

EFFECT OF THERMAL PROCESSING ON NUTRIENT PROFILE

- Several factors influence nutritional content of food, and type and level of losses due to processing
 - Biochemical composition of food
 - Type of harvesting
 - Packaging and storage conditions
 - Method of preparation for processing

- Effect of processing on nutrient content depends on:
 - Sensitivity of nutrient to conditions prevailing during processing – heat, oxygen, pH, light
 - Characteristics of food
 - Concentration of nutrient in food
 - Macronutrient and vitamin content more likely to be affected than micro nutrients

- Effect of processing on nutrient content more significant – food serves as a worthwhile source of a particular nutrient
- Processing – recommended guidelines
- Over processing – destroy not only nutrients, but also taste and appearance

Effect of processing conditions on nutrients

Nutrient	Effect of Processing
<ul style="list-style-type: none">• Fat• Protein• Amino Acids	<ul style="list-style-type: none">• Oxidation accelerated by light• Denatured by heat (improves digestion)• Some are sensitive to light. Lysine bio -availability reduced by non-enzymatic browning
<ul style="list-style-type: none">• Vitamin C (Ascorbic acid)	<ul style="list-style-type: none">• Decreases during storage, drying, heating, oxidation, cell damage (e.g. chopping or slicing) Losses due to oxidation catalysed by copper, iron• Stable to heat under acidic conditions
<ul style="list-style-type: none">• Vitamin B1 (Thiamine)	<ul style="list-style-type: none">• Destroyed by high temperatures, neutral and alkaline (e.g. baking soda, baking powder) conditions.• Lost in cooking water
<ul style="list-style-type: none">• Vitamin B2 (Riboflavin)	<ul style="list-style-type: none">• Sensitive to light at neutral and alkaline conditions• Moderately heat stable under neutral conditions• Sensitive to heat under alkaline conditions

- Vitamin B3
(Niacin, Nicotinamide)
 - The most stable vitamin
 - Stable to heat and light
 - Leaches into cooking water
- Folate
 - Decreases with storage, or prolonged heating
 - Lost in cooking water
 - Destroyed by use of copper utensils
- Vitamin B6
(Pyridoxine, Pyridoxal)
 - Heat stable in alkaline and acidic conditions
 - Pyridoxal is heat labile
- Vitamin B12
 - Destroyed by light and high pH
- Carotenes
 - Easily destroyed by heat
 - Oxidises and isomerises when exposed to heat and light
- Vitamin A
 - Very heat labile – easily destroyed by heat
 - Easily oxidised
- Vitamin D
 - Oxidises when exposed to heat and light
- Vitamin E
 - Oxidises readily

Effects of Heat Processing on Foods

- Heat processing – both beneficial and detrimental effects on food
- Beneficial effects – increase acceptability
- Processing prevents nutrient loss and loss of wholesomeness of foods, which would occur quickly if the fresh food is not processed
- Desirable sensory qualities of foods - better preserved or improved - appetite and total food intake improved- higher nutrient absorption
- Increase digestibility of foods - resulting in greater bioavailability of nutrients
- Unacceptable detrimental changes - spoilage

- Thermal processing - ensures commercial sterility – undesirable changes in food
- Canned foods – degrade in nutritive value, colour, flavour and texture
- Heating – irreversible changes in food components *viz* proteins, fats, carbohydrates – impairs nutritive value

- Canning - most of the detrimental changes arrested - excluding oxygen, destroying enzymes and microorganisms by heat
- Some changes- more slowly take place - characteristics change over a period of time – food not acceptable.

- Changes in canned foods - classified as
 - those taking place during processing
 - those taking place after processing
- Changes during processing
 - **Desirable changes:**
 - Absorption of salt by fish
 - Destruction of enzymes
 - Destruction of microorganisms
 - Increased digestibility of proteins
 - Softening of bones, fins and scales and becomes edible; uniformity of taste and flavour throughout the pack (e.g. curry packs).

– Undesirable changes

- Loss of amino acids
- Loss of vitamins
- Fat oxidation /rancidity
- Non-enzymatic browning reactions
- Drying and browning solids at the top end
- Retort burn in foods adhered to can surface
- Sulphide blackening
- Internal corrosion by electrochemical reaction - catalyzed by oxygen and acid - tin and iron gets into foods - metallic taste
 - produces hydrogen - reduces vacuum
 - metal content exceeding certain limits - product becomes unacceptable
- Loss or absorption of moisture by the solids in the pack - alteration in net weight of solids - generally observed in shrimp cans.

- **Changes during storage of processed cans**
 - Exchange of various food components – balanced in taste and flavour
 - All changes happening during heat processing also happens during storage even though at a slow rate
 - Long storage period - vacuum inside can reduces
 - composition of head space gases changes - Oxygen content reduces within a short time
 - hydrogen and CO₂ content increases - in some foods ammonia and other gases may be produced

- Loss of colour and flavour, softening of solids, fat oxidation, rancidity and subsequent browning, loss of clarity of brine etc occur during long term storage of canned foods.

