Modifications of Food Proteins

Food Processing and Storage

- Cooking and Industrial processing
  - Overall beneficial effect
    - Decrease spoilage
    - Increases shelf stability
  - Unfavorable reactions at primary structure level
    - Losses in nutritional quality
    - Losses in functionality
    - Increased risk of toxicity
    - Desirable and undesirable flavor changes

Processing & Storage

- Factors that can adversely affect proteins include
  - Heat
  - Extremes in pH
  - Exposure to oxidative conditions
    - Caused by oxidizing lipids
    - Other oxidizing agents
  - Reaction with CHOs

Moderate Heat Treatments

- Globular proteins
  - Reduces solubility
  - No disruption or formation of covalent bonds
  - Primary structure unaffected
- Beneficial
  - Inactivation of enzymes
  - Destruction of toxins or anti-nutritional factors
  - Improve digestibility

Moderate Heat Treatments

- Thermal treatments > 115C
  - Partial destruction of cysteine and cystine
    - Formation of hydrogen sulfide, dimethylsulfide and cysteic acid
  - Deamidation reactions (>100C)
    - Release of ammonia
    - Change in pI of proteins
    - Covalent Cross-links
  - Thermal treatments in presence of oxygen
    - Partial destruction of tryptophan residues

Severe Heat Treatments

- Temperatures > 200C as well as alkaline conditions
  - Isomerization
    - ß-elimination
    - Reduces nutritional value
    - Digestibility
  - Cyclic derivatives
    - Strong mutagenic action
    - Tryptophan $\Rightarrow$ carbolines
  - Destruction of Aas at alakaline conditions
    - Arginine
    - Cysteine
    - Ser, Thr, Lys

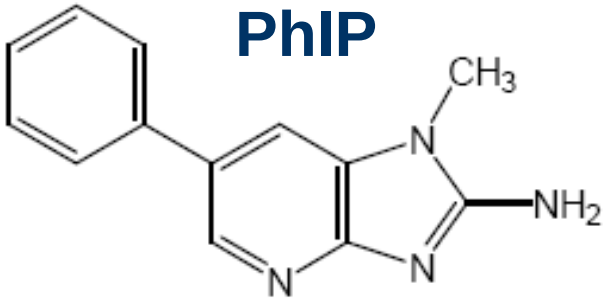
Influence of Severe Heat

- Lysine and Arginine side chains react with the free acids of glutamic and aspartic acid
  - isopeptide cross-links which can impede digestion and exhibit major effects on functionality
- Temperatures of 180 – 300C
  - Such as occur in roasted coffee, meat, fish and in the baking of some biscuits
- These reactions also account for some of the flavor and color developed as a result of the roasting process

Influence of Severe Heat

- Possible formation of toxic products
  - Mutagenic activity on flame-broiled fish and beef
  - Several mutagens are of protein and amino acid origin
- These compounds are only formed at temperatures in excess of 300°C

PhIP



MeIQx

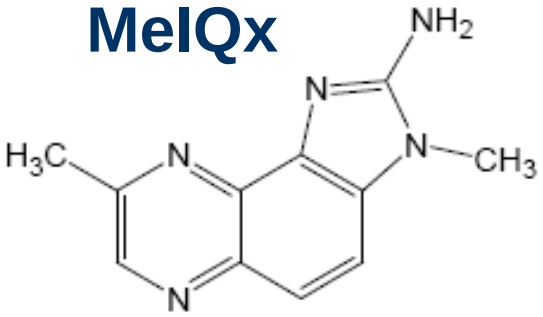


Table 1. Reported Levels of PhIP and MeIQx in Selected Meats, Poultry, and Fish Products

	PhIP (ng/g product)	MeIQx (ng/g product)
Hamburgers, pan-fried ("home-cooked")	0-32	0-10
Beef steak, broiled/grilled/fried	0.6-48.5	0.5-8.3
Chicken breasts, pan-fried	12-70	0
Chicken breasts, grilled (barbecued)	27-480	0-9
Fish, broiled/grilled	2-73	0-5
Fish, pan-fried	1.7-69	1.4-6
Fast food hamburgers (fried or charbroiled)	0.1-0.6	0-0.3
Fast food chicken (chicken breast sandwiches and deep-fried chicken)	0	0
Fast food breakfast sausages	0	0-0.3
Fast food fish (sandwiches)	0	0

Alkaline pH

- Thermal treatments at alkaline
  - Covalent Cross-Links
  - Condensation reaction of Lys, Cys or Ornithine with DHA (cysteine or phosphoserine)
  - Lower nutritional value
  - Toxicity?

Photo-oxidation of Proteins

- The precise changes and pathways of destruction are influenced by
  - Irradiation wavelength
  - Irradiation dose
  - Reaction conditions
  - Individual amino acid being irradiated
- Two of the potent photosensitizers in foods are riboflavin and chlorophyll
- The sulfur amino acids exhibit more measurable photo-decomposition than the aliphatic amino acids

Interaction with Lipids

- Lipid hydroperoxides causes polymerization of proteins
- Lipid peroxidation free radicals serve as initiators
- Substantial losses in amino acids when proteins are exposed to peroxidizing lipids
- Methionine, histidine, cystine and lysine are the most vulnerable to damage
- Losses in digestibility and biological value of the proteins after oxidation

Interaction with Lipids

- Maximum interaction or degradation of the protein takes place when the lipid oxidation is at the stage of maximum peroxide formation
  - Losses in available lysine appeared to take place in the initial induction period and during the induction of peroxides
  - Oxidations and cross-links generated tend to adversely affect
    - Solubility
    - Enzyme activity
    - Nutritive quality

Interaction with Oxidizers

- Chlorine
  - Environmental oxidizer which can damage protein quality
  - The initial side of attack of the chlorine is the sulfur of methionine
  - Nutritional impact not likely to be significant, since foods produced from chlorinated flour are not generally consumed as sole sources of protein
    - The loss of small amounts of methionine would not be significant

Interaction with Carbohydrates

- Maillard