



# **CULINARY ESSENTIAL OILS AND THE GUT MICROBIOME**



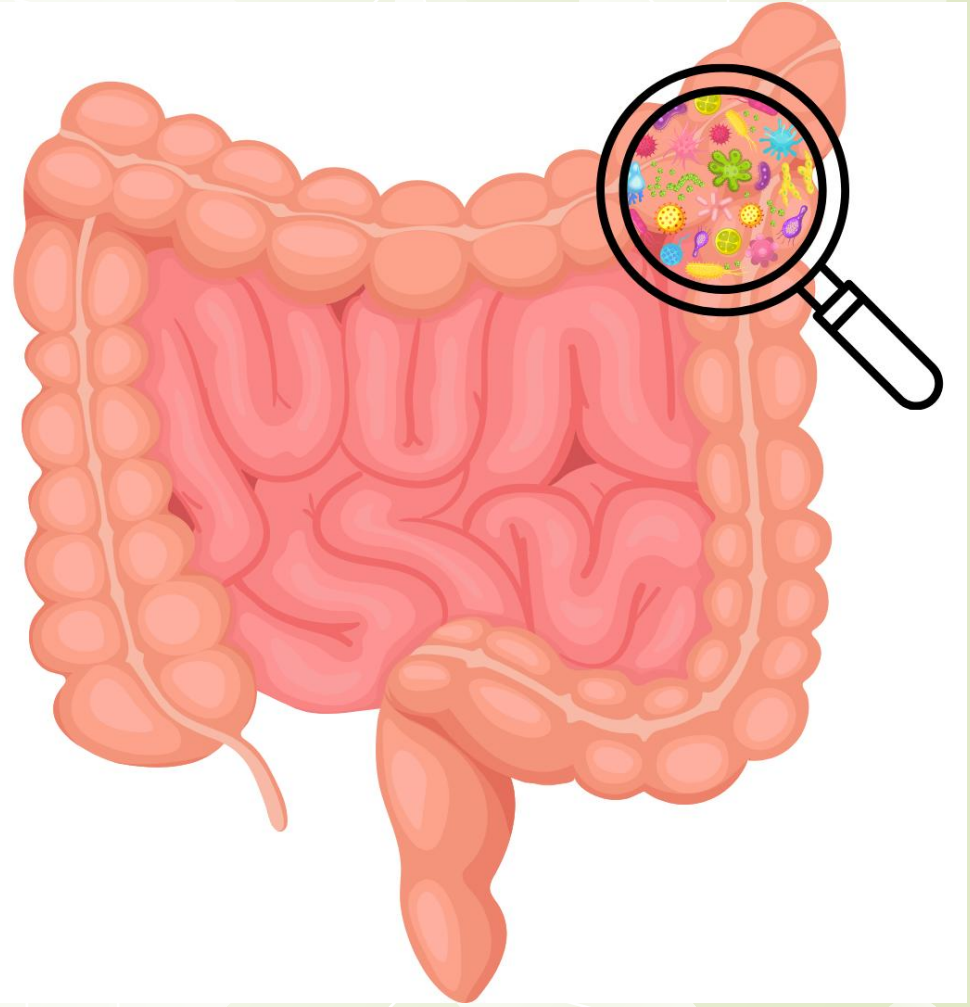
# Roadmap



- The benefits of a healthy gut microbiome
- Historical human use of culinary herbs and spices
- Effects of culinary essential oils on gut microbiome and gut health

# Part I: The Gut Microbiome: Our Fountain of Youth

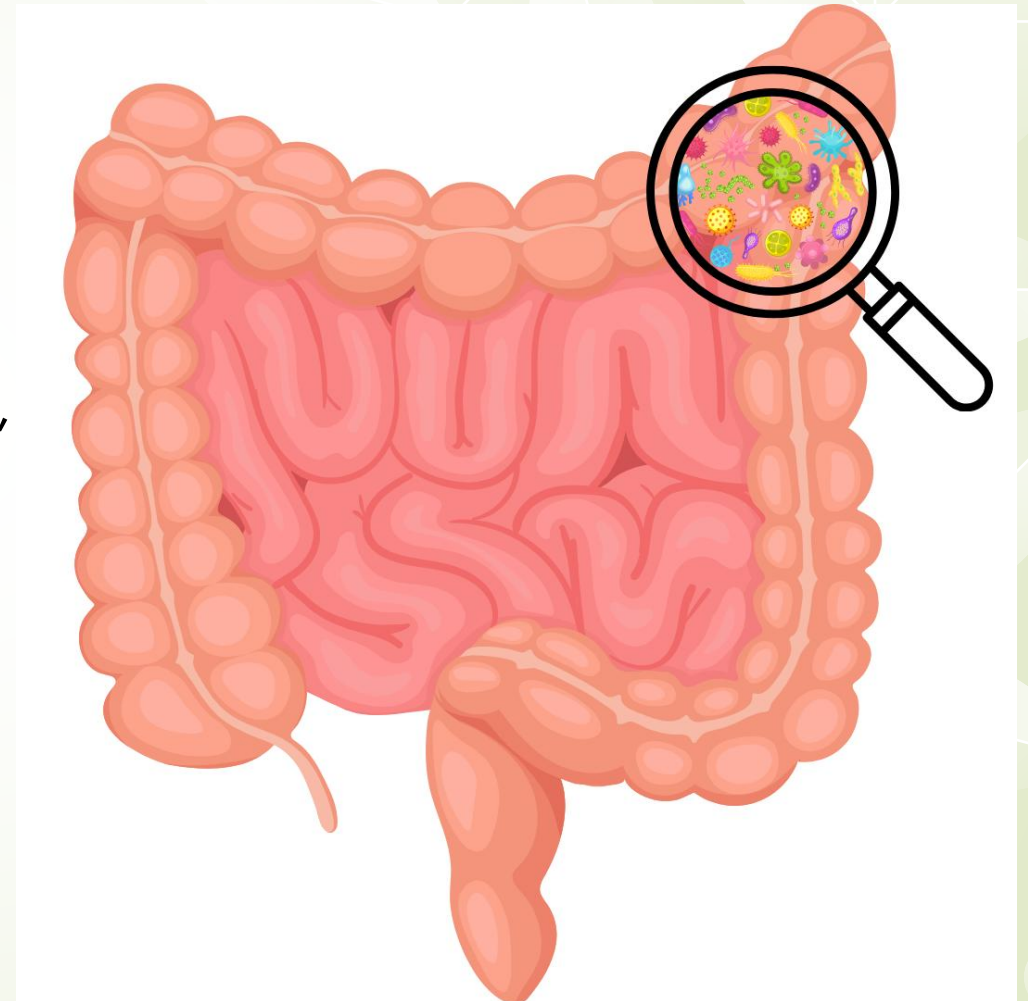
- Over 100 trillion individual microbes
  - Vs 30 trillion human cells in the body
- Over 5,000 different species of bacteria.
  - Each species has numerous different strains.
- Fungi (yeast, saccharomyces, etc.) and viruses are also part of a healthy gut microbiome (“gut virome”)



