat content reduces energy density slightly
CF	Slightly higher than corn	May reduce digestibility at high inclusion levels
ME	~95–100% of corn's energy value	High-energy grain; comparable to corn (97–100%)
Vitamins / Minerals	Similar to corn; provitamin A and pigments lower	Lower carotenoid content results in paler egg yolks and skin pigmentation in poultry
Phenolic Compounds	Contains phenolic acids, flavonoids, and tannins	Reduce palatability and nutrient digestibility
Tannins	High in brown sorghum varieties; low in white types	High-tannin varieties cause constipation and colic in horses; reduce feed intake and growth in monogastrics
Antinutritional Factors	Condensed tannins (polyphenols)	Bind proteins and digestive enzymes, lowering nutrient utilization
Processing	Should be cracked or ground before feeding	Improves digestibility and feed efficiency
Pigmentation Effect (Poultry)	Lacks carotenoids and xanthophylls	Leads to pale yolk and skin color when used as a full corn replacement
In Poultry	Can replace up to 100% of corn with proper formulation	Must consider pigment deficiency and amino acid balance
In Ruminants	Suitable energy feed, comparable to corn	Well-digested when properly processed
In Horses	High-tannin sorghum may cause constipation and colic	White, low-tannin varieties are safer
Overall Feeding Value	~95% of corn's feeding value	Excellent alternative to corn in most animal rations



