Amino acids, peptides, protein

Amino acids have:

- functional groups: NH2 COOH
- units: amino acids linked by a peptide bond

Peptides:

- 2-100 amino acids

Proteins:

- > 100 amino acids

Amino acids

Amino acids are the basic building blocks of proteins. Chemically, they are organic compounds connected to each other by a peptide bond. At least one primary amino group –NH 2 and at the same time at least one carboxyl group –COOH must be present in the amino acid. Chemically, they have substituted derivatives of carboxylic acids.

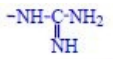
- 2–100 amino acids (monomers) – peptides
- 100 or more amino acids - proteins

More than 700 different AMKs have been demonstrated in nature. That is why we also divide AMK according to their occurrence:

- amino acids found in all living organisms
  - bound in proteins (21 proteinogenic AMK), peptides or as free AMK
- amino acids found only in some organisms
  - bound in peptides or as free AMK
  - they are not components of proteins

Proteinogenic amino acids, or coded ones, occur in proteins as L-alpha-amino acids (the exception is glycine). This is due to the chemical arrangement that is necessary for biogenic function. Specific types of amino acids, their sequence and spatial structure then give proteins their biological properties.

Structure

- amino group (-NH 2, free, substituted)
- carboxyl group (-COOH)
- other functional groups
  - hydroxyl -OH
  - sulfhydryl (mercapto group) -SH
  - sulphide -SR
  - guanidyl ()
  - phenyl etc. ()

Classification

- according to the structure of the side chain and functional groups
- according to side chain polarity
  - polar
  - non-polar
- according to importance in human nutrition
  - essential = the human organism is unable to create them endogenously
    - valine, leucine, isoleucine, phenylalanine, lysine, methionine, tryptophan, threonine
  - conditionally essential = essential in the absence of precursors or immaturity of enzymatic systems
    - arginine, histidine
  - completely non-essential
    - glycine, alanine, serine, cysteine, aspartic acid and asparagine, glutamic acid and glutamine, selenocysteine, tysorine, proline

Classification
▪ 19 α-amino acid with a primary amino group (-NH 2)

- 1 α-amino acid with a secondary amino group (-NH-)

n=0, pyrrolidine

- 18 amino acids = chiral compounds of the L series
  - trivial names, systematic names, symbols (three-letter, one-letter)

Classification of basic amino acids

By side chain structure and functional groups

- aliphatic with an unsubstituted chain
  - glycine , alanine , valine , leucine , isoleucine
- aliphatic hydroxyamino acids
  - serine , threonine
- aliphatic sulfur
  - cysteine , methionine
- with a carboxyl group in the side chain (monoaminodicarboxylic, acidic)
  - aspartic acid , glutamic acid
- their monoamides (with a carboxamide group in the side chain)
  - asparagine , glutamine
- with basic groups in the side chain
  - amino group
  - guanidyl group
  - imidazoyl cycle
  - lysine , arginine , histidine
- with an aromatic (heterocyclic) side chain
  - phenylalanine , tyrosine , tryptophan , proline

According to the polarity of the side chain and its ionic form (in a neutral environment)

- non-polar, hydrophobic
  - Val, Leu, Ile, Phe, Tyr, Met, Pro;
  - sometimes Gly, Ala, Trp (amphiphilic)
- polar, hydrophilic
  - Ser, Thr, Cys, Asp, Glu, Asn, Gln, Lys, Arg, His
  - Hydrophilic (according to the ionic form of the side chain in a neutral environment)
    - neutral (has no electrical charge): most
    - acidic (negative charge): Asp, Glu
    - basic (positive charge): Lys, Arg, His

Representatives

Derivatives of basic proteinogenic amino acids

- the emergence of specific modifications
  - L-cystine (CySSCy)
  - 4-hydroxy-L-proline (Hyp)
  - 5-hydroxy-L-lysine (Hyl)
  - 3-methyl-L-histidine
  - O-phospho-L-serine

Other non-protein amino acids

N-substituted α-amino acids

- N-methylglycine (sarcosine), N,N-dimethylglycine, N,N,N-trimethylglycine
- L-carnitine (3-hydroxy-4-trimethylaminobutyrate, vitamin Bt)
- ß-alanine (3-aminopropionic acid), γ-aminobutyric (4-aminobutyric) acid (GABA)

