Will plant protein foods led to a healthier and more sustainable diet?

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