# The Gut Microbiome

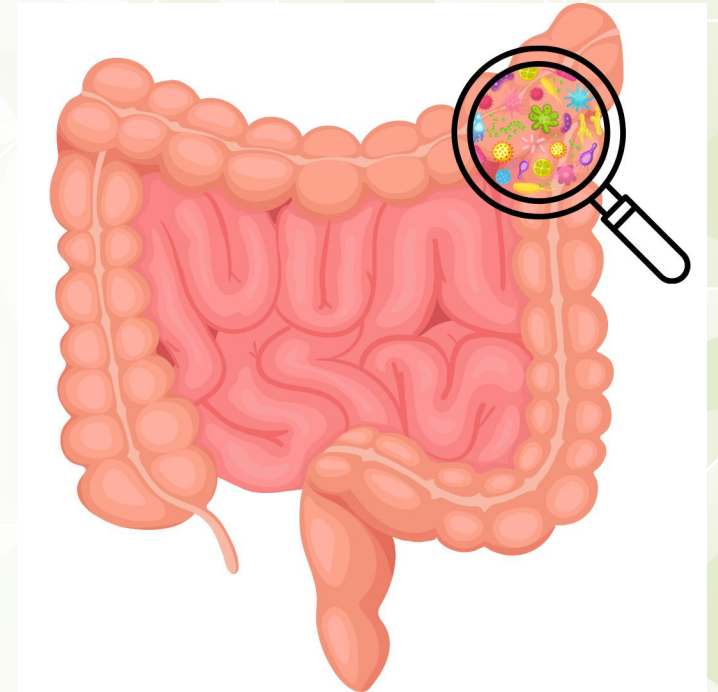
## Dominant phyla

- Firmicutes: Gram positive
  - e.g. Clostridium, Lactobacillus, Faecalibacterium
- Bacteroidota: Gram negative
  - e.g. Bacteroides, Prevotella
- Actinobacteria
  - e.g. Bifidobacteria



# Firmicutes-to-Bacteroidota Ratio


- Higher Firmicutes-to-Bacteroidota ratio is associated with conditions like obesity
- Firmicutes bacteria are more efficient at breaking down carbohydrates,
- Bacteroides are better at digesting complex fibers




# Gut Microbiome: Our Fountain of Youth

## Common Beneficial Gut Microbe Species

<i>Akkermansia muciniphila</i>	<i>Clostridium butyricum</i>
<i>Faecalibacterium prausnitzii</i>	<i>Ruminococcus spp.</i>
<i>Bifidobacterium spp.</i>	<i>Escherichia coli (Beneficial Strains)</i>
<i>Lactobacillus spp</i>	<i>Veillonella spp.</i>
<i>Roseburia spp.</i>	<i>Streptococcus thermophilus</i>
<i>Prevotella spp.</i>	<i>Eubacterium spp.</i>
<i>Saccharomyces boulardii and cerevisiae (fungus)</i>	<i>Cladosporium (fungus)</i>



Chinese pre-diabetic and diabetic patients displayed reduced counts of *Bacteroides*, *Akkermansia*, and *Faecalibacterium*.



# Gut Microbiome: Our Fountain of Youth

## Healthy Actions of the Beneficial Gut Microbes

- Break down undigested fiber and resistant starches into short-chain fatty acids (butyrate, propionate, acetate)
  - improve glucose regulation
  - promote IGF-1 that improves bone growth
  - Reduce gut inflammation and leaky gut
  - block systemic inflammation
  - stimulate GLP-1 production by enteroendocrine L cells
- Produce essential vitamins K2 and B12
- Reduce Trimethylamine production (decreasing TMAO)
- Train immune system to recognize foreign vs self
- Stimulate production of protective mucus

...continued



# Gut Microbiome: Your Fountain of Youth

## Healthy Actions of the Beneficial Gut Microbes - continued

- Compete with pathogens (bad microbes) and prevent them from attaching to gut lining
- Produce serotonin, dopamine, GABA
- Reduce stress hormones and promote resistance to anxiety and depression
- Break down carcinogens
- Produce anti-cancer substances
- Produce substances that lower blood pressure



# Gut Dysbiosis: The Den of Disease

## Pathogenic microbes

*(when they overpopulate the gut, you definitely know it!)*

- ***Clostridium difficile***: Massive leaky gut, colitis, and systemic inflammation
- ***Escherichia coli* (pathogenic strains like EPEC, EHEC)**: Gut inflammation and damage
- ***Salmonella***: Inflames and disrupts gut barrier
- ***Shigella***: Inflames and disrupts gut barrier
- ***Campylobacter***: Causes inflammation and damages the intestinal lining.
- ***Desulfovibrio spp.***: Toxic to intestinal epithelial cells and can disrupt the gut barrier.