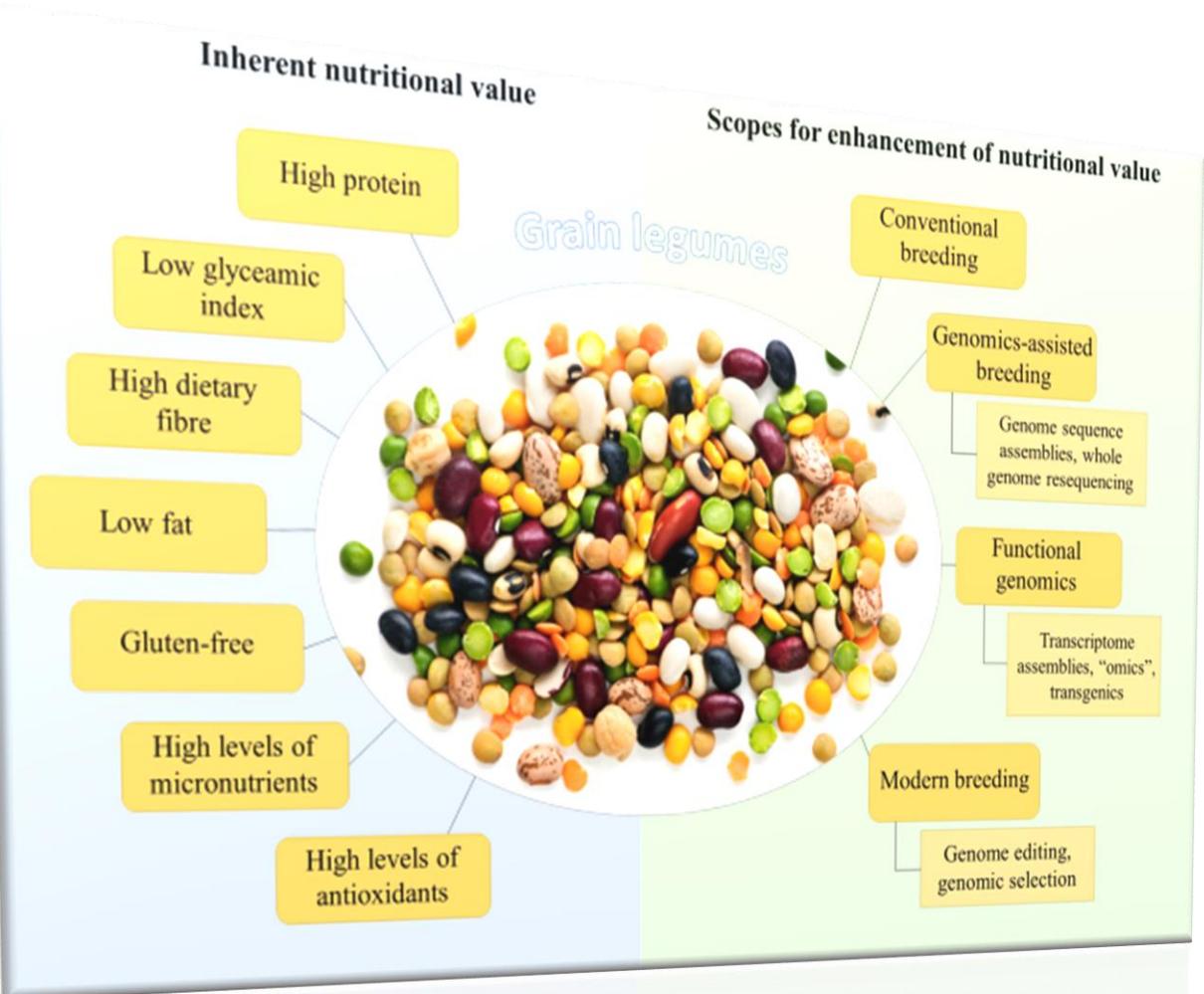
To sum up

Component, %	Wheat	Maize	Barley	Oats	Rye	Triticale	Sorghum	Rice
DM	90	88–90	88–90	88–90	88–90	88–90	88–90	88–90
CP	12	8	11–12	11–12	12	12–14	11–12	7–8
EE	2	4	2	4–6	2	2	2–3	2
CF	2	2	6	11	2	2	2	8–10
CA	2	2	2	2	2	2	1–2	3–4
ME, kcal/kg	3100	3300–3400	2650	2600–2700	2900–3000	2900–3000	3300–3400	2900–3000

Inclusion Levels of Cereal Grains in Livestock

Grain	Dairy Cows	Beef Cattle	Sheep / Lambs	Poultry	Horses	Remarks
Wheat	30–50% of concentrate (≈4–5 kg/day; 25–30% of DM)	≤40% of concentrate; combine with slowly fermentable grains	25% (lambs), up to 35% (ewes)	Broilers: ≤20% Layers: ≤30% (with enzyme + pigment)	500 g/100 kg BW/day	High starch → risk of acidosis; feed coarsely ground or pelleted; not too finely milled.
Maize	Excellent energy source; slow rumen starch degradation (~30% bypass)	Widely used; safe due to low acidogenic value	Suitable	Up to 60% in poultry rations	Suitable	High ME (3300–3400 kcal/kg); appropriate for all species.
Barley	≤50% of concentrate	Up to 70% (finishing period)	Highly palatable and digestible	≤20% for adult poultry (with β-glucanase enzymes)	Suitable	Rapid rumen fermentation; feed rolled or coarsely ground to prevent acidosis.
Oats	≤20% in dairy cow and calf concentrates	30–40% of concentrate	Suitable for breeding ruminants	Limited (<10%); may help reduce cannibalism	Recommended; good for performance horses	Rich in unsaturated fats → improves milk fat; excess causes soft butter.
Rye	≤40% in concentrate mixtures	≤40% in concentrate	Consumed readily (~0.5 kg/day)	Not recommended	≤15–20% in mixed feeds	Contains ergot alkaloids (ergotamine) → risk of abortion and vasoconstriction; laxative at high levels.
Triticale	Up to 30%	Up to 30%	—	30–40%	—	Higher in lysine and methionine than wheat; energy value similar to corn.
Sorghum	Can replace other grains in ruminant rations	Suitable	—	Up to 30% in chick diets (low-tannin types)	—	Should be cracked or ground; high-tannin varieties reduce palatability and digestibility.

