Protein

Table 3–1 Protein Content of Some Selected Foods

Product	*Protein (g/100 g)*
Meat: beef	16.5
pork	10.2
Chicken (light meat)	23.4
Fish: haddock	18.3
cod	17.6
Milk	3.6
Egg	12.9
Wheat	13.3
Bread	8.7
Soybeans: dry, raw	34.1
cooked	11.0
Peas	6.3
Beans: dry, raw	22.3
cooked	7.8
Rice: white, raw	6.7
cooked	2.0
Cassava	1.6
Potato	2.0
Corn	10.0

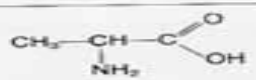
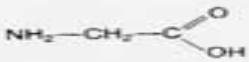
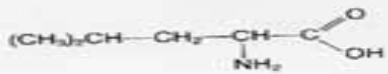
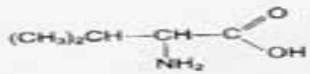
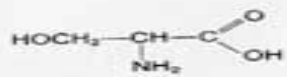
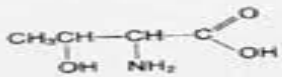
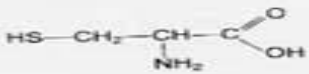
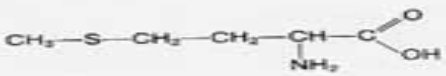
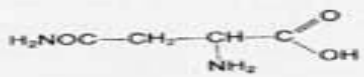
Dietary essential amino acids

- histidine
- isoleucine
- leucine
- lysine
- methionine/cystine
- phenylalanine
- tyrosine
- threonine
- tryptophan
- valine

Amino acid content in select foods

Amino Acid	*Meat (Beef)*	*Milk*	*Egg*	*Wheat*	*Peas*	*Corn*
Isoleucine	301	399	393	204	267	230
Leucine	507	782	551	417	425	783
Lysine	556	450	436	179	470	167
Methionine	169	156	210	94	57	120
Cystine	80	—	152	159	70	97
Phenylalanine	275	434	358	282	287	305
Tyrosine	225	396	260	187	171	239
Threonine	287	278	320	183	254	225
Valine	313	463	428	276	294	303
Arginine	395	160	381	288	595	262
Histidine	213	214	152	143	143	170
Alanine	365	255	370	226	255	471
Aspartic acid	562	424	601	308	685	392
Glutamic acid	955	1151	796	1866	1009	1184
Glycine	304	144	207	245	253	231
Proline	236	514	260	621	244	559
Serine	252	342	478	281	271	311

Table 13.1 Amino Acids in Foods

Name	Formula	Isoelectric Point	Type
Alanine		6.0	Neutral—aliphatic
Glycine		6.0	Neutral—aliphatic
Isoleucine*		6.0	Neutral—aliphatic
Leucine*		6.0	Neutral—aliphatic
Valine*		6.0	Neutral—aliphatic
Serine		5.7	Neutral—hydroxy
Threonine*		6.2	Neutral—hydroxy
Cysteine		5.1	Neutral—sulfur-containin
Cystine		4.6	Neutral—sulfur-containi
Methionine*		5.7	Neutral—sulfur-contain
Asparagine		5.4	Neutral—amide
Glutamine		5.7	Neutral—amide

(conti

Table 3–3 Limiting Essential Amino Acids of Some Grain Proteins

Grain	*First Limiting Amino Acid*	*Second Limiting Amino Acid*
Wheat	Lysine	Threonine
Corn	Lysine	Tryptophan
Rice	Lysine	Threonine
Sorghum	Lysine	Threonine
Millet	Lysine	Threonine