Sulfur amino acids

- S-alk(en)yl-L-cysteines, S-alk(en)yl-L-cysteine sulfoxides

Basic amino acids and related compounds

- L-ornithine (n = 2)
- L-citrulline (n = 2, carbamoyl derivative of ornithine)
- creatine phosphate

Aromatic amino acids

- tetraiodothyronine (thyroxine), R = R1 = R2 = R3 = I
- 3,4-dihydroxy-L-phenylalanine (DOPA)

Essential amino acids

foods deficient in certain amino acids

- Lys - cereals (plant proteins in general)
- Met - milk, meat
- Thr − wheat, rye
- Trp - casein, corn, rice

Physico-chemical properties

Physico-chemical properties

- acid-base (pK and pI)
- optical
- sensory

Acid-base properties (Gly)

ion I 1 (cation)	ion I 2 (amphion)	ion I 3 (anion)
free charge +1	free charge 0	free charge -1
pH < 2	pH ≈ 6	pH > 10

Dependence of the ionic forms of Gly on pH

cation (I 1) → amphion (I 2) → anion (I 3)

Optical properties

- Gly = exception
- majority = chiral atom C α... 2 optical isomers (enantiomers)
- some 2 chiral centers... Ile, Thr, Hyp, CySSCy

L- and D-amino acids, L-amino acids = (S)-stereoisomers, *exception* : L-cysteine = (R)-stereoisomer

D-amino acids = (R)-stereoisomers

Content

- L-amino acid ie: (S) -amino acid
- D-amino acid ie: (R) -amino acid

Diastereoisomers of amino acids

- L-isoleucine (2S, 3S)-isoleucine
- D-isoleucine (2R, 3R)-isoleucine
- L-allo-isoleucine (2S, 3R)-isoleucine
- D-allo-isoleucine (2R, 3S)-isoleucine

Organoleptic properties

- sweet - Gly, Ala, Thr, Pro
- acidic - Asp, Glu
- bitter - Leu, Ile, Phe, Tyr, Trp
- indifferent - others

Unique properties = umami taste

- sodium hydrogen glutamate

Peptides

Structure

- condensation (amino acids -› peptides)

- binding of some amino acids in an unusual way (Glu distal group COOH = γ-peptide bond)
- bound D-amino acids
- unusual amino acids bound
  - ß-alanine (3-aminopropionic), α-aminobutyric (2-aminobutyric), γ-aminobutyric (4-aminobutyric), taurine , 2-aminoacrylic (dehydroalanine), (E)-2-aminocrotonic (dehydrobutyrin), pyroglutamic

Classification

Number of bound monomers (amino acids)

- oligopeptides (2–10 amino acids)
- polypeptides (formerly macropeptides, 11–100 amino acids)

String type

- linear
- cyclical

type of bonds

- homodet (peptide bonds only)
- heterodet (peptide and other bonds)
  - disulfide -SS-, ester (depsipeptides) -CO-OR

Bound folders

- homeomeric containing only amino acids
- heteromeric (peptoids) containing also other compounds
  - nucleopeptides - phosphopeptides
  - lipopeptides – chromopeptides
  - glycopeptides – metallopeptides

Occurrence

- products of metabolism, natural peptides
- products of proteolysis, enzymatic or non-enzymatic hydrolysis
- synthetic peptides, substitute sweeteners

Properties

- biological activity
- sensory properties
- products of metabolism of lactic acid bacteria = bacteriocins
- nisin (Streptococcus cremoris, syn. Lactococcus lactis ssp. Lactis)
- preservative, stabilization of fermented products

Significant peptides

Glutathione

(G-SH or GSSG) γ-L-glutamyl-L-cysteinylglycine (γ-amide bond)

Occurrence

- microorganisms, plants, animals
  - wheat flour (10-15 mg/kg)
  - meat (300-1500 mg/kg)

Function

- detoxification of toxic forms of oxygen
- transport (transfer) of amino acids into cells
- metabolic processes (leukotriene biosynthesis)
- stabilization of the oxidation state of SH-proteins (substrate of peroxidase, glutathione reductase)
- technology