Legume Grains



Essential amino acid content is higher than that of cereals; however, their **protein biological value** is not high.

Contain non-protein nitrogen (NPN) compounds in their structure.

Contain Antinutritional factors in their structure (ANFs)

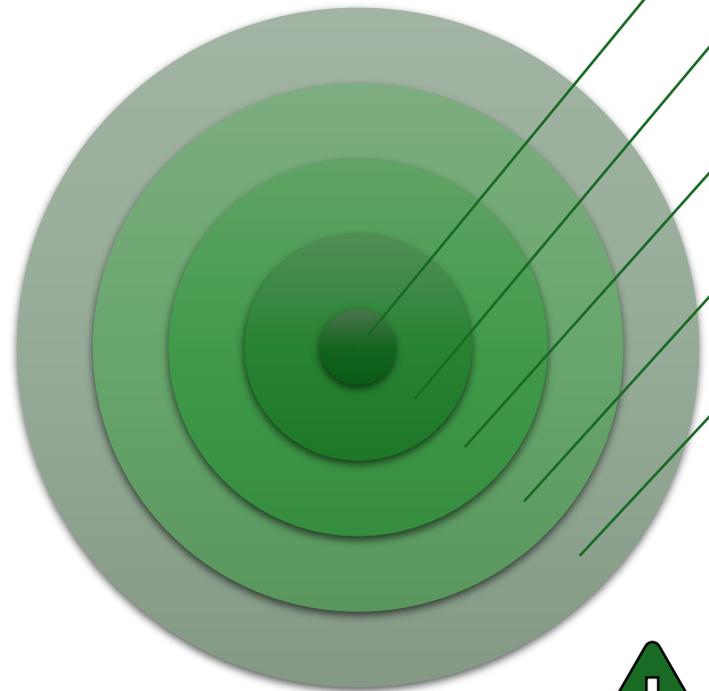
Tannins – cause slowing of intestinal motility, leading constipation

Protease inhibitors – inactive trypsin and chymotrypsin, reducing protein utilization

Cyanogenic glycosides, alkaloids, toxalbumins and lectins also present

Starch content is approximately 30-40 % on average

Legume Grains



DM %: 88 – 90

CP %: 20 – 45

EE %: 2 – 6

CF %: 4 – 8

CA %: 3-4

Deficient in some essential amino acids, especially sulfur ones, lysine ↑, cystine and methionine are ↓

Proteins of NPN (Non-Protein Nitrogen) nature contain free amino acids, purine and pyrimidine bases, nucleic acids. Soybean protein stands out in terms of quantity and quality, being close to animal-based proteins

Except soybean, it has 18 – 20 % of EE

Ca and P ↑, P is bound in the form of **Phytin**, *it cannot be utilized by monogastrics and poultry*. Phytates reduce the utilization of other minerals



The feed value of legume seed can be improved by cooking, boiling, or steaming

Faba Bean, Field Pea and Lupin



Parameter	Faba Bean (<i>Vicia faba</i>)	Field Pea (<i>Pisum sativum</i>)	Lupin (<i>Lupinus spp.</i>)
CP	22–26%	16–26%	35–45%
Key Amino Acids	Lysine ↑, Methionine ↓, Cystine ↓	Methionine ↓	Lysine ↑, Methionine ↓
ANFs	Vicine, Convicine, Tannins	Generally low ANFs	Alkaloids (especially in blue lupin)
Digestibility	Moderate	High	Moderate to high (varies by species)
Physiological / Nutritional Effects	↓ Egg production and egg size (poultry); constipation due to tannins; firm butter texture in dairy cows	High digestibility; well tolerated in ruminants and poultry	Bitter taste when alkaloid content is high; white lupin suitable for poultry
Notable Characteristics	High lysine, low sulfur amino acids; quality reduced by ANFs	Balanced energy-protein ratio; palatable	Species distinguished by flower color (white, blue, yellow); sweet and bitter cultivars; blue lupin high in alkaloids