Influence of canning on fish

- Most fishery products cooked/blanched before canning
- Cooking - enhances digestibility of fish proteins
- Loss of nutrients on cooking depends on temperature, duration of cooking and type of nutrients
- Mild cooking - little loss of protein with only a slight loss in available lysine, whereas drastic heating can significantly reduce protein quality
- Boiling – little effect in the composition of shellfish
- Cooking - negligible effect on fatty acid composition of fish
- Canned fish in oil - increases calorie content and vitiates beneficial effects of n3 PUFA
- Cooking - negligible effect on cholesterol content - relative concentration may increase because of water loss
- Canning of fish and shellfish – less impact on proximate composition

Effect on Proteins

- Heat processing - responsible for reductions in protein value as a result of destruction or unavailability of constituent amino acids
- 3 types of reactions - responsible for nutritional changes
 1. Maillard reactions - amino groups (ϵ -amino group of lysine) react with aldehyde groups of reducing sugars or carbonyls from oxidized fat – forms an indigestible complex - render lysine metabolically unavailable to the body

2. Cross-linkage reactions - protein-protein interactions- resistant to enzymic hydrolysis in the gut
 3. Damage to sulphur amino acids by oxidation or desulphydration – serious effect – limiting amino acids in most flesh foods
- Lowers NPU and available lysine content

- Proteins – denatured by heat – configuration of native protein molecules change – lose specific immunological properties
- Enzymes – completely inactivated
 - Animal meat - denaturation and inactivation of endogenous enzymes that act as natural tenderizers - cellular proteases and collagenases - breakdown of meat fibrous proteins to allow protein digestibility for maximum energy and nutritional release.
- Increase in free sulfhydryl groups – taste changes
- Denatured proteins – coagulate (adjacent protein molecules join together – side chain H bonds) and precipitate
- Adversely affect digestibility of proteins – impairs nutritive value with no change in amino acid composition

Effect on Fats

- Heating of fats in the presence of air - promotes oxidation and rancidity – makes food unpalatable
- Fats susceptible to hydrolytic/oxidative rancidity during canning
- Lypolytic enzymes – microbes – destroyed by heating – enzymic hydrolysis not probable

- Oxidative rancidity – production of hydroperoxides – accelerated by heat, metal ions, light and moisture
- Flavour reversion in de-odourised unsaturated fats – accelerated by heat
- Oxidized fats react with lysine – reduce lysine availability

- Fats – stable to moist heat in the absence of oxygen
- Fats and oils – relatively stable in canned foods – good vacuum maintained

Effect on Carbohydrates

- Carbohydrates – degraded by heating – browning reaction or caramelization at higher temperature
- Fish – presence of ribose and glucose – more affected than animal meat

Effect on Vitamins

- Vitamins - most susceptible to loss during heat treatment
- Magnitude of loss depends on specific vitamins and conditions employed
- Loss - leaching of water soluble vitamins into cooking medium and destruction of unstable vitamins under certain treatment conditions
- Combination of O₂, light and heat - greater loss of nutrients than any one of these factors individually

- Blanching - water soluble vitamins - thiamine, riboflavin, and vitamin C - susceptible to leaching into water used for blanching
- Leaching of nutrients - reduced by using steam or hot air instead of hot water for blanching
- Vitamin C and thiamin (~ 75 % loss in fish) - more sensitive to heat required for commercial sterilization in canning than fat soluble vitamins
 - Vitamin C – destroyed by heating at low temperature for longer periods – combined effect of heat, metal ions, oxygen
 - Thiamin – may be retained in acid foods because of low heat processing requirements

- Riboflavin – stable to heat, but sensitive to light
- Folic acid and vitamin B₆ - susceptible to oxidation
- Blanching of mussels – 68% loss of vitamin B₆ and 72% loss of vitamin B₄

- Exact amount of nutrients lost depends on the food composition, container, and heat

- Fat soluble vitamins A and D – relatively stable to heat
- Heating in the presence of oxygen – appreciable loss of vitamins A and D
- Vitamin E – oxidizes readily
- Carotenes
 - relatively stable at normal cooking temps
 - higher temperatures - produce oxidative losses and isomerization of carotenes with significant loss of biological activity

Effect on Minerals

- Minerals - generally not sensitive to heat - leached to cooking water inside the can
- Over 50% of the manganese, cobalt, and zinc can be lost to the fluid

Effect on Colour

- Changes in colour of canned food – immediately perceptible on opening
- Heating – degradation of pigments – accelerated by metallic ions
 - Carotenoid pigment in shrimp – astaxanthine-degrades during canning
 - Anthocyanin pigment in fruits

- Heating – promotes formation of undesirable coloured compounds
 - Maillard reaction
 - Absence of amino acids – polyhydroxycarbonyl compounds undergo caramelization on heating
- Presence of air in headspace – oxidative browning of foods
- Enzymic browning – prevented since enzymes are destroyed
- Products of enzymic discolouration developed prior to processing – remains after canning

Effect on Flavour and Texture

- Extent of degradation – depends on sensitivity of food to heat and duration of heating
- Flavour-bearing components of food – heat sensitive
- Heating – softens texture – fish and shell fish
- Pre-treatments done to maintain firm texture

Minimizing nutrient loss due to processing

- Newer techniques – HTST processing combined with aseptic packaging and ultra-high-temperature (UHT)
- Aseptic packaging - reduces the temperature and time necessary for sterilization of the food - resulting in less nutrient loss
- Flash-18 process- uses increased atmospheric pressure to increase the boiling point of water and reduce the amount of heating time
- In general higher temperatures used results in greater nutrient retention, because the rate of microbial destruction increases faster with increasing temperature than the rate of nutrient destruction.

- Nutrient losses in food during processing - vary with type of nutrient and processing conditions
- Factors that affect nutrient loss - light, oxygen, pH, water content, natural biological enzyme systems of food, and heat
- Evaluation of value of a food processing procedure - benefits from increased food availability - weighed against nutrient loss and importance of lost nutrients in food
- Although some nutrients are lost during blanching and canning processes, many foods would not be as steadily and conveniently available throughout the year if not for these preservation techniques, or would be spoiled and inedible, resulting in complete nutrient loss.