Chorleywood method of making white bread, ascorbic acid

- H 2 A + ½ O 2 → A + H 2 O (ascorbate)
- A + 2 G-SH → H 2 A + GSSG (glutathione dehydrogenase)
- GSSG – without influence on the rheological properties of the dough
- G-SH – negative influence (gluten protein depolymerization)
- PSSP + G-SH → PSSG + P-SH

β-alanylhistidine dipeptides

- carnosine , anserine , balenin

Occurrence

- in meat

Function

- participation in skeletal muscle contraction
- buffering capacity of the muscle
- organoleptic properties

Proteolysis products

- spontaneous proteolysis (autolysis)
  - desired maturation of meat (consistency, aroma), production of yeast autolysates (additives)
  - undesirable
- intentional proteolysis
  - cheese production (desired consistency, aroma)
  - production of malt (stabilization of beer foam)
  - production of protein hydrolysates
    - enzymatic:
      - soy sauce
      - hydrolysates of waste proteins (blood, whey, caseins)
    - sour: soup spices, etc. preparations

Bitter peptides of enzyme hydrolysates and foods

- hydrophobic amino acids: Val, Leu, Ile, Phe, Tyr, Trp (M < 6000 Da)

Synthetic peptides

- substitute sweetener Aspartame (Asp-Phe)

Proteins

Proteins, or polypeptides, are organic macromolecular substances. Their molecular weight exceeds 10,000. They consist of more than 100 amino acids. A typical protein contains 200-300 of them.

Building

peptide bond The amino acids in a peptide are linked to each other by a peptide bond. A peptide bond connects the amino group of one amino acid and the carboxyl group of another amino acid by a simple covalent bond. The value of the Gibbson energy of this reaction is equal to G = 10 kJ/mol.

Polycondensation creates an arbitrarily long chain of amino acids. The end of the chain that has a free (unreacted) amino group is called the N-terminus. On the opposite side of the chain we find a free carboxyl group. This end is called the C-end.

Structure

The structure of proteins is based on the arrangement of amino acids in the chain. The structure of proteins is very important for their function.

Primary structure

The primary structure is defined by the exact order of the amino acids in the chain.

Secondary structureα-helix

β-folded sheet

By secondary structure we mean the spatial arrangement of amino acids in the chain and stabilization by hydrogen bridges.

There are two basic secondary structures:

1. α-helix: The chain is twisted into a right-handed helix. The length of one turn of the helix is equal to 3.6 amino acid residues. The α-helix structure can be found mainly in fibrous proteins (keratins) or muscle proteins.
2. β-folded sheet: Two parallel and antiparallel arranged chains resembling a folded sheet of paper.

Tertiary structure

Tertiary structure is characterized by additional intramolecular bonding interactions. For example, disulfide bonds, ionic bonds and van der Waals forces. Additional H-bonds can also form in the molecule.

Quaternary structure

Quaternary structure occurs in proteins that consist of two or more polypeptide chains. Their connection is ensured by mutual extramolecular bonding interactions. Quaternary structure can be found, for example, in hemoglobin. Conversely, myoglobin does not have a quaternary structure.

Denaturation of proteins

Protein denaturation is a process where the secondary and tertiary structure changes. The protein thus loses its biological activity. Denaturation can be achieved, for example, by heating or changing the pH.

Major nutrients

- peptide bonds
- other bonds
  - disulfide -SS-
  - ester
  - amides
- components other than amino acids (physically or chemically)
  - water
  - inorganic ions
  - lipids, sugars, nucleic acids, colored compounds

Classification

Division

By origin

- animal (meat, milk, eggs) − 60% of food proteins
- vegetable (cereals, legumes, fruits, vegetables) − 30% of food proteins
- unconventional (algae, microorganisms)

By function

- structural (building components of cells, collagen)
- catalytic (enzymes, hormones)
- transport (transfer of compounds, myoglobin)
- movement (muscle proteins, actin, myosin)
- defensive (antibodies, immunoglobulins, lectins)
- storage (ferritin)
- sensory (rhodopsin)
- regulatory (histones, hormones)
- nutritional (source of essential amino acids, source of nitrogen, materials for building and restoring tissues)

