• EXTRINSIC PARAMETERS

- The extrinsic parameters of foods are not substrate dependent.
- They are those properties of the storage environment that affect both the foods and their microorganisms.
- As follows:

1. Temperature of storage
2. Relative humidity of environment
3. Presence and concentration of gases
4. Presence and activities of other microorganisms

1. Temperature of storage

- It is customary to place microorganisms into several groups based on their temperature requirements for growth:
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Table 3.12 *Cardinal temperatures for microbial growth*

	Temperature (°C)		
Group	*Minimum*	*Optimum*	*Maximum*
Thermophiles	40–45	55–75	60–90
Mesophiles	5–15	30–40	40–47
Psychrophiles (obligate psychrophiles)	−5 to +5	12–15	15–20
Psychrotrophs (facultative psychrophiles)	−5 to +5	25–30	30–35

- Most psychrotrophs of importance in foods belong to the genera:
  - Pseudomonas
  - Enterococcus
  - Shewanella
  - Brochothrix
  - Flavobacterium
  - Lactobacillus
  - Psychrobacter

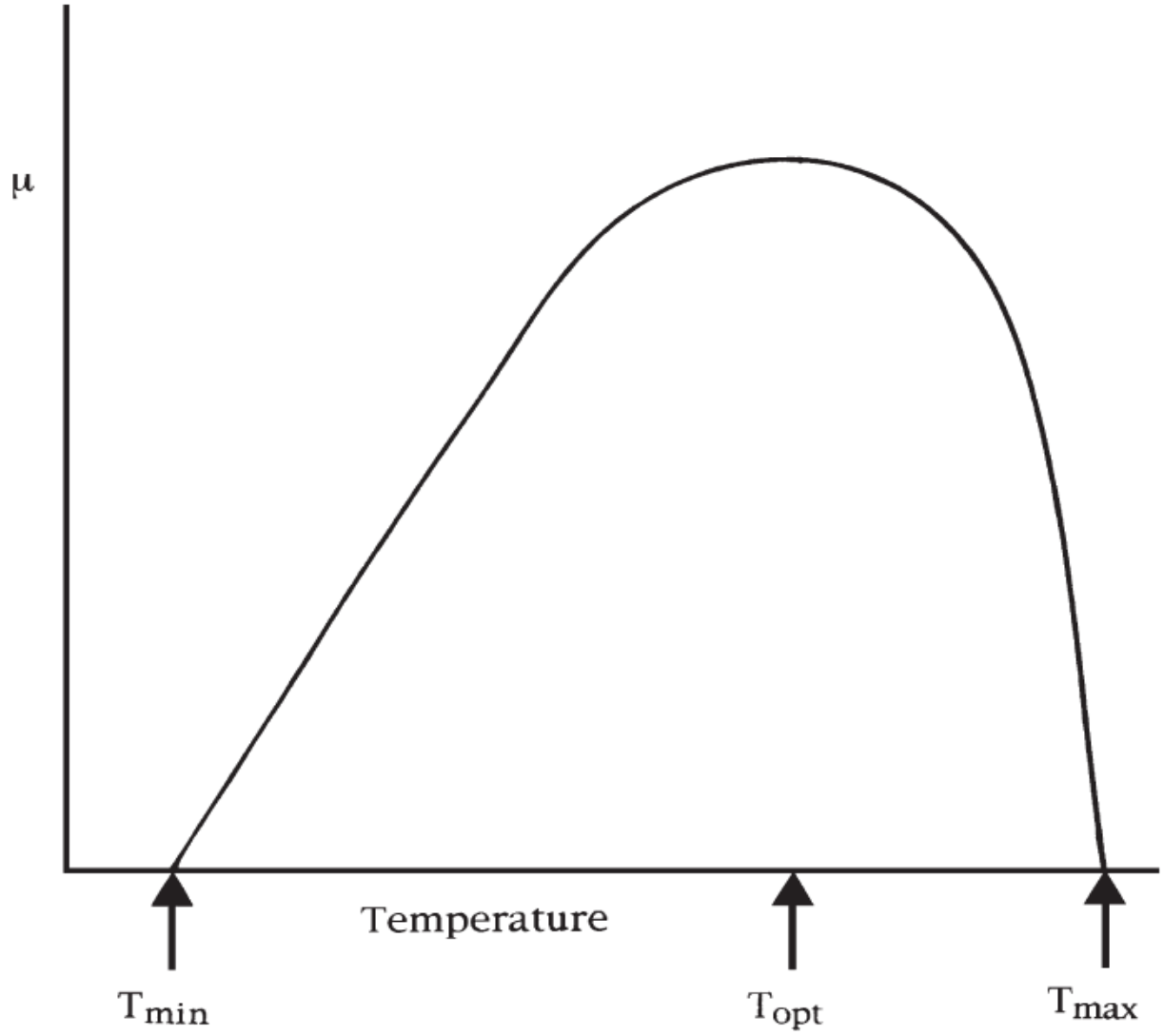
- Psychrotrophs grow well at refrigerator temperatures and cause spoilage at 5–7◦C of meats, fish, poultry, eggs, ...
- The psychrotrophs found most commonly on foods are those that belong to the genera Pseudomonas and Enterococcus.