Vetch, Bitter Vetch, Grass Pea and Chick Pea



Parameter	Vetch (<i>Vicia sativa</i> , <i>V. villosa</i> , <i>V. pannonica</i> , <i>V. grandiflora</i>)	Bitter Vetch (<i>Vicia ervilia</i>)	Grass Pea (<i>Lathyrus sativus</i>)	Chickpea (<i>Cicer arietinum</i>)
CP	25–30%	21–23%	25–32%	~16.5%
Key Nutrients	Contains choline and betaine	–	High starch content (major NFE component)	Moderate starch; good energy source
ANFs	Vicine, vicianin (cyanogenic glycosides)	High tannin content	Alkaloids, protease inhibitors, tannins, lathyrogens	Protease inhibitors
Physiological / Nutritional Effects	Excess causes colic in horses; alters milk flavor in cows	Should not be fed to horses; reduce ANFs by cracking and gradual adaptation	Excess consumption causes skeletal deformities, reproductive suppression, paralysis, and death (lathyrism)	Reduces protein digestibility and biological value
Digestibility / Palatability	Moderate; improves after heating or steaming	Moderate; increases with proper processing	Moderate to low (depends on alkaloid content)	Moderate; improved by heat treatment
Special Notes	Used as green forage or grain; cyanogenic compounds limited by cooking or steaming	Requires processing before feeding; suitable for ruminants in limited amounts	Toxicity related to lathyrogens; used cautiously in ruminant rations	Common in human and animal diets; heat treatment recommended before feeding

Soybean & Full-Fat Soybean



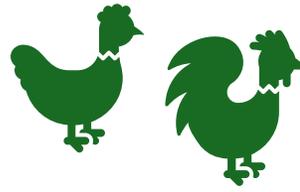
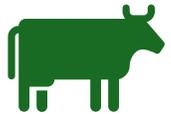
Parameter	Soybean (<i>Glycine max</i>)	Full-Fat Soybean (Heat-treated / Extruded)
CP	36–38%	36–38%
EE	18–20% (high in linoleic acid)	18–20%
CF	5–6%	5–6%
CA	~5%	~5%
Key Amino Acids	Lysine ↑, Methionine ↓	Lysine ↑, Methionine ↓
Rumen Fermentation	Raw soybean protein is rapidly degradable in the rumen	Rumen degradable protein ↓, rumen-undegradable protein digestibility ↑, metabolizable protein ↑
Digestibility	High (especially when heat-treated)	High; improved amino acid availability
ANFs	Trypsin inhibitors, goitrogenic substances, rachitism-inducing factors, urease, hemagglutinin (soy), antivitamin B ₁₂ , pancreatic hypertrophy factors	Eliminated or inactivated by extrusion and heat treatment
Processing Effects	Requires heating to inactivate ANFs	Heat and pressure remove ANFs; suitable for all livestock
Special Notes	Should not be fed raw due to ANFs; provides high-quality plant protein	Same nutrient composition as soybean; enhanced rumen bypass protein efficiency



To sum up

Component (%)	Faba Bean	Field Pea	Lupin	Vetch	Bitter Vetch	Grass Pea	Chickpea	Soybean
DM	88–90	88–90	88–90	88–90	88–90	88–90	88–90	88–90
CP	22–26	16–26	35–45	25–30	21–23	25–32	16–20	36–38
EE	1–2	1–2	5–6	1	1	1–3	4–6	18–20
CF	8	6	~	5–6	5–6	3–6	6–9	5–6
CA	4–6	2–3	4	4	3–4	2.5–4.5	2–3	5
ME, kcal/kg	2400–2500	2400–2500	~	2800	2750	~	~	~

