Objectives

After this session, participants will be able to:

• Summarize the current evidence on dairy food consumption and inflammatory responses as it relates to chronic disease risk and incidence
• Explain how dairy foods provide nutrients that have potential anti-inflammatory effects
• Share tips and recipes that incorporate anti-inflammatory foods including milk, lactose free milk, cheese and yogurt
Disclosures

Research Funding:
- CS Health Solutions
- Fritz Friday Chair of Vegetable Processing Research
- Kikkoman USA R&D Laboratory
- National Dairy Council
- USDA HATCH WIS02094
- USDA NIFA AFRI WIS0909
- UW Dairy Innovation Hub
- UW-Madison Graduate School
- UW-Madison Dept. of Food Science
- Wisconsin Alumni Research Foundation

Honoraria/Travel Support: National Dairy Council

Patent: US Application 17/003,625

What is the “perfect meal”? What is the “perfect diet”?

Dietary Recommendations

DGA: Healthy U.S.-Style Dietary Pattern
DGA: Mediterranean-style Dietary Pattern
DGA: Vegetarian Dietary Pattern
Dietary Approaches to Stop Hypertension (DASH)

Dietary Approaches to Stop Hypertension (DASH)

INFLAMMATION is a vital part of the immune system’s response to injury and infection. It is one of the ways to defend against foreign invaders as well as a way to signal the immune system to heal and repair damaged tissue.
**Chronic Inflammation**

**Characteristics**
- Low-grade & unresolved
- May not have outward symptoms
- Associated with chronic diseases

**Risks**
- Obesity
- Environmental chemical exposure
- Stress
- Nutrition
- Microbiome

**Foods, immune health and inflammation**

**Pro-inflammatory foods**
- Allergic responses: acute, potentially severe immune response
- Celiac disease: immune response to gluten

**Are other foods or nutrients pro-inflammatory or anti-inflammatory?**

**Cells**

**Cytokines**

**Chemokines**

**Biomarkers**
- C-reactive protein (CRP)
- Tumor necrosis factor (TNF)-α
- Interleukins (IL): IL-6, IL-10

**Tissues**
- The gut is an important site of immune function

**Gut**

**Biomarkers**
- C-reactive protein (CRP)
- Tumor necrosis factor (TNF)-α
- Interleukins (IL): IL-6, IL-10

**Tissues**
- The gut is an important site of immune function
Connecting Diet and Immune Health

**Interventions (RCTs)**
- Pre-clinical
- Epidemiological

*Meta-analyses and systematic reviews of observational studies and mechanistic studies can also be possible.


Diet and Lifestyle Factors that Affect Immune Health

**Epidemiological studies**
- Yuan et al., Nutrients 2021;13:506

**Intervention studies**
- Systematic reviews
  - Nieman et al., J. Am. Col. Nuts. 2020;1800532
- Pei et al., J. Nutr. 2018;148:910-6

Overview of Dairy Specific Studies

**Epidemiological studies**
- Yuan et al., Nutrients 2021;13:506

**Intervention studies**
- Systematic reviews
  - Nieman et al., J. Am. Col. Nuts. 2020;1800532
- Pei et al., J. Nutr. 2018;148:910-6

Dairy Foods have Unique Components that Could Benefit Health

**Bioactives**
- α-lactalbumin
- β-lactoglobulin
- Glycosylated peptide lactoferrin
- Lipids

**Bioactives**
- Cultures probiotics peptides metabolites
- Peptides exopolysaccharides

Images: Milk, Cheese: UW-Madison College of Agriculture and Life Sciences (CALS); Yogurt: Michael P. King/UW-Madison CALS
Epidemiology

Dairy Consumption is Associated with Anti-inflammatory Dietary Factors

Development and Validation of Novel Dietary and Lifestyle Inflammation Scores

Reasons for Geographic and Racial Differences in Stroke Study (REGARDS)

N = 14,210 for hsCRP


Outcomes
• DIS, LIS positively associated with hsCRP
• Individual diet and lifestyle factors have modest association with inflammation (hsCRP)
• Aggregation of these factors may have more significant impact on inflammation

Dairy Consumption is Inversely Associated with CRP and IL-6 Biomarkers

“Higher intakes of total dairy, low-fat dairy, full-fat dairy, total cheese, full-fat cheese, and total yogurt (1 serving increments) were associated with lower CRP and IL-6 concentrations, with yogurt showing the largest percent decrease (-10.0%...).”