By structure

(the presence of a non-protein component)

1. Simple proteins (contain only a protein chain - globular, fibrillar proteins)

- globular, spheroproteins (albumins, globulins)
- fibrillar (fibrous), scleroproteins, stromal proteins (collagens, keratins, elastins)

1. Complex proteins (contain a protein chain and a non-protein part – a prosthetic group – lipoproteins, glycoproteins)

- nucleoproteins (nucleic acids)
- lipoproteins (neutral lipids, phospholipids, sterols)
- glycoproteins (carbohydrates)
- phosphoproteins (phosphoric acid)
- chromoproteins (derivatives of porphyrin, flavin)
- metalloproteins (coordinatively bound metals)

According to solubility

Soluble

- albumins − milk (*lactalbumin*), egg white (*ovalbumin, conalbumin*), wheat (*leucosin*)
- globulins - meat (*myosin, actin*), milk (*lactoglobulin*), egg (*ovoglobulin*)
- gliadins or prolamins − wheat (*gliadin*), barley (*hordein*), corn (*zein*)
- glutelins − wheat (*glutenin*), rice (*oryzenin*)
- protamines - fish milk (*cyprimin, salmin, clupein, scombrin*)
- histones - blood (*hemoglobin and myoglobin globins*)

Insoluble

- collagen, elastin, keratin

According to the status

- native (natural, biological functions)
- denatured
- modified (modified, additives)

Nutritional aspect

- complete (essential amino acids in optimal amounts)
  - egg and milk
- almost complete (some essential amino acids deficient)
  - animal muscle
- incomplete (some essential amino acids deficient)
  - all plant and animal connective tissues

Foods deficient in some amino acids

- Lysine - Cereals (generally plant proteins)
- Methionine - milk, meat
- Threonine − wheat, rye
- Tryptophan - casein, corn, rice

Content in food

- 0-100% P (in dry matter)
- animal food > plant food
- legumes, oilseeds > fruits, vegetables

  eggs - 75% H 2 O, 13% P (whole), 52% P dry matter
  legumes – 12% H 2 O, 24% P (soy 32-45%), 27% in dry matter
  meat (H) – 69% H 2 O, 21% P, 68% in dry matter
  bread - 38% H 2 O, 7% P, 11% in dry matter
  milk - (3.5% L) 87-90% H 2 O, 3.4% P, 28% dry matter
  potatoes - 78% H 2 O, 2% P, 9% in dry matter

Coverage of energy needs: ~ 10% Recommended daily dose : 1-1.2 g/kg
Nutrient ratio

- proteins : lipids : carbohydrates (weight = 1 : 1 : 4)
- energy = < 14 : < 14 : <56%

Physiology and nutrition

- minimum need for complete protein 0.5-0.6 g·kg -1
- recommended dose 1.0-1.2 g·kg -1 (not used optimally)

  ~ 2.4 g·kg -1 growth period, lactating women, convalescents etc.

- nutritional value (nutritional, biological)
- total income

Availability of peptide bonds to digestive enzymes

Other factors

Previously

- BV (Biological Value) (= g P formed in the organism / 100 g P in food)
- NPU (Net Protein Utilization)
- PER (Protein Efficiency Ratio) etc. (animals)

Depends on the:

- absolute content of essential amino acids
- relative ratio

- ratio to non-essential amino acids
- digestibility

Today

- amino acid score AAS (Amino Acid Score)
- essential amino acid index EAAI (Essential Amino Acid Index) − more accurate data

  AAS (%) = 100 A i /A si

where:

- A i = essential amino acid content in the protein
- A si = content of the same amino acid in the standard (reference) protein

Standard protein = fictitious protein with an optimal composition of essential amino acids (AAS = 100%)

Physico-chemical properties

- solubility, hydration and swelling
- dissociation
- optical activity
- formation of gels
- formation of emulsions
- foam stabilization
- denaturation
  - physical factors - changes in temperature, pressure, ultrasound, penetrating electromagnetic radiation
  - chemical factors - salts, pH changes (acids, bases), surfactants
- consequences
  - more accessible to the digestive enzymes of the digestive tract
  - denaturation of antinutritional factors, toxic substances (protease inhibitors, amylases, lectins)
  - inhibition of unwanted enzymes and microorganisms