Inclusion Levels of Legume Grains in Livestock



Feedstuff	Dairy Cows	Beef Cattle	Sheep	Horses	Poultry (Young breeders)	Poultry (Adults)
Faba bean	Up to 20% in concentrate feed	Up to 25% (produces firm meat); 15% for young calves	—	Up to 1.5–2 kg/day (risk of colic due to tannins)	2.5–10%	5–10%
Field pea	1–1.5 kg/day (≈20% of concentrate)	0.5–1 kg/100 kg BW	0.25–0.5 kg/day	—	2.5–10%	5–15%
Lupin	1.5–2 kg/day (sweet lupin)	1.5–2 kg/day (sweet lupin)	300 g/day	1.5–2 kg/day	—	Up to 10% (white lupin preferred)
Vetch	2 kg/day	—	250 g/day	—	5%	5–10%
Grass pea	Up to 10% in concentrate feeds	Up to 10%	—	—	Up to 10%	Up to 10%
Chickpea	1.5–2 kg/day	—	250 g/day	—	5–10%	Up to 20%
Soybean	1 kg/day ; up to 15–20% in concentrates	Up to 15–20% in ruminant concentrates	—	0.5 kg/day	Up to 15–20%	Up to 15–20%

Oilseeds



Oilseeds



Oil Seeds

Rich sources of energy, protein, and essential fatty acids

Contain unsaturated fatty acids (e.g., linoleic, linolenic acids)

Protein quality is generally good, with high lysine but limited methionine and cystine

May contain anti-nutritional factors (ANFs) such as trypsin inhibitors, tannins, gossypol, and glucosinolates

Heat or solvent processing is applied to deactivate ANFs and improve digestibility

Canola (*Brassica napus*, Rapeseed)



Parameter	Description
DM	90
CP	20–25
EE	43–50
CA	4
CF	8
Main Fatty Acids	High in unsaturated fatty acids – oleic, linoleic, and α -linolenic acids
Anti-Nutritional Factors	Low levels of glucosinolates and erucic acid (higher in traditional rapeseed varieties, “colza”)
Feeding Form	Can be used as full-fat or partially defatted seed
Digestibility	Energy utilization is limited because oil is encased in thick polysaccharide layers
Physical Properties	Very small seeds; cell rupture is difficult , reducing oil availability
Ruminant Effects	High fat levels may impair rumen microbial activity , decreasing feed intake and fiber digestibility

Cottonseed



Feature	Cottonseed
Usage Form	Whole or decorticated (hulled) seeds
Nutritional Value	High in energy (from oil), protein, and fiber; suitable for beef and dairy cattle
Fermentation Characteristics	Low fermentable carbohydrate → lower methane production
Feeding Recommendations	When not crushed, can be soaked in water and fed with green forages
Toxic Compound	Gossypol (toxic polyphenolic pigment)
Animal Sensitivity	Young ruminants are more sensitive to gossypol
Rumen Detoxification	Rumen microbes detoxify gossypol in adult ruminants
Critical Gossypol Level	>24 g free gossypol/day reduces milk yield in high-yielding dairy cows
Processing Effects	Heat treatment and extrusion reduce free gossypol
Feed Additives	FeSO ₄ (up to 500 g/kg DM) reduces blood gossypol
Other Limiting Factors	Contains cyclopropenoid fatty acids (malvalic and sterculic acids)
Effects in Poultry	Causes pink egg whites and increased stearic/palmitic acid deposition
Raw Cottonseed Oil	Contains 0.6–1.2% cyclopropenoid fatty acids

Whole Cottonseed vs. Decorticated Cottonseed



Feature	Whole Cottonseed	Decorticated Cottonseed
DM	90	90
CP	20	32
EE	19	31
CF	27	13
Ash	4	5
ADF	35	18
Lignin	10	6
Rumen Degradability of Nitrogen	>70	—
Major Fatty Acids	Linoleic, Oleic, Palmitic ↑	Palmitic acid ↑ (higher than other oilseeds)
Cyclopropenoid Fatty Acids	—	CPE 18:1 (Malvalic), CPE 19:1 (Sterculic)