# Gut Dysbiosis: The Den of Disease

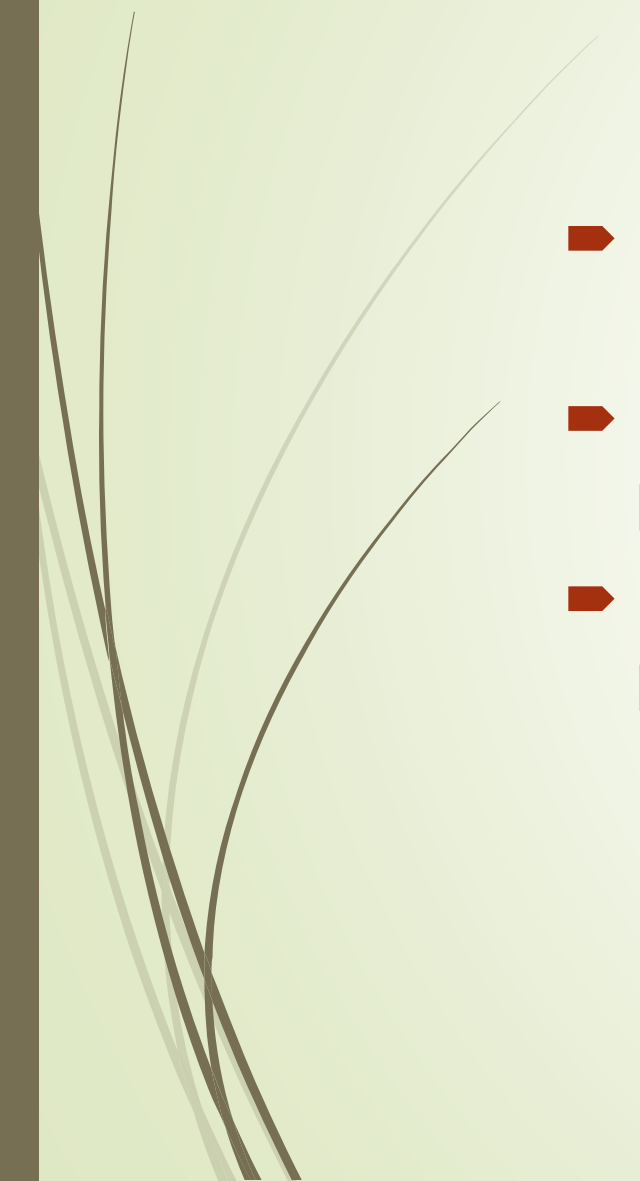
## Dysbiotic microbes

*(when they overpopulate the gut, you may not know it)*

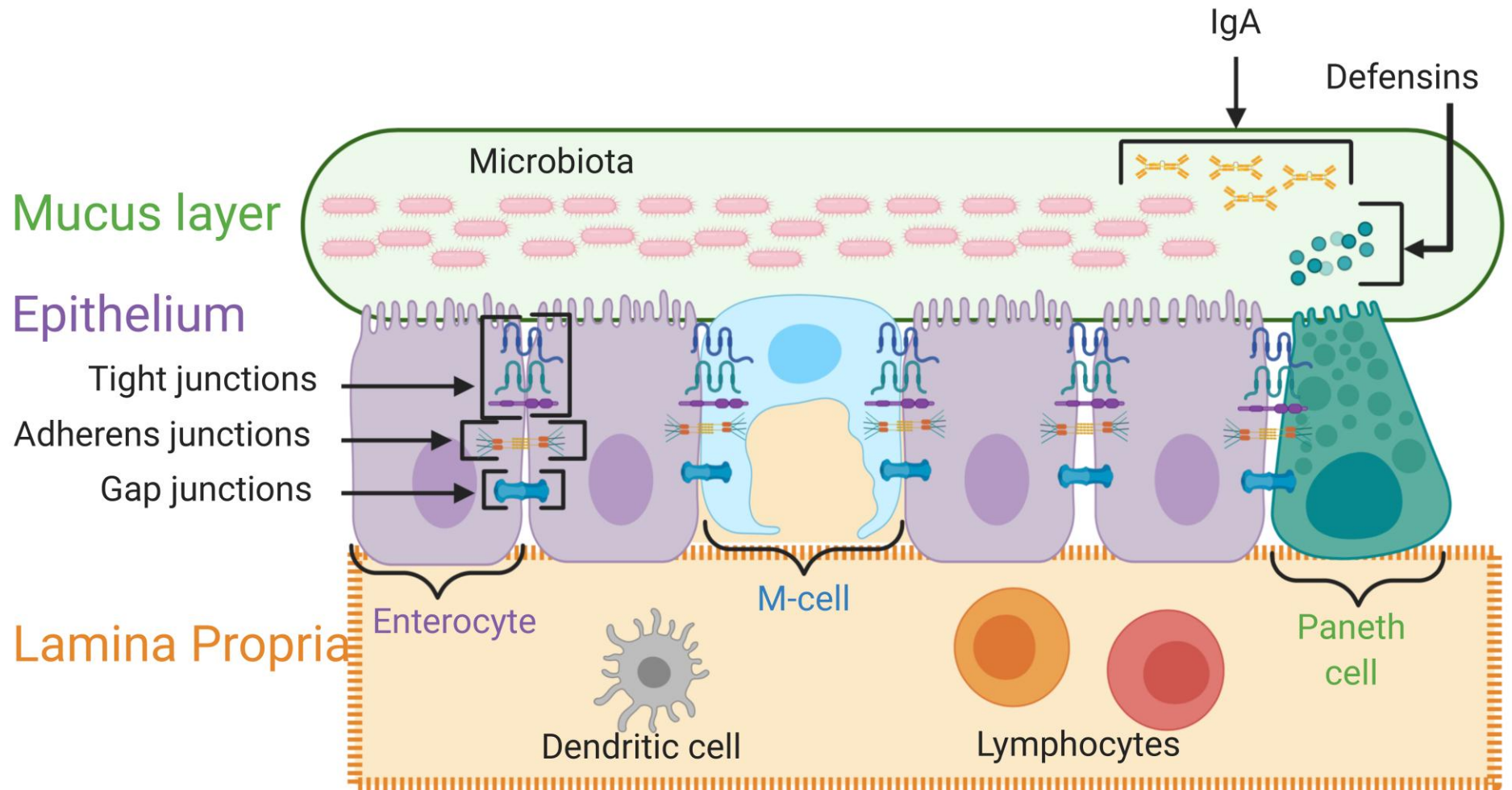
- ***Bacteroides fragilis* (pathogenic strains)**: tight junction disruption and inflammation. Linked to inflammatory bowel diseases (IBD) and colorectal cancer.
- ***Enterococcus faecalis***: gut inflammation and barrier dysfunction; degrades intestinal lining
- ***Klebsiella pneumoniae***: increased intestinal permeability and autoimmune diseases like ankylosing spondylitis and Crohn's disease.
- ***Candida albicans***: Degrades protective mucus layer