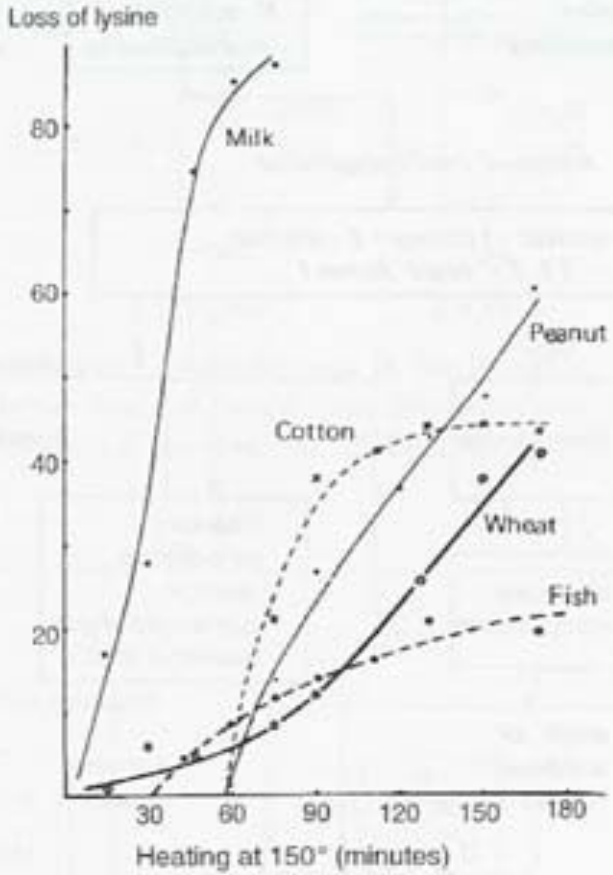
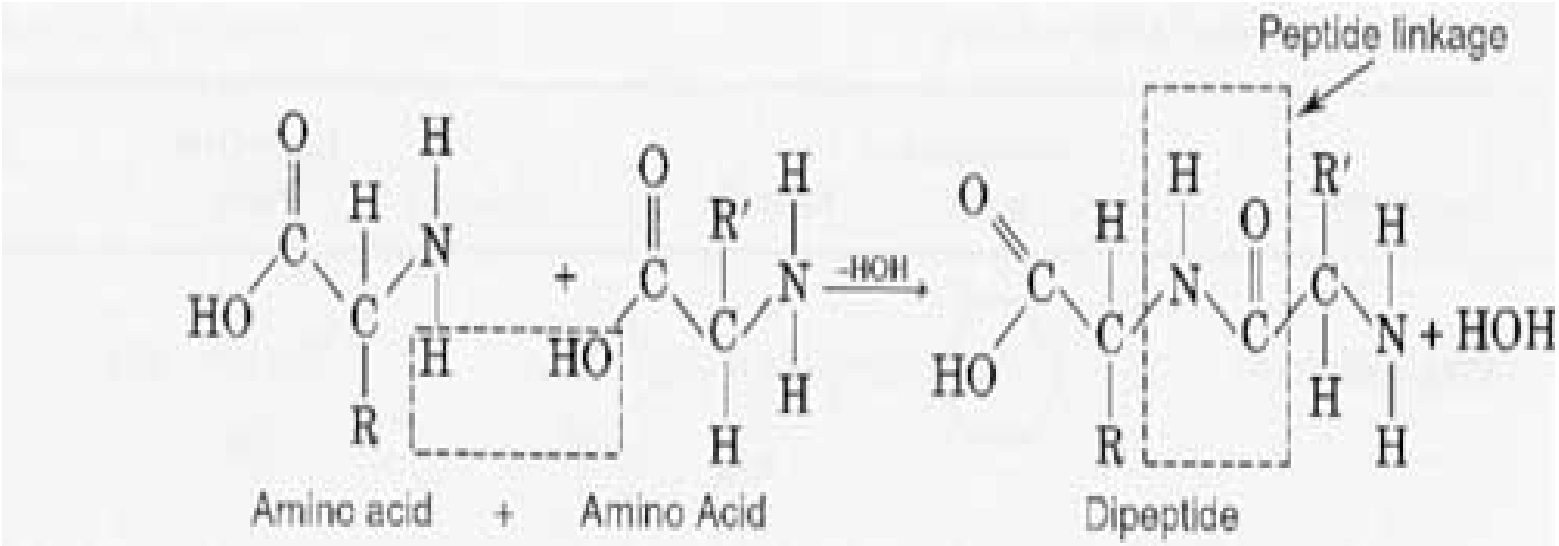