Epidemiology

Overview of Dairy Specific Studies

Epidemiological studies
• Byrd et al., J. Nutr. 2019;149:2206-2218
• Yuan et al., Nutrients 2021;13:506

Intervention studies
• Systematic reviews
  • Nieman et al., J. Am. Col. Nutr. 2020;1800532
  • Pei et al., J. Nutr. 2018;148:910-6

• Dairy is not “pro-inflammatory”
• Some inverse associations w/ inflammatory biomarkers, esp. yogurt

Table 2. Adjusted mean levels of inflammation biomarkers according to dairy food intake category.

Framingham Offspring Study
n = 1753

Dairy intake from diet records
Biomarkers: CRP, IL-6, TNF-α, ICAM1, MCP1, fibrin

“Results showed that those who consumed yogurt (vs. who did not) had statistically significantly lower levels of interleukin-6 (IL-6) (mean log-transformed levels of 1.33 and 1.26 in consumers/non-consumers, respectively, p = 0.02) and fibrin (mean log-transformed levels of 5.05 and 5.89 in consumers/non-consumers, respectively, p = 0.03); ... no statistically significant associations were observed between any of these inflammation biomarkers and milk or cheese intakes.”

Dairy Foods Do Not Cause Inflammation

The American Journal of CLINICAL NUTRITION

The Effects of Dairy Product and Dairy Protein Intake on Inflammation: A Systematic Review of the Literature

Critical Reviews in Food Science and Nutrition

Dairy products and inflammation: A review of the clinical evidence

Advances in Nutrition

Milk and Dairy Product Consumption and inflammatory Biomarkers: An Updated Systematic Review of Randomized Clinical Trials

Systematic Review

27 Randomized Control Trials

"This systematic review shows that consumption of dairy products [i.e., milk, cheese, yogurt] and proteins [i.e., whey, casein] has neutral to beneficial effects on biomarkers of inflammation."

Systematic Review

52 Clinical Trials

"Our review suggests that dairy products, in particular fermented products, have anti-inflammatory properties in humans not suffering from allergy to milk, in particular in subjects with metabolic disorders."

Systematic Review

16 Studies

"The consumption of milk or dairy products did not show a proinflammatory effect in healthy subjects or individuals with metabolic abnormalities."

Interventions (Review)

N = 52 intervention studies

Conclusions:

• Overall, net anti-inflammatory trend observed in both LF and HF dairy products
• Pro-inflammatory effects in allergic subjects

"The IS was strongly indicative of an anti-inflammatory activity in subjects with metabolic disorders and of a pro-inflammatory activity in subjects allergic to bovine milk."

Recent RCTs Do Not Support a “Pro-inflammatory” Effect of Dairy Consumption in Healthy Adults - Rather the Trend is Anti-inflammatory

Systematic review

N = 16 intervention studies,
1/12 - 4/18

Conclusions:

• Lack of pro-inflammatory effect in healthy or overweight/obese participants
• Weak anti-inflammatory effect in healthy and metabolically abnormal adults with long-term supplementation, but inconclusive from short-term interventions

The consumption of milk or dairy products did not show a proinflammatory effect in healthy subjects or individuals with metabolic abnormalities. The majority of studies documented a significant anti-inflammatory effect in both healthy and metabolically abnormal subjects, although not all the articles were of high quality.

