

Tutorial 2 : Characteristics of Food

1. The Importance of Water in Food and Its Role in Preservation (Presentation 1)

Introduction

Water is a fundamental component of food, influencing its texture, stability, and preservation. Its role in food safety is crucial, as it directly affects microbial growth and biochemical reactions responsible for product deterioration. One of the key parameters for assessing water availability in food is water activity (a_w), which determines how easily microorganisms can grow and cause food spoilage.

1. Definition of Water Activity (a_w)

Water activity (a_w) is a measure of the free water available in a food product to participate in biochemical reactions and support microbial growth. It is expressed as the ratio between the vapor pressure of the food and that of pure water at the same temperature, ranging from 0 to 1.

Unlike total water content, a_w reflects water availability rather than its absolute quantity. For example, foods such as bread and meat have similar water content, but their a_w values differ due to the nature of the bonds between water and food components. A low a_w (<0.6) limits enzymatic and microbial activities, contributing to longer food shelf life.

2. Relationship Between a_w and Food Stability

Water activity directly influences the physical, chemical, and biological stability of food. A high a_w promotes microbial proliferation and certain spoilage reactions, whereas a low a_w slows these processes.

- **Effect on Microbiological Preservation:**
 - An a_w above 0.91 allows the growth of most pathogenic bacteria, such as *Salmonella* and *Clostridium botulinum*.
 - Molds and certain yeasts can survive at lower a_w values (0.7-0.8), explaining the spoilage of dried fruits and bread.
 - An a_w below 0.6 inhibits almost all microbial activity, ensuring the long-term preservation of foods like biscuits and powdered milk.
- **Effect on Chemical and Enzymatic Reactions:**
 - A high a_w accelerates lipid oxidation, leading to rancidity in oils and fats.
 - It also promotes non-enzymatic browning (Maillard reaction), altering the color and taste of food products.
 - A moderate a_w (0.2-0.6) can lead to sugar crystallization in certain products, modifying their texture.

3. Impact on Microbial Growth and Food Quality

Water activity is a key factor in controlling food contamination and spoilage. By adjusting a_w , it is possible to extend shelf life and ensure food safety.

Food industries use various techniques to control a_w :

- **Drying and Freeze-Drying:** Reducing free water to prolong shelf life (dried fruits, powdered milk).
- **Addition of Hygroscopic Solutes (Sugar, Salt, Glycerol):** Binding water to limit microbial growth (jams, cured meats).
- **Modified Atmosphere Packaging:** Maintaining low humidity to preserve texture and prevent microbial growth.

However, excessive modification of a_w can alter the organoleptic properties of food. For instance, a significant decrease can make a product hard and brittle (biscuits), while excessive moisture can cause softening and mold formation.

Conclusion

Water plays a fundamental role in the stability and preservation of food. Water activity is a key parameter for controlling microbial growth, optimizing preservation processes, and ensuring product quality. By adjusting a_w through appropriate techniques, it is possible to enhance food safety while maintaining the sensory characteristics of food.

2. Lipid Oxidation: Mechanisms, Factors, and Prevention (Presentation 2)

Introduction

Lipid oxidation is a chemical reaction that occurs in many fat-containing foods. This phenomenon alters the organoleptic quality of products and can lead to the formation of toxic compounds. Lipid oxidation is a major challenge for the food industry, as it affects the shelf life and safety of food products. This process is influenced by several factors and can be controlled through various prevention strategies.

1. Factors Promoting Lipid Oxidation

Lipid oxidation primarily follows a free radical chain reaction consisting of three stages: initiation, propagation, and termination. Several factors can accelerate this process, including:

- **Presence of oxygen:** Atmospheric oxygen is essential for the oxidation process. The more a food product is exposed to air, the more vulnerable it is to rancidity.
- **Light exposure:** UV rays and visible light promote the formation of free radicals and accelerate lipid degradation, particularly in oils and products rich in unsaturated fatty acids.
- **Temperature:** High temperatures speed up chemical reactions and encourage the breakdown of lipids into undesirable secondary compounds.
- **Lipid composition:** Polyunsaturated fatty acids, such as omega-3 and omega-6, are more sensitive to oxidation than saturated fatty acids due to the presence of double bonds in their structure.
- **Transition metals (iron, copper):** These metals catalyze free radical formation and accelerate lipid degradation. They are often present in food as trace elements or impurities.
- **Humidity:** Excessive moisture can promote lipid hydrolysis and increase their susceptibility to oxidation.

2. Consequences on Food Quality

Lipid oxidation has a significant impact on food quality, affecting taste, odor, and safety:

- **Alteration of organoleptic properties:**
 - The formation of volatile compounds, such as aldehydes and ketones, is responsible for the appearance of unpleasant odors and flavors, often described as rancid.
 - The texture of products can also be affected, particularly in bakery products and margarines.
- **Reduction of nutritional value:**
 - Oxidation leads to the degradation of essential fatty acids (omega-3, omega-6), reducing the nutritional quality of food.
 - It can also destroy certain fat-soluble vitamins, such as vitamin E, which plays a key role in cellular protection.
- **Toxicity and health risks:**
 - The formation of lipid peroxides and secondary oxidation compounds can have toxic effects, promoting oxidative stress in the body.

- Some oxidation products, such as oxidized aldehydes, are suspected of being carcinogenic and are linked to cardiovascular and neurodegenerative diseases.

3. Prevention and Inhibition Techniques for Oxidation

To minimize the harmful effects of lipid oxidation, the food industry implements several strategies:

- **Use of antioxidants:**
 - **Natural antioxidants:** Vitamin E (tocopherols), vitamin C, polyphenols, and flavonoids are used to slow free radical formation.
 - **Synthetic antioxidants:** Compounds such as BHT (butylated hydroxytoluene) and BHA (butylated hydroxyanisole) are commonly added to oils and margarines to stabilize lipids.
- **Control of storage conditions:**
 - **Reduction of oxygen exposure:** Modified atmosphere packaging (using nitrogen or carbon dioxide) limits oxygen access to lipids.
 - **Protection from light:** Opaque or colored packaging prevents photo-oxidative degradation.
 - **Low-temperature storage:** Cold temperatures slow down chemical reactions and extend the shelf life of lipid-rich foods.
- **Selection of raw materials:**
 - Using more stable oils, such as coconut oil and olive oil, which are rich in saturated and monounsaturated fatty acids, reduces oxidation susceptibility.
 - Hydrogenation or esterification processes modify lipid structures to improve their resistance to oxidation.

Conclusion

Lipid oxidation is a complex phenomenon that affects food quality and can have negative health effects. This process is influenced by various environmental and intrinsic factors related to lipids. Through the addition of antioxidants, appropriate packaging, and controlled storage, it is possible to slow down oxidation and preserve the freshness of lipid-containing foods. A better understanding of oxidation mechanisms helps improve the stability and safety of food products.