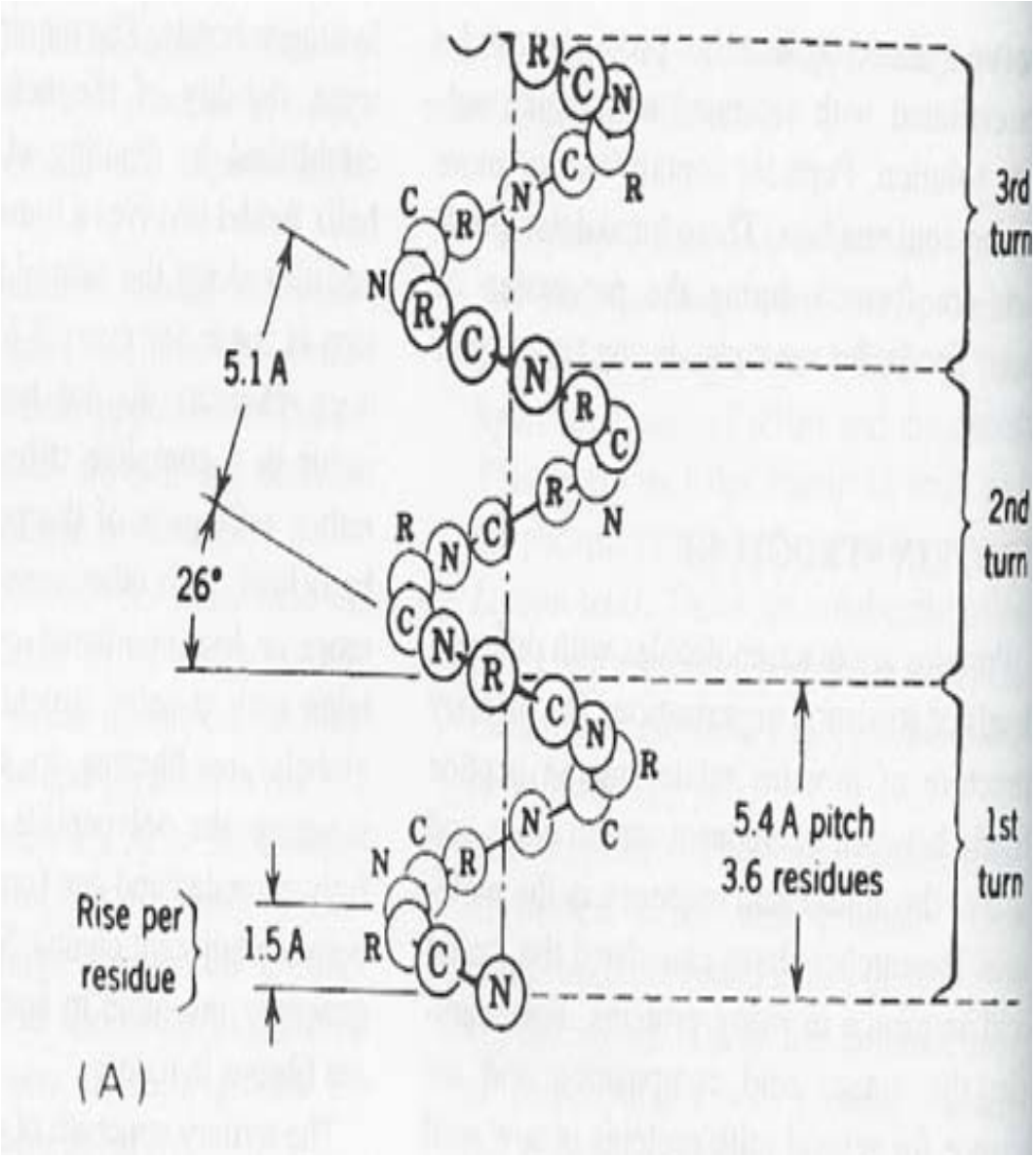
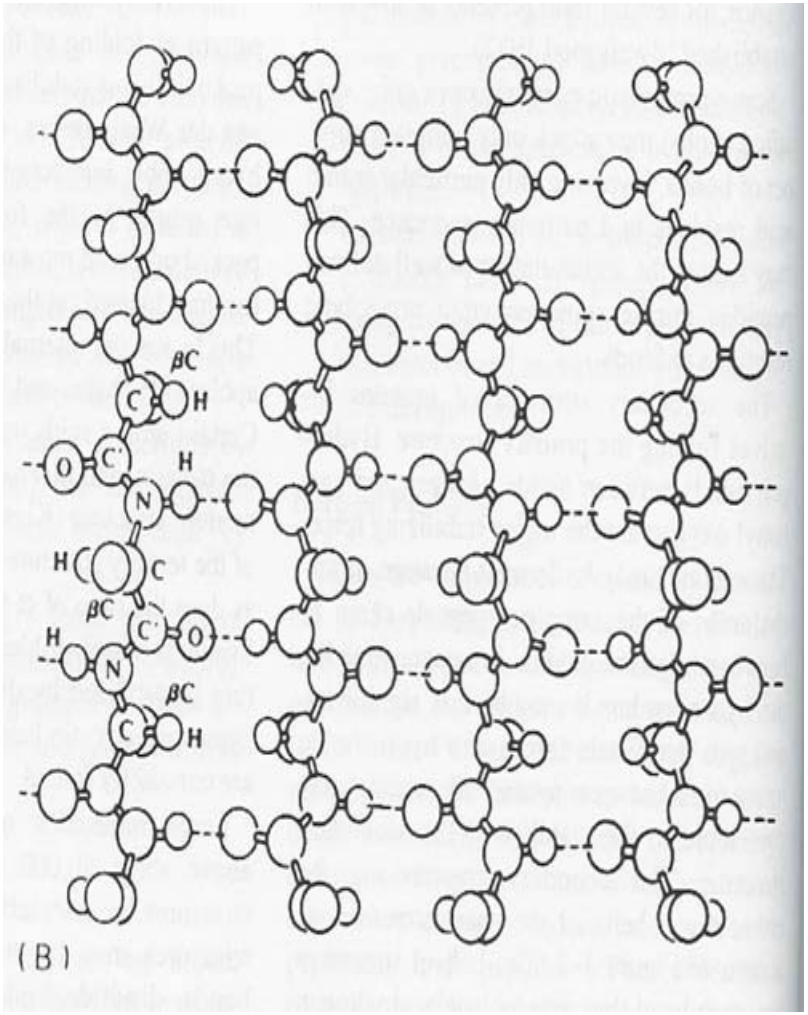