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The consumption of milk or dairy products did not show a proinflammatory effect in healthy subjects or individuals with metabolic abnormalities. The majority of studies documented a significant anti-inflammatory effect in both healthy and metabolically abnormal subjects, although not all the articles were of high quality.
After 9 Weeks, Yogurt Improves Markers of Chronic Inflammation and Metabolic Endotoxemia in Obese & Non-obese Women

<table>
<thead>
<tr>
<th>Marker</th>
<th>(O) Yogurt</th>
<th>(O) Control</th>
<th>(N) Yogurt</th>
<th>(N) Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>sCD14</td>
<td>↔</td>
<td>↔</td>
<td>↔</td>
<td>↔</td>
</tr>
<tr>
<td>LBP/sCD14*</td>
<td>-5%</td>
<td>+11%</td>
<td>+12%</td>
<td>+17%</td>
</tr>
<tr>
<td>Endocab*</td>
<td>+5%</td>
<td>-1%</td>
<td>+6%</td>
<td>-2%</td>
</tr>
</tbody>
</table>

IL-6 ↔ ↔ ↔ ↔
hsCRP ↔ ↔ ↔ ↔

TNF-α/sTNFRII* -7% -2% -8% +10%
P<0.05, *treatment, #obesity, interaction


Pre-meal Consumption of Yogurt Prevents Post-prandial Inflammation and Barrier Dysfunction

960 kcal
56-60 g fat
82 g carbohydrate
28-30 g protein

Inflammatory cocktail (IC) + TNF-α, IFN-γ, IL-1β, L, PS

Chronic Inflammation Reduces Intestinal Barrier Function

Tight Junctions in Caco-2 cells
Green = ZO-1
Blue = Nuclei

Yogurt Prevents Intestinal Barrier Dysfunction

Lyophilized yogurt powder retains capacity to inhibit barrier disruption of Caco-2 cells by inflammatory cytokines. Yogurt powder was tested at 30 mg/mL after >3 y storage at -20°C. Inflammatory cocktail consisted of TNF-α, IL-1β, and IFN-γ at concentrations previously described (Poll et al., 2016). TEER was measured by CellZScope (nanoAnalytics). Data are means ± SEMs, n = 6 per group. **P < 0.001 for time, treatment and interaction by two-way repeated measures ANOVA.
Yogurt Prevents Loss of Tight Junctions in Inflamed Caco-2 Cells

Take Home Messages
- Dairy is not pro-inflammatory, some studies indicate anti-inflammatory effects.
- Still working to understand the importance of food, diet, and immune health.
- Healthful dietary patterns still advised and include dairy.
- Certain foods might modestly reduce biomarkers of inflammation, but more work is needed to confirm importance with chronic disease risk.

Emerging evidence
- Scientific agreement
- Consensus

Collaborators
- Richard Bruno
- Heather White
- Cameron Scarlet

Grad Students
- Ruisong Pei (PhD)
- Kelley Putt
- Diana DiMarco
- Derek Martin

Undergraduates
- Yiming Chen
- QinLei Gu

Research Support
- National Dairy Council
- USDA HATCH WIS02094

UW-Madison Dept. Food Science

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- Bradley Bolling
- A103B Babcock Hall
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- 608-890-0212
- bwbolling@wisc.edu

Dietary Guidelines for Americans, 2020-2025

- 3 c dairy for 1,600 to 3,200 kCal
- 2020-2025 Dietary Guidelines for Americans state:
  "A healthy dietary pattern is associated with beneficial outcomes for all-cause mortality, cardiovascular disease, overweight and obesity, type 2 diabetes, bone health, and certain types of cancer (breast and colorectal)...."
I currently serve as a National Dairy Council Ambassador for this presentation, including:

- Honoraria

*Other Disclosures:* California Grapes, Soy Institute, Plenity, National Cattlemen’s Beef Association
What are people saying about dairy?

Dairy in the media
in celebrity media spokespeople

“Chemical defoamers are added to yogurt.”

No: Coffee, alcohol, caffeine, tomatoes, peppers, mushrooms, eggplants, fungus, dairy, gluten, corn, soy, added sugar, artificial sweeteners, MSG, GMOs.

“Don’t drink less than 2% milk because it contains more sugar than full fat”

“I just tried a goat milk cleanse for eight days to rid my system of parasites.”

Dairy in the community
in our hometowns
Dairy and dietary recommendations

Conflicting Information Creates “Confusion”

59% Strongly or Somewhat Agree

78% Encounter a lot of conflicting information

80% Strongly or somewhat agree


What are the science-based recommendations on inflammation?