# Gut Mucus Layer

- Provides a habitat and nutrient source for specific bacteria through its complex sugar molecules (glycans)
  - Acts as a barrier to prevent harmful bacteria from penetrating the intestinal lining
  - The microbiome can influence the production and properties of the mucus layer
- 

# The Gut Tight Junctions and Mucus Layer



# Gut Dysbiosis: Pathogenic Mechanisms



- **Disruption of Tight Junction Proteins:** damage tight junctions between intestinal epithelial cells, increasing intestinal permeability.
- **Mucus Layer Degradation:** Certain bacteria and fungi degrade the protective mucus layer, exposing the epithelium to bacteria and damage.
- **Inflammation:** Microbial metabolites (e.g., LPS, hydrogen sulfide) and toxins stimulate the immune system, causing chronic low-grade inflammation.
- **Toxin Production:** Some microbes release enterotoxins or cytotoxins that directly damage the gut lining.

# Gut Dysbiosis: Consequences

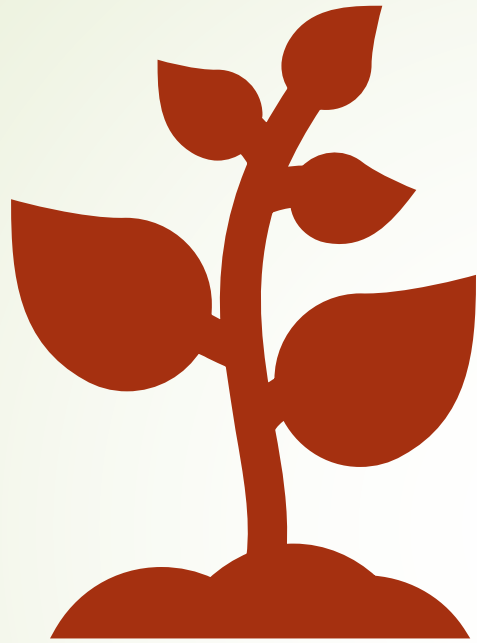
- **Autoimmune Diseases:** Leaky gut allows microbial components (e.g., LPS) to enter the bloodstream, triggering autoimmune responses.
- **Metabolic Disorders :** Dysbiosis and LPS-induced inflammation contribute to insulin resistance, obesity, and type 2 diabetes.
- **Cardiovascular Diseases:** Increased systemic inflammation from gut-derived endotoxins is linked to atherosclerosis and hypertension.
- Continued...



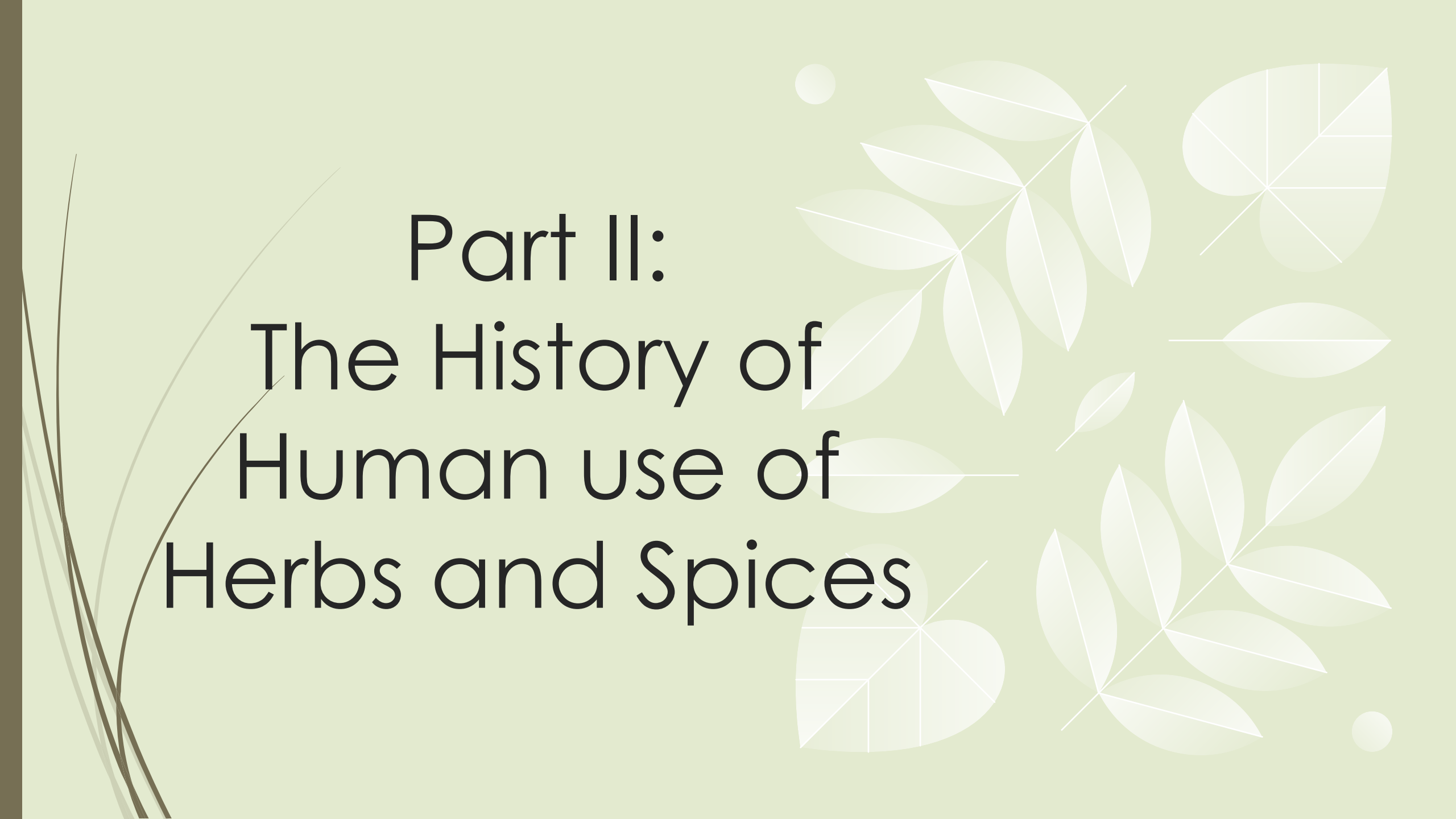
# Gut Dysbiosis: Consequences (continued)