Figure 3–6 Loss of Lysine Occurring as a Result of Heating of Several Foods. *Source*: From J. Adrian, The Maillard Reaction. IV. Study on the Behavior of Some Amino Acids During Roasting of Proteinaceous Foods, *Ann. Nutr. Aliment.* (French), Vol. 21, pp. 129–147, 1967.


Peptide linkage
-HOH
+ HOH
Amino acid + Amino Acid
Dipeptide


3rd turn
2nd turn
1st turn
5.1 A
26°
5.4 A pitch
3.6 residues
Rise per residue
1.5 A
(A)



(B)

Table 3–5 Oligomeric Food Proteins

Protein	*Molecular Weight (d)*	*Subunits*
Lactoglobulin	35,000	2
Hemoglobin	64,500	4
Avidin	68,300	4
Lipoxygenase	108,000	2
Tyrosinase	128,000	4
Lactate dehydrogenase	140,000	4
7S soy protein	200,000	9
Invertase	210,000	4
Catalase	232,000	4
Collagen	300,000	3
11S soy protein	350,000	12
Legumin	360,000	6
Myosin	475,000	6

Table 3–4 Bond Energies of the Bonds Involved in Protein Structure

Bond	*Bond Energy* (kcal/mole)*
Covalent C-C	83
Covalent S-S	50
Hydrogen bond	3–7
Ionic electrostatic bond	3–7
Hydrophobic bond	3–5
Van der Waals bond	1–2

*These refer to free energy required to break the bonds: in the case of a hydrophobic bond, the free energy required to unfold a nonpolar side chain from the interior of the molecule into the aqueous medium.