Anti-Inflammatory lifestyle practices

50% Stress

21% Exercise

40 M Sleep

American Psychological Association

National Institute of Health

Sleep Association
Stress Causes Inflammation

- Acute, high intensity, or unaccustomed exercise causes the skeletal muscles to release pro-inflammatory molecules.
- A single bout of exercise may elevate oxidative stress which increases inflammation.
- According to research, exercise decreases inflammation in the long term by:
  1. Reducing fat mass
  2. Increasing the production of anti-inflammatory molecules

Exercise recommendations for adults

Cardiovascular training
- All healthy adults aged 18–65 years should participate in moderate intensity aerobic physical activity for a minimum of 30 min on five days per week, or vigorous intensity aerobic activity for a minimum of 20 min on three days per week.

Weight training
- Every adult should perform activities that maintain or increase muscular strength and endurance for a minimum of two days per week.

Sleep and Impact on Inflammation

Impact of Poor Sleep
- Fatigue
- Growth hormone
- Immune system
- Testosterone
- Obesity
- Increased cortisol

Impact of Good Sleep
- Fatigue
- Mood
- Better reaction time
- Regulates metabolism
- Anti-inflammatory properties when prolactin released
- Muscle repair
MYTH 1: Dairy products cause inflammation

Dairy foods reduce inflammatory biomarkers

Foods Found to Reduce Inflammatory Biomarkers
- Apples
- Berries
- Tomatoes
- Deep yellow and orange fruits and vegetables
- Dairy foods (e.g., whole and low-fat milk, cheese and yogurt)
- Leafy green vegetables
- Cruciferous vegetables
- Nuts
- Legumes
- Fish
- Poultry
- Coffee
- Tea


The evidence is clear – dairy foods do not cause inflammation

Case study: Feared Dairy Caused inflammation

Meet Victor
- Lost 93 pounds over 2 years
- Gained 100 pounds on his bench press

Resources and recipes available on USDairy.com

Client testimonials have approved with Jim White Fitness Inc. to showcase their success stories for all and any presentation materials.
MYTH 2: Lactose Intolerance = Lactose Avoidance

What’s the difference between milk allergy and lactose intolerance?

**Prevalence**
- **Milk Allergy**: More common in children 0 to 3 years old (2.5%); 89% outgrow by 16 years.
- **Lactose Intolerance**: Rare in young children.

**Mechanism**
- **Milk Allergy**: Reaction to milk protein (i.e., casein).
- **Lactose Intolerance**: Intolerance to milk sugar (lactose).

**Symptoms May Include**
- Mild or severe symptoms involving skin, mouth, lungs, heart, gut and brain.
- Abdominal pain, flatulence, bloating and/or diarrhea.

**System Impacted**
- Response triggered by the immune system.
- Gastrointestinal (GI) response from an inadequate supply of lactase enzyme, which breaks down lactose.

**Management**
- **Milk Allergy**: Avoid milk and milk products (unless allergy is outgrown).
- **Lactose Intolerance**: Find management strategies that work for them like inclusion of low lactose dairy foods and lactose-free milk.