Sunflower Seed



Feature	Sunflower Seed
DM	90
CP	16–20
CF	16–20
EE	42–50
Ash	3–4
Major Fatty Acids	Oleic and Linoleic acids ↑
Energy Value	High-energy feed ingredient
Processing Effect	Dehulling reduces fiber and increases nutritive value
Milk Fatty Acid Profile	Increases polyunsaturated fatty acids, especially conjugated linoleic acid (CLA) and omega-6 fatty acids
Feeding Limitation	Excessive inclusion may reduce feed intake and milk yield due to high fat content

Linseed (Flaxseed)



Feature	Linseed (Flaxseed)
DM	90
CP	20–28
CF	10
EE	31–43
CA	4
Major Fatty Acids	High in unsaturated fatty acids; rich in α -linolenic acid (ALA, omega-3; 45–60%) and conjugated linoleic acid (CLA)
ME	Ruminants: 4300 kcal/kg DM; Poultry: 3800 kcal/kg DM
Physiological Effects	Mild laxative effect; improves skin and hair quality
Bioactive Compounds	Contains lignans (phytoestrogenic and anticarcinogenic properties)
Antinutritional Factors	Linamarin (cyanogenic glucoside), Linatine (vitamin B6 antagonist), phytic acid, and goitrogenic substances
Other Characteristics	Contains 2–7% water-soluble carbohydrates (mucilage), which increase intestinal viscosity and contribute to the laxative effect

Camelina (Camelina sativa)



Feature	Camelina (False Flax)
Cultivation Type	Grown as both spring and winter crop; low production cost; short vegetation period (60–90 days)
Adaptation	Highly resistant to many pests and diseases; well adapted to cold and semi-arid climates
EE	40–45
CP	19–22
Major Fatty Acids	High content of essential fatty acids, particularly omega-3 and α -linolenic acid
Erucic Acid	2–5% (below the safety threshold of 5% for edible oils); low-erucic-acid varieties have been developed through breeding
Antinutritional Factors	Contains glucosinolates; safe inclusion levels for monogastric animals ≤ 1.5 mmol/kg diet
Other Notes	Promising oilseed with high yield potential and strong environmental adaptability



To sum up

Component (%)	Canola (Rapeseed)	Cottonseed (Whole)	Cottonseed (Dehulled)	Sunflower Seed	Linseed (Flaxseed)	Camelina Seed
DM	90	90	90	90	90	90
CP	20–25	20	32	16–20	20–28	19–20
EE	43–50	19	31	45–50	31–43	42–45
CF	8	27	13	16–20	10	10–12
CA	4	4	5	3–4	4	4–4.5
ME (kcal/kg)	~	2870	~	~	3800	~

Inclusion Levels of Oilseeds in Livestock

Animal	Canola (Rapeseed)	Whole Cottonseed	Dehulled Cottonseed	Sunflower Seed	Linseed (Flaxseed)
Dairy Cows	Up to 5% of total diet	≤ 6% of dietary DM	1 kg/head/day or 10–15% of DM	Up to 8% (increases milk CLA, omega-6)	Up to 10% (increases omega-3 and CLA)
Beef Cattle	–	≤ 6% of dietary DM	1 kg/head/day	Up to 15% (replacing barley, improves feed efficiency)	Up to 10%
Sheep / Goats	–	300 g/head/day	300 g/head/day	Up to 10%	Up to 10%
Poultry (Broilers)	Up to 10%	–	–	Up to 20%	Up to 10%
Poultry (Layers)	Up to 10%	–	–	Up to 10% (increases yolk PUFA)	Up to 10%
General Notes	Low glucosinolate and erucic acid varieties preferred	High in energy and fiber; gossypol limits use	High protein and fat; lower fiber	Improves CLA, omega-6 and energy efficiency	High omega-3 (ALA); excessive levels reduce performance

Thank you for your attention!