- **Neurodegenerative Diseases:** Leaky gut can lead to "leaky brain," where inflammatory molecules cross the blood-brain barrier, contributing to diseases like Alzheimer's and Parkinson's, anxiety, and depression
- **Inflammatory Bowel Diseases (IBD):** Dysbiosis and pathogenic bacteria exacerbate conditions like Crohn's disease and ulcerative colitis.
- **Colorectal Cancer:** Chronic inflammation and toxins from bacteria like *B. fragilis* and *E. coli* are associated with tumorigenesis.





So how do essential oils affect the gut microbiome?

The background is a light green color. On the left side, there is a vertical line and some curved lines that look like grass or reeds. On the right side, there are several stylized leaf patterns in a lighter shade of green. The text is centered in the middle of the page.

# Part II: The History of Human use of Herbs and Spices

# Prehistoric Use of Culinary Herbs

Archeological evidence for use of culinary herbs dating back 10,000 years

- Wild herbs **like thyme, rosemary,** and **garlic** were used in primitive societies to flavor and preserve meats and grains.



# Ancient Historical Use of Culinary Herbs from the Ancient Texts

- Mesopotamia (3,000 BCE): **Garlic, coriander,** and **dill** cultivated and used for flavor and preservation.
- Ancient Egypt (2,500 BCE): **Cumin, fenugreek,** and **coriander** used in food preservation, including embalming processes, indicating an intuitive understanding of their antioxidant and antimicrobial properties.
- Ancient India and China: **Turmeric, ginger,** and **cinnamon** used in preserving food and preventing decay.
- The Bible: **Mint** and **dill** used for both cooking and preservation.

# Historical Use of Culinary Herbs

## Greek and Roman Empires (500 BCE–500 CE)

- Herbs like **oregano**, **thyme**, and **bay leaves** were used to preserve meats, oils, and wines.
- Romans utilized salt combined with herbs like **rosemary** and **garlic** to cure and preserve meats and fish.

## Middle Ages

- With the **Silk Road**, spices and herbs such as **clove**, **cinnamon**, and **nutmeg** became highly valued for their preservative effects.

# Historical Use of Culinary Herbs

## Early Modern Period (1400s–1700s)

- Explorers carried preserved foods on long voyages.
- Herbs like **dill**, **mustard**, and **tarragon** were integral to pickling vegetables and preserving fish

## Industrial Revolution (1800s)

- Traditional herbal preservation methods remained in widespread use, particularly in **rural** areas.

## Contemporary Era

- Still used in artisanal and cultural practices



# How Herbs and Spices Helped our Ancestors

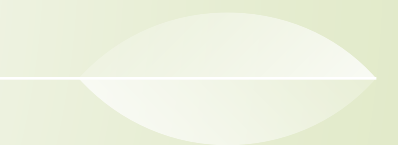
**Antimicrobial Properties:** Many herbs naturally inhibit the growth of bacteria, molds, and yeasts.

**Antioxidant Properties:** They prevent the oxidation of fats, which causes rancidity.

**Flavor Enhancement:** Herbs not only preserve food but also improve its taste.

**Medicinal Benefits:** Herbs provided protection against foodborne illnesses and enhanced health.

**Pest Repellent:** Herbs like peppermint and lavender deter insects and rodents.



# Culinary Herbs are Rich in Volatile Compounds

- **Basil:** methyl eugenol, methyl chavicol, linalool, estragole
- **Dill:** carvone, limonene, and  $\alpha$ -phellandrene
- **Lemongrass:** citral, geranial, neral
- **Marjoram:** terpinen-4-ol, sabinene hydrate
- **Oregano:** carvacrol, thymol
- **Peppermint:** menthol, menthone
- **Rosemary:** 1,8-cineole,  $\alpha$ -pinene, camphor, camphene
- **Sage:**  $\alpha$ -thujone, camphor, 1,8-cineole
- **Thyme:** thymol, carvacrol