### Dairy Food Serving Size Lactose (g)* Did You Know?

<table>
<thead>
<tr>
<th>Dairy Food</th>
<th>Serving Size</th>
<th>Lactose (g)</th>
<th>Did You Know?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-fat and fat free milk</td>
<td>8 oz</td>
<td>12g</td>
<td>Try small amounts of milk in smoothies, on cereal or with meals.</td>
</tr>
<tr>
<td>Lactose-free cow’s milk</td>
<td>8 oz</td>
<td>0g</td>
<td>Lactose-free cow’s milk is real milk – just without the lactose.</td>
</tr>
<tr>
<td>Ultra-filtered milk</td>
<td>8 oz</td>
<td>0g**</td>
<td>Most ultra-filtered milks have lactase enzyme to lower the lactose.</td>
</tr>
<tr>
<td>Fat-free plain Greek yogurt</td>
<td>1 cup</td>
<td>6.5g</td>
<td>There is less lactose in Greek yogurt because the straining process removes some of the lactose.</td>
</tr>
<tr>
<td>Mozzarella cheese ***</td>
<td>1.5 oz</td>
<td>0.3g</td>
<td>Due to the steps in cheese making and natural aging, natural cheese contains minimal amounts of lactose.</td>
</tr>
<tr>
<td>Cheddar cheese ***</td>
<td>1.5 oz</td>
<td>1.25g</td>
<td>Processing milk to make cheese lowers the lactose content.</td>
</tr>
<tr>
<td>Processed American cheese</td>
<td>2 oz</td>
<td>1.4g</td>
<td>American cheese, which is made from natural cheese, does not contain much lactose.</td>
</tr>
<tr>
<td>Ricotta cheese</td>
<td>½ c</td>
<td>&lt;1-4g</td>
<td>Ricotta cheese - a soft, natural cheese can contain minimal amounts of lactose.</td>
</tr>
<tr>
<td>Ice cream</td>
<td>½ c</td>
<td>14g</td>
<td>There are lactose-free cow’s ice creams available.</td>
</tr>
<tr>
<td>Cream</td>
<td>1 Tbsp</td>
<td>&lt;1g</td>
<td>Cream for coffee has minimal lactose.</td>
</tr>
</tbody>
</table>

*A Food Data Central database: https://fdc.nal.usda.gov/*

**Case study: Feared Milk Bothered Her Stomach**

- **Weight Lost**: 70 lbs
- **Timeframe**: 1.5 years
- **Body Composition**: Lost 14% body fat
- **Muscular Strength**: Is able to do step ups with 10 lbs
- **Started incorporating dairy and plants**
- **Decreased fiber from 65 g to 25 g**

Client testimonials have approved with Jim White Fitness Inc. to showcase their success stories for all and any presentation materials.
Super restrictive diets

Elimination of dairy = benefits lost

<table>
<thead>
<tr>
<th>Dairy Food</th>
<th>Protein</th>
<th>Leucine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-fat Cheddar Cheese (1 oz)</td>
<td>7 g</td>
<td>0.61 g</td>
</tr>
<tr>
<td>Low-fat Milk (regular or lactose-free)</td>
<td>8.5 g</td>
<td>0.8 g</td>
</tr>
<tr>
<td>Low-fat Cottage Cheese (4 oz)</td>
<td>14 g</td>
<td>1.44 g</td>
</tr>
<tr>
<td>Low-fat Greek Yogurt (8 oz)</td>
<td>18.5 g</td>
<td>1 g</td>
</tr>
<tr>
<td>Whey Protein Isolate Powder (unflavored)</td>
<td>24 g</td>
<td>3.2 g</td>
</tr>
</tbody>
</table>

Dairy delivers protein along with great taste

Nutrition information obtained from:
USDA FoodData Central:
Low-fat Cheddar Cheese (173439) Low-fat milk (170873) Cottage cheese (173417) Strawberry Greek yogurt (171300)
https://fdc.nal.usda.gov/fdc-app.html#/ 


Milk is a good or excellent source of 13 essential nutrients.

+ FDA's Daily Value (DV) for potassium of 4700 mg is based on a 2005 DRI recommendation. In 2019, NASEM updated the DRI to 3400 mg. Based on the 2019 DRI, a serving of milk provides 10% of the DRI. FDA rule-making is needed to update this value for the purpose of food labeling.

#HaveAPlantWithDairy

- Cheese + apple
- Yogurt + blueberries + nuts
- Milk + fruit
- Cottage cheese + cucumbers
- Grilled halloumi and veggie skewers
- Veggie grain bowl with cheese
- Veggies + ranch-style Greek yogurt dip
- Fruit smoothie w/spinach

Anti-inflammatory meal plan

- **Breakfast:** Plain yogurt, handful of nuts, handful of blueberries, coffee
- **Snack:** Avocado toast with smoked salmon, cucumber, tomato, tea
- **Lunch:** Salad with chicken, topped with cheese + Greek yogurt dressing
- **Snack:** Almond butter + apple
- **Dinner:** Fish, veggie + brown rice bowl
• 3 servings dairy a day
• Limit inflammatory foods and habits
• Include anti-inflammatory foods
• However, we can enjoy ALL foods!