Table 3–12 Functional Properties of Food Proteins

General Property	*Functional Criteria*
Organoleptic	Color, flavor, odor
Kinesthetic	Texture, mouth feel, smoothness, grittiness, turbidity
Hydration	Solubility, wettability, water absorption, swelling, thickening, gelling, syneresis, viscosity
Surface	Emulsification, foaming (aeration, whipping), film formation
Binding	Lipid-binding, flavor-binding
Structural	Elasticity, cohesiveness, chewiness, adhesion, network cross-binding, aggregation, dough formation, texturizability, fiber formation, extrudability
Rheological	Viscosity, gelation
Enzymatic	Coagulation (rennet), tenderization (papain), mellowing ("proteinases")
"Blendability"	Complementarity (wheat-soy, gluten-casein)
Antioxidant	Off-flavor prevention (fluid emulsions)

Source: From J.E. Kinsella, Structure and Functional Properties of Food Proteins, in *Food Proteins*, P.F. Fox an J.J. Condon, eds., 1982, Applied Science Publishers.

Table 3–13 Functional Properties of Proteins in Food Systems

Functional Property	*Mode of Action*	*Food System*
Solubility	Protein solvation	Beverages
Water absorption and binding	Hydrogen bonding of water; entrapment of water (no drip)	Meat, sausages, bread, cakes
Viscosity	Thickening; water binding	Soups, gravies
Gelation	Protein acts as adhesive material	Meat, sausages, baked goods, pasta products
Elasticity	Hydrophobic bonding in gluten; disulfide links in gels	Meats, bakery products
Emulsification	Formation and stabilization of fat emulsion	Sausages, bologna, soup, cakes
Fat absorption	Binding of free fat	Meats, sausages, doughnuts
Flavor-binding	Adsorption, entrapment, release	Simulated meats, bakery products, etc.
Foaming	Forms stable films to entrap gas	Whipped toppings, chiffon, desserts, angel cakes

Source: From J.E. Kinsella, Structure and Functional Properties of Food Proteins, in *Food Proteins*, P.F. Fox and J.J. Condon, eds., 1982, Applied Science Publishers.

Properties affecting functionality

- **Amphoteric –** act like either an acid or base. Resist small changes in pH
- **Isoelectric point –** pH at which overall charge is 0. Precipitate out. Molecules that repel each other (carry like charge) and form stable dispersion in water. Dairy product (lactic acid/cottage cheese, curd)

Properties affecting functionality

- **Water binding capacity-**closer to IEP less ability to bind water. Water maintains stability of protein dispersion
- **Salting in** –solubilize protein in dilute salt (myofibrillar proteins). Charged groups bind cations/anions stronger than water, then form hydration layer
- **Salting out** – high salt concentrations – precipitate proteins. Problem with increased solute concentration during freezing

Table 3–14 Contribution of Hydrophobicity, Charge Frequency, and Structural Parameters to Functionality of Proteins

	Hydrophobicity	*Charge frequency*	*Structure*
Solubility	–	+	–
Emulsification	+sur	(–)	+
Foaming	+tot	–	+
Fat binding	+sur	(–)	–
Water holding	–	+	?
Heat coagulation	+tot	–	+
Dough making	(+)	–	+

+: positive contribution; –: negative contribution; sur: surface hydrophobicity; tot: total hydrophobicity; ( ): contributes to a lesser extent.

Source: Reprinted with permission from S. Nakai and W.D. Powrie, Modification of Proteins for Functional and Nutritional Improvements, *Cereals—Renewable Resource, Theory and Practice*, Y. Pomeranz and L. Munck, eds., p. 235, © 1981, American Association of Cereal Chemists.

Properties affecting functionality

- **Denaturation** – change in secondary, tertiary or quaternary structure.
- Heat, pH, ionic strength change, freezing, surface changes (mechanical – foam, dough formation)
- Break hydrogen bonds and salt bridges. Protein unfolds, expose ‘buried’ side chains

Properties affecting functionality

- **Amphiphilic-** have hydrophobic and hydrophilic sections. Emulsifiers (casein) and foaming agents (albumin).
- **Gel forming abilities** – heat set (gelatin, albumin, whey)
- Gelatin – heat set, thermoreversible, H bonded
- Egg white – disulfide linkages and hydrophobic interactions
- Gluten- disulfide linkages
- Casein – ionic, hydrophobic and hydrophilic