# Culinary Spices are Even Richer in Volatile Compounds

- **Cardamom:** 1,8-cineole,  $\alpha$ -terpinyl acetate
- **Cinnamon:** cinnamaldehyde
- **Clove:** eugenol,  $\beta$ -caryophyllene,  $\alpha$ -humulene
- **Coriander:** linalool,  $\gamma$ -terpinene,  $\alpha$ -Pinene
- **Cumin:** cuminaldehyde,  $\gamma$ -terpinene,  $\beta$ -pinene, p-cymene
- **Ginger:**  $\alpha$ -zingiberene,  $\beta$ -phellandrene,  $\beta$ -sesquiphellandrene
- **Nutmeg:**  $\alpha$ -pinene, sabinine, myristicin, 4-turpineol
- **Peppercorn:**  $\alpha$ -pinene,  $\beta$ -caryophyllene, Limonene,  $\beta$ -pinene
- **Turmeric:**  $\alpha$ -turmerone, curcunone,  $\alpha$ -turmerone,  $\beta$ -sesquiphellandrene



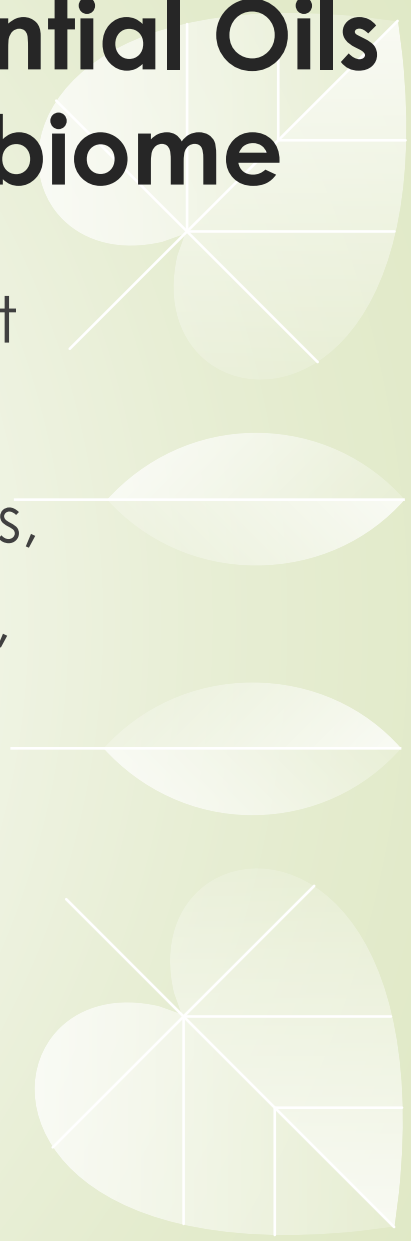
## Part III: Culinary Essential Oils and the Gut Microbiome

- Culinary herbs and spices have been in contact with the human gut for thousands of years
- Culinary herbs and spices have antimicrobial effects
- **Question: are culinary essential oils beneficial or harmful to the gut microbiome? Did they co-evolve?**



## Part III: Culinary Essential Oils and the Gut Microbiome

- ▶ Recent research suggests that essential oils can have both positive and negative impacts, depending on the type, dose, and context of use.



# Essential Oils and Selective Anti-microbial Modulation

Inhibiting pathogenic bacteria while supporting beneficial bacteria

- **Thymol and carvacrol** have been shown to reduce harmful bacteria while promoting the growth of beneficial bacteria like *Lactobacillus* and *Bifidobacterium*.
- **Eugenol**: Has shown the ability to suppress harmful bacteria like *Helicobacter pylori* without significantly affecting beneficial microbes.



# Essential Oils and the Gut Inflammation

## Antioxidant and Anti-inflammatory Effects

- Oxidation and inflammation within the gut create a leaky gut.
- Leaky gut creates further systemic inflammation.
- An inflamed gut produces by-products that preferentially feed the pathogenic bacteria.
  - Amino acids
  - Saturated fats
  - Sugars



# Antioxidant Effects of Culinary Essential Oils

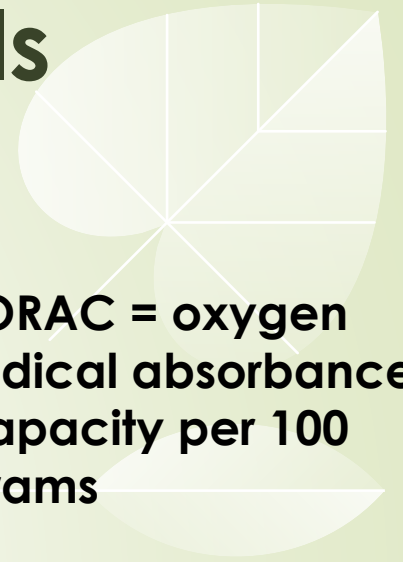
Antioxidant Effects: ORAC\* ratings per 100 g

<u>Clove</u> - 1,078,700	<u>Marjoram</u> - 151,000
<u>Myrrh</u> - 379,800	<u>Ginger</u> - 99,300
<u>Anise</u> - 333,700	<u>Cumin</u> - 82,400
<u>Citronella</u> - 312,000	<u>Black Pepper</u> - 79,700
<u>Coriander</u> - 298,300	<u>Thyme</u> - 15,960
<u>Fennel</u> - 238,400	<u>Oregano</u> - 15,300
<u>Nutmeg</u> - 158,100	<u>Cinnamon Bark</u> - 10,340

\*ORAC = oxygen radical absorbance capacity per 100 grams

ORAC of turmeric powder is around 160,000

ORAC of sumac powder is 312,000



# Anti-inflammatory Effects of Essential Oils

The most anti-inflammatory culinary essential oils

**Thyme**

**Fennel**

**Clove**

**Ginger**

**Peppermint**

**Turmeric ( $\alpha$ -turmerone, not curcumin)**



# Essential Oils and Gut Permeability

## Direct Effects on Gut Tight Junctions

- Several aromatic compounds have been shown to increase the expression of tight junction proteins, often secondary to their anti-inflammatory effects.
  - **Carvacrol**
  - **Eugenol**
  - **Cinnamic aldehyde**
  - **D-limonene**



# Essential Oils and Synergy with Probiotics

- Research indicates that essential oils and probiotics may work synergistically to improve gut health:
- Combining EOs like thyme or oregano with probiotics has been shown to enhance antimicrobial activity against pathogens while supporting beneficial strains.