Meat, meat products, poultry, fish

Meat, meat products, poultry, fish

4 main tissue types (additional blood)

- epithelial
- supporting (binder)
- muscular (striated, smooth)
- nervous

Definition

Parts of warm-blooded animals in a fresh, processed state
In a narrow sense: skeletal muscle tissue - number of muscles, attachments to bones, blood supply, nerves, skin, cartilage, bones, fat

Other folders

- vitamins
- free amino acids 0.1–0.3%

  taurine (0.02-0.1%), component of bile acids, transmission of nerve impulses

- quaternary ammonium compounds

  choline 0.02-0.06%, phospholipids, transmethylation reaction, acetylcholine, sinapine
  carnitine 0.05-0.2%, transport of fatty acids

- guanidine compounds
- glycogen
- sugar phosphates and free sugars
- lactic acid and other acids
- purines and pyrimidines

Use for food and non-food purposes.

Myofibrillar proteins

- muscle fiber
- myofibrils (contractile fibers)
- microfilaments
  - myosin
  - actin
  - other proteins

In vivo response

For more detailed information, see Excitation-Contraction Coupling.

Post mortem reaction

- ATP by anaerobic glycolysis from glycogen
- lactic acid › pH drop from 6.8 to < 5.8
- inhibition of glycolytic enzymes
- Ca2+ / reaction of actin with myosin, no ATP › rigor mortis

Effect on meat quality

Aging of meat

- cleavage of actomyosin by endogenous proteases (mainly cathepsins)
- cleavage of collagen by collagenases

Flesh defects

- DFD (dry-firm-dark) and DCB (dry-cutting-beef)
  - dark, high strength, low retention
  - removal of lactic acid during bleeding, pH~ 6
- PSE (pale-soft-exudative)
  - light, low viscosity, gray-green surface
  - increased glycolysis stimulated by hormones, pH~ 5.6

Processing changes

- ~35° C association of sarcoplasmic proteins, decrease in viscosity, increase in stiffness
- ~45° C visible changes, shortening = denaturation of myosin
- ~50-55° C denaturation of actomyosin
- ~55-65° C denaturation of sarcoplasmic proteins, associated structures and gel
- ~60-65° C collagen conformation changes (1/3-1/4 shortening)
- ~80° C oxidation of SH-groups
- ~90° C gelatinization of collagen (release of tropocollagen fibers, gelatin salt)
- ~100 ° C elimination of NH 3, H 2 S, other substances, aromatic substances, color change

Milk and milk products

- Nutrient content of milk
- Water according to the type of milk (origin) 63 - 88%

Complicated dispersion system

- globular whey proteins − colloidal dispersion
- casein molecules − micellar dispersion
- fat − fat globules (microsomes, φ 0.1-10 µm): emulsion
- lipoprotein particles − colloidal suspension
- low molecular weight substances (lactose, amino acids, minerals, hydrophilic vitamins) - the right solution

Coloring

Protein composition of cow's milk

- Protein composition of cow's milk

Amino acid content of milk

- casein
  - α-caseins = phosphoproteins, α S1, α S2, phosphoserine

- ß-caseins = phosphoproteins
- γ-caseins = degradation products of ß-caseins
- κ-caseins = glycoproteins (2 genetic variants, B), sugar = tetra-, tri-, di-, mono-, GalNAc, Gal,

NeuAc, binding to Thr (133)

- caseins − αS-, ß-, κ-caseins aggregation into submicelles and micelles, casein molecules › submicelle › micelle

Changes in storage and processing

Heat treatment

- aggregation of fat globules in raw milk, ~ macroglobulin
- thermolabile whey proteins denature, caseins practically do not denature