- Some organisms such as **Enterococcus faecalis** can grow over a range from **0°C to >40°C**.
- Most thermophilic bacteria of importance in foods belong to the genera:
  - Bacillus
  - Paenibacillus
  - Clostridium
  - Geobacillus
  - Alicyclobacillus
  - Thermoanaerobacter

- Molds have wider ranges of temperature than bacteria (like pH, osmotic pressure and nutrient content).
- Many molds are able to grow at refrigerator temperatures, notably some strains of Aspergillus, Cladosporium, and Thamnidium.
- Yeasts grow over the psychrotrophic and mesophilic temperature ranges but generally not within the thermophilic range.

- Although it would seem desirable to store all foods at refrigerator temperatures or below, this is not always best for the maintenance of desirable quality in some foods.
- For example, bananas keep better if stored at 13–17◦C than at 5–7◦C.
- A large number of vegetables such potato as are favored by temperatures of about 10◦C.

- Temperature of storage is the most important parameter that affects the spoilage of highly perishable Foods.
- The rate of spoilage of fresh poultry :
  - at 10◦C is about twice that at 5◦C
  - a15◦C is about three times that at 5◦C



Effect of temperature on growth rate

Table 3-10. Approximate minimum, maximum and optimum temperature values in °C (°F) permitting growth of selected pathogens relevant to food.

Organism	Minimum	Optimum	Maximum
Salmonella spp.	5 (41)	35 - 37 (95 - 99)	45 - 47 (113 - 117)
Staphylococcus aureus growth	7 (45)	35 - 40 (95 - 104)	48 (118)
Staphylococcus aureus toxin	10 (50)	40 - 45 (104 - 113)	46 (115)
Shigella spp.	7 (45)	37 (99)	45 - 47 (113 - 117)
Vibrio cholerae	10 (50)	37 (99)	43 (109)
Vibrio parahaemolyticus	5 (41)	37 (99)	43 (109)
Vibrio vulnificus	8 (46)	37 (99)	43 (109)
Yersinia enterocolitica	-1 (30)	28 - 30 (82 - 86)	42 (108)

2. Relative humidity of environment

- The RH of the storage environment is important both from:
  - The standpoint of a_w within foods
  - The growth of microorganisms at the surfaces
- When foods with low a_w values are placed in environments of high RH, the foods pick up moisture until equilibrium has been established.
- Likewise, foods with a high a_w lose moisture when placed in an environment of low RH.
- **Relationship between RH and temperature:**

The higher the temperature, the lower the RH, and vice versa.

- **Surface spoilage:** In the refrigerator, surface spoilage occurred before deep spoilage occurs in food such as improperly wrapped beef cuts.

Why?

- High RH of the refrigerator
- Meat-spoilage biota is generally aerobic (deep sections of meat have often low O_2).

Group 1: Fruits and vegetables, 0 to 2°C (32 to 36°F), 90-95% relative humidity. Many products in this group produce ethylene.

Apples
Apricots
Asian pears
Grapes (without sulfur dioxide)
Horseradish
Kohlrabi
Parsnips
Peaches
Pears

Group 2: Fruits and vegetables, 0 to 2°C (32 to 36°F), 95-100% relative humidity. Many products in this group are sensitive to ethylene.

Amaranth*
Anise*
Artichokes*
Asparagus
Bean Sprouts
Corn, sweet*
Daikon*
Endive*
Escarole*
Grapes (without sulfur dioxide)
Parsley*
Parsnips*
Peas*
Pomegranate
Raddichio

Group 3: Fruits and vegetables, 0 to 2°C (32 to 36°F), 65-75% relative humidity. Moisture will damage these products.

Garlic Onion, dry

Group 4: Fruits and vegetables, 4.5°C (40°F), 90-95% relative humidity.

Cactus leaves	Lemons*	Tamarillo
Cactus pears	Lychees	Tangelos*
Caimito	Kumquat	Tangerines*

Group 5: Fruits and vegetables, 10°C (50°F), 85-90% relative humidity. Many of these products are sensitive to ethylene. These products are also sensitive to chilling injury.

Beans	Kiwano	Pummelo
Calamondin	Malanga	Squash, summer (soft shell)
Chayote	Okra	Tamarind
Cucumber	Olive	Taro root

Group 6: Fruits and vegetables, 13 to 15°C (55 to 60°F), 85-90% relative humidity. Many of these products produce ethylene. These products also are sensitive to chilling injury.

Atemoya
Avocados
Babaco
Bananas
Bitter melon
Black sapote
Ginger root
Granadilla
Grapefruit
Guava
Jaboticaba
Jackfruit
Papayas
Passionfruit
Pineapple
Plantain
Potatoes, new
Pumpkin

Group 7: Fruits and vegetables, 18 to 21°C (65 to 70°F), 85-90% relative humidity.

Jicama
Pears (for ripening)
Sweet potatoes*
Tomatoes, mature green
Watermelon*
White sapote
Yams*

Food item	RH
Sugar	20 - 35%
Breweries	35 - 45%
Coffee Powder	30 - 40%
Milk Powder	20 - 35%
Seed Storage	35 - 45%

3. Presence and concentration of gases

- Carbon dioxide (CO_2) is the single most important atmospheric gas that is used to control microorganisms in foods.
- O_2 and O_3 (Ozone) are important in modified atmosphere packaged (MAP) foods.
- **O_3 :**
  - has antimicrobial properties.
  - strong oxidizing agent.
  - should not be used on high-lipid-content foods since it would cause an increase in rancidity.
  - is recognized GRAS (generally recognized as safe) in Australia, France, and Japan and USA.

4. Presence and activities of other microorganisms

- Some foodborne organisms produce substances that are either inhibitory or lethal to others;
  - These include:
  - Antibiotics
  - Bacteriocins
  - Hydrogen peroxide
  - Organic acids