# Essential Oils and the Gut Microbiome: Potential Risks

- While essential oils have promising effects, they should be used with caution:
- **High doses:** Excessive use of EOs can disrupt the microbiome by killing beneficial bacteria along with harmful ones.
- **Potential toxicity:** Some essential oils, like clove and oregano, are potent and may cause irritation or toxicity if not diluted or used improperly.
- **Individual variation:** The effects of EOs on the microbiome may vary depending on an individual's existing gut health and microbial composition.

# Specific Culinary Essential Oils

- **Cinnamon**
- **Lemon**
- **Oregano**
- **Rosemary**
- **Clove**
- **Peppermint**
- **Ginger**
- **Fennel**



# Cinnamon EO and the Gut

## Antimicrobial Properties

- ▶ Active compounds such as **cinnamaldehyde**, **eugenol**, and **linalool**, have broad-spectrum antimicrobial activity.
- ▶ **Suppress pathogenic bacteria:** has been shown to inhibit harmful microbes like *Escherichia coli*, *Salmonella enterica*, and *Clostridium perfringens*.
- ▶ **Combat antibiotic-resistant bacteria:** has been shown to be effective against antibiotic-resistant strains like *Staphylococcus aureus* and *Helicobacter pylori*.



# Cinnamon EO and the Gut

## Selective Effects on Gut Microbes

- Appears to inhibit harmful bacteria more effectively than beneficial strains, such as *Lactobacillus* and *Bifidobacterium*, which are less sensitive to its effects.



# Cinnamon EO and the Gut

## Anti-inflammatory Effects

- **Cinnamaldehyde** has been shown to reduce gut inflammation
  - lowers oxidative stress
  - protects gut epithelial cells
  - promotes beneficial microbes



A glass bottle of cinnamon essential oil and several cinnamon sticks are shown on the left side of the slide. The bottle is partially filled with a dark liquid, and the sticks are stacked behind it. The background is a light green gradient with a dark green vertical bar on the left.

## Cinnamon EO and the Gut

- **Improved gut barrier function:** Supports the integrity of intestinal epithelial cells, reducing "leaky gut" and promoting a healthier microbiome.
- **Short-chain fatty acids (SCFAs):** Increases the beneficial bacteria that produce SFCA's.
- **Mucus barrier:** Cinnamaldehyde has been shown to increase the number of goblet cells (mucus-producing cells) in pig intestines.

# Cinnamon EO and the Gut

## Potential Risks and Considerations

- High doses may disrupt beneficial bacteria
- High concentrations may irritate intestinal cells
- Variations in individual responses and sensitivities may occur



# Lemon EO and the Gut



## Antimicrobial Properties

- ▶ Lemon EO has demonstrated antimicrobial activity against certain harmful bacteria in the gut, such as *Escherichia coli* and *Salmonella typhimurium*.

# Lemon EO and the Gut

## Modulation of Gut Bacteria

- ▶ Studies suggest that lemon essential oil may selectively inhibit pathogenic bacteria while allowing beneficial microbes like *Lactobacillus* and *Bifidobacterium* to thrive.

# Lemon EO and the Gut

## Anti-inflammatory and Antioxidant Effects

- Active compounds like **D-limonene**, **beta-pinene**, **citral**, and **gamma-terpene** have antioxidant and anti-inflammatory properties.
- Reduce oxidation and inflammation of gut lining
- A healthier gut environment encourages the growth of beneficial bacteria while inhibiting harmful ones.



# Lemon EO and the Gut

## **Support for Digestive Health**

- ▶ Lemon essential oil can stimulate bile production, which helps with digestion and the breakdown of fats.
- ▶ Reduces undigested food that tends to foster growth of harmful bacteria.

# Oregano EO and the Gut

## Antimicrobial Effects

- Reduces pathogenic bacteria such as *Escherichia coli*, *Salmonella*, and *Clostridium difficile*.
- Reduces fungi like *Candida albicans*, which can disrupt gut health when overgrown.
- High doses or prolonged use may harm beneficial gut bacteria (e.g., *Lactobacillus* and *Bifidobacterium*), leading to an imbalance (dysbiosis).



# Oregano EO and the Gut

## Anti-Inflammatory/Antioxidant Effects

- ▶ Reduces gut inflammation by modulating inflammatory pathways.
  - ▶ Carvacrol inhibits pro-inflammatory cytokines
- ▶ Carvacrol and thymol protect gut cells from oxidative stress.
  - ▶ Reduces leaky gut





# Oregano EO and the Gut

## Evidence from Research

- **Antimicrobial Action:** A 2019 study showed that OEO selectively inhibited harmful gut microbes without significantly disrupting beneficial ones when used at low doses.
- **Gut Barrier Integrity:** A 2020 study found that carvacrol enhanced tight junction proteins, reducing leaky gut.
- **Synergy with Probiotics:** OEO combined with probiotics improved microbial diversity and resilience in animal models better than probiotics alone.