Pasteurization

- 72-74 °C (20-40 s): denatures about 50-90% of serum proteins
- > 75 °C:
  - most enzymes are inactivated
  - reduction of disulfide bonds
  - elimination of H 2 S (ß-lactoglobulin)
  - sulfides, disulfides cooking flavor (Met)
  - degradation of thiamine
  - formation of lactones and methyl ketones
- sterilization 140 °C (4 s)
  - denatures 100% of proteins
  - reaction of lactose with whey proteins
  - loss of lysine (Maillard reaction), aromatic substances - raw and pasteurized milk ~ 400 aromatic substances (1-100 mg/kg)

Precipitation and proteolysis of caseins

- fresh milk − pH 6.5-6.75
- precipitation of caseins − pH 4.6 (contaminating, cultural microbes)

Hard cheeses

- microorganisms (lactic acid), acidification (pH 5.5)
- proteolytic enzyme rennin (chymosin, rennet), specific hydrolysis of κ-casein − para-κ-casein = hydrophobic part, part of micelles, κ-casein macropeptide = hydrophilic part, coagulation
- curd, (storage › firmness, acidity, centrifugation of whey, salting, ripening (for Emmental type cheese, lactic conversion › propionic acid + CO 2), proteolysis, lipolysis › hard cheese

Soft cheeses, yogurts

- precipitation, low pH (fermentation of lactose, lactic acid), partial coagulation of caseins, association of micelles (gel structure) in yogurts

Insoluble acid casein

Sweet casein (rennet coagulation)

Caseinates (soluble
Na, K, NH 4 ; dispersible: Ca, Mg)

Insoluble coprecipitates

Whey

Egg

Egg

- egg white proteins 53%, yolk 47%
- nutrient content of chicken eggs
- protein composition of hen's egg white and yolk

Egg white proteins

~ 40 proteins (globulins, glycoproteins and phosphoproteins)

- enzymes (lysozyme, N-acetylmuramidase activity, murein, bacterial cell walls)
- protein components of enzymes (flavoprotein/riboflavin, avidin/biotin)
- protease inhibitors (ovomucoid, ovoinhibitor)

Consequences

- viscosity and gel-like consistency of albumin − ovomucoid and ovomucin
- stability of whipped egg white foam − ovoglobulins G2 and G3
- antimicrobial effects − lysozyme (ovoglobulin G1)
- antinutritional effect − avidin

Yolk proteins (fat-in-water emulsion)

- 1/3 = proteins, 2/3 = lipids
- glyco-, lipo-, glycophospho- and glycophospholipoproteins
- granules − lipovitellin and phosvitin
- plasma − lipovitellenin and livetin

Changes in storage and processing

- partial denaturation of egg white proteins during whipping
- heat denaturation
  - 57 °C − start
  - 60-65 °C - denatures most proteins (not ovomucoid)
  - 65-70 °C - most yolk proteins (not phosvitin)

Foods of plant origin

Foods of plant origin

- main sources - plant seeds
- limited resources − fruits, leaves, tubers, tubers and other parts of plants (fruits, vegetables, roots)

Cereals and pseudocereals

- Basic chemical composition of cereals
- Cereal proteins and their composition

Wheat proteins

Flour 7-13 (up to 15)% protein

- 15% albumin (water soluble) leucosin
- 7% globulin (0.4 M-NaCl) edestin
- 33% prolamine (70% ethanol) gliadin
- 46% glutelin (rest) glutenin

  ratio of prolamin / glutelin = 2 : 3

1. Strong flour = bread flour (12-14%)

- (dough elastic, stiff, requires intensive mixing, retains carbon dioxide, air, bulkier products)

1. Weak flour = production of biscuits, sweets (< 10%)

Dough

- gluten = viscoelastic mass, 2/3 water, 1/3 hydrated glutelin (viscosity),
- gliadins (elasticity), gluten dry matter = 90% proteins, 8% lipids, 2% sugars

Gluten-free products

- allergic celiac disease (~0.05% of children in Europe)
- changes in the epithelial cells of the intestinal wall, impaired absorption of nutrients
- prolamin fractions of wheat, rye, barley, sequence: Pro-Ser-Gln-Gln and Gln-Gln-Gln-Pro

limits < 100 mg gliadin/kg (dry matter)

Rye proteins

- no gluten
- baking properties: pentosans, some proteins (swelling in an acidic environment)
- formation of acids by microorganisms (*S. cerevisiae*, *S. minor*, *L. plantarum*, *L. brevis*)

Proteins of legumes and oilseeds

- high globulin content, germination function

More detailed information can be found on the amino acid content in legumes page.