# Rosemary EO and the Gut

## Antimicrobial Properties

- **1,8 cineole** has been shown to improve the balance of *Lactobacillus* and *E. coli*
  - Inhibits virulence genes in *E. coli*
  - Does not inhibit non-virulent *E. coli*
- **1,8 cineole** has been shown to inhibit *Salmonella*
- **Alpha pinene** has been shown to increase the susceptibility of the antibiotic-resistant pathogenic bacteria *C. jejuni* to antibiotics



# Rosemary EO and the Gut

## Anti-inflammatory and Antioxidant Properties

- **Antioxidant-rich:** Protects gut lining from oxidative damage.
- **Anti-inflammatory:** Calms gut inflammation and irritation. Has been shown in research to heal ulcers in inflammatory bowel disease.
- **Supports gut-brain connection:** Has been shown to enhance cognitive function and mood in correlation with improved gut health



## Clove EO and the Gut

- **Antimicrobial:** Targets harmful pathogens while supporting gut microbiota balance
- **Antioxidant-rich:** Contains eugenol, a powerful antioxidant that protects gut cells from oxidative stress.
- **Anti-inflammatory:** Reduces intestinal inflammation.



**Evidence:** Eugenol has been shown to improve gut health and reduce oxidative stress in animal studies.

## Peppermint EO and the Gut

- **Antimicrobial:** Targets harmful bacteria like *E. coli* while sparing beneficial bacteria at low doses.
- **Reduces gut spasms:** Helps alleviate irritable bowel syndrome (IBS) symptoms by relaxing intestinal muscles.
- **Improves digestion:** Enhances bile flow and reduces bloating.



# Other Essential Oils and the Gut

## Ginger

- **Microbiome modulation:** May encourage a balance of beneficial bacteria.
- **Anti-inflammatory:** Calms inflamed gut tissues, particularly in IBD.
- **Gut motility support:** Reduces nausea and promotes gut motility .



- **Studies** show ginger essential oil helps improve symptoms of gut dysmotility and inflammation.



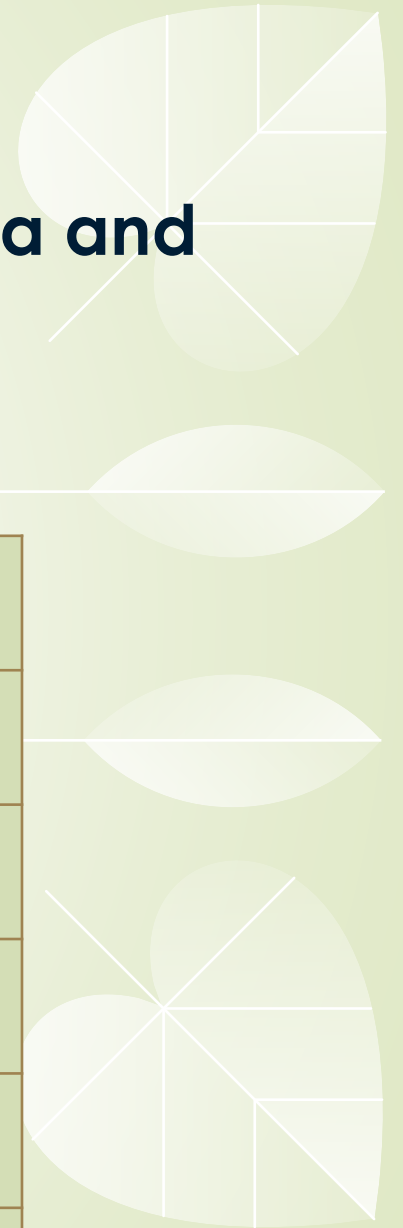
## Fennel and the Gut

- **Antimicrobial:** Helps manage microbial imbalances.
- **Digestive aid:** Eases bloating, gas, and cramping.
- **Gut motility support:** Promotes healthy bowel movements.

# Essential Oils and the Gut Fungi

- **Culinary Essential oils that inhibit fungi including Candida and Saccharomyces in vitro**

Allspice	Marjoram
Cinnamon	Oregano
Clove	Orange peel
Lemon	Rosemary
Lemon grass	Thyme
Mint	



# Conditions that May Warrant Essential Oil Gut Application

- **Small Intestinal Bacterial Overgrowth (SIBO)**
- **Irritable Bowel Syndrome (IBS)**
- **Inflammatory Bowel Disease (IBD)**
- **Leaky gut**
- **Auto-immune Disease**
- **Neurodegenerative Diseases (Parkinson's or Alzheimer's)**
- **Obesity or Type 2 Diabetes**
- **Heart Disease**



# Potential Side Effects of Ingested EOs

- **Gut Dysbiosis:** Prolonged or high-dose use may harm beneficial bacteria.
- **Gastrointestinal Irritation:** Undiluted EOs can irritate the mucosal lining.



# Suggested Safe Use of EOs for Gut Health



1. Use 1–2 drops diluted in a carrier oil or liquid to minimize mucosal irritation and potential disruption to beneficial microbes.
2. Limit use to 7–14 days to avoid long-term microbiome disruption (***long-term phyto-aromatherapy uses much lower doses***).
3. Consider supplementing with probiotics (e.g., yogurt, kefir, sauerkraut, or a quality probiotic supplement) concurrent with and following EO use.

# For Preventive Gut Microbiome Maintenance: Lifestyle

- Eat a variety of high-fiber (soluble and insoluble) foods
  - Fruits, vegetables, whole grains, legumes, nuts, seeds
- Regularly use a variety of herbs and spices in cooking
  - Rich in volatile compounds
- Limit animal protein which increases inflammatory bacteria
- Do Intermittent fasting
  - Has been shown to increase the abundance and diversity of beneficial gut microbes

# Conclusion

- A healthy gut microbiome promotes health and longevity
- Humans have had a relationship with culinary herbs and spices for thousands of years.
- Herbs and spices are rich in volatile compounds.
- Several essential oils have been shown to have a beneficial effect on the gut microbiome and overall gut health.
- Effects are largely due to antimicrobial, anti-inflammatory, and antioxidant properties.
- Essential oils should be used carefully to avoid disrupting the gut's natural balance.

Thank you!