Use of non-traditional protein sources

Textured vegetable proteins

Preparations rich in proteins

Reaction

Reaction

- elimination, isomerization, addition, oxidation
- complex reaction
- influence of food composition, conditions: temperature, pH, O 2, other substances

Consequences

- decrease in biological value
  - breakdown of essential amino acids
  - formation of non-metabolizable products
  - reducing digestibility
  - formation of anti-nutritional and toxic substances
- formation of aromatic substances
  - mainly Cysteine, Methionine, Ornithine, Proline
  - amines, aldehydes, alcohols, S-compounds

Elimination reaction

- decarboxylation (elimination of carbon dioxide)

  aromatic substances
  biologically active substances (biogenic amines)

- - histamine (His), cadaverine (Lys)

Elimination of ammonia and water

- formation of 2,5-dioxopiperazines (cyclic dipeptides)
- formation of alk-2-enoic acids
- formation of γ-lactams from γ-amino acids, γ-amino acid Glu, creatine

Elimination of functional groups of side chains

- reactions in an acidic environment or thermal reactions
  - deamidation of proteins, hydrolysis
- reactions in a neutral environment or thermal reactions
  - the emergence of unusual bonds
- reactions in an alkaline environment or thermal reactions
  - formation of unusual bonds, unusual amino acids, D-amino acid (abiogenic)

Consequences

- reducing digestibility
- reduction of nutritional value
- formation of potentially toxic amino acids
- formation of aromatic substances

Acidic environment

- Production of protein hydrolysates
  - autolysis enzymes, yeast autolysates, food hydrolysates, soy sauce
  - acid food hydrolyzates

Neutral environment

- formation of cross-links and unusual amino acids

ε-amino group Lys, carboxamide group Asn, Gln

Alkaline environment

- loss of Lysine, Cysteine, Serine, Threonine, Arginine etc.
- 1,2-elimination of HX (Ser, Thr, Cys, SySSCy) and hydrolysis

X = OH, SH, SR, SSR etc.

Cys, Ser›2-aminoacrylic acid (dehydroalanine), Thr › 2-aminocrotonic acid (dehydrobutyrin)

- addition of amino acid functional groups (intra- and intermolecular crosslinks)
- hydrolysis of the cross-linked protein and the formation of unusual amino acids, lysinoalanine, lanthionine
- isomerization and formation of D-amino acids, reduced usability

Addition reaction

- reaction with carbohydrates (aldehydes, ketones), Maillard reaction
- - colored substances, aromatic substances, biologically active substances

Oxidation reaction

- oxidative deamination and transamination
  - Enzyme reactions
    - deaminases or transaminases, hydrolases
- - - aldehydes − fruit and vegetable aroma
    - alcohols − aroma of alcoholic beverages (alcohols of acorns)

Strecker degradation (oxidative decarboxylation)

- formation of Strecker aldehydes
  - Non-enzymatic reaction

Oxidizing agents

- dicarbonyl compounds
- carbohydrates
- quinones
- inorganic substances (hypochlorites)

Emergence of other products

- N- and S-heterocyclic compounds

Further oxidation

- oxidized lipids and phenols, O 2 (photosensitizers)
- cysteine and cystine
  - oxidation of Cys to sulfenic, sulfinic, sulfonic (cysteic) acid (unusable)
  - oxidation of Cys to CySSCy
  - oxidation of CySSCs
  - oxidation of Met

Reactions with food ingredients

- reaction with polyphenols
  - dark color of scrap isolates
  - unusable products, reduced digestibility
- reactions with oxidized lipids
  - unusable products, reduced digestibility

Links

Related articles

- Peptides (1. LF UK, NT)
- Proteins (1. LF UK, NT)
- Amino acids (1. LF UK, NT)

Source

- *2. AMINO ACIDS, PEPTIDES, PROTEINS* [online]. [feeling. 2012-03-10]. < https://el.lf1.cuni.cz/p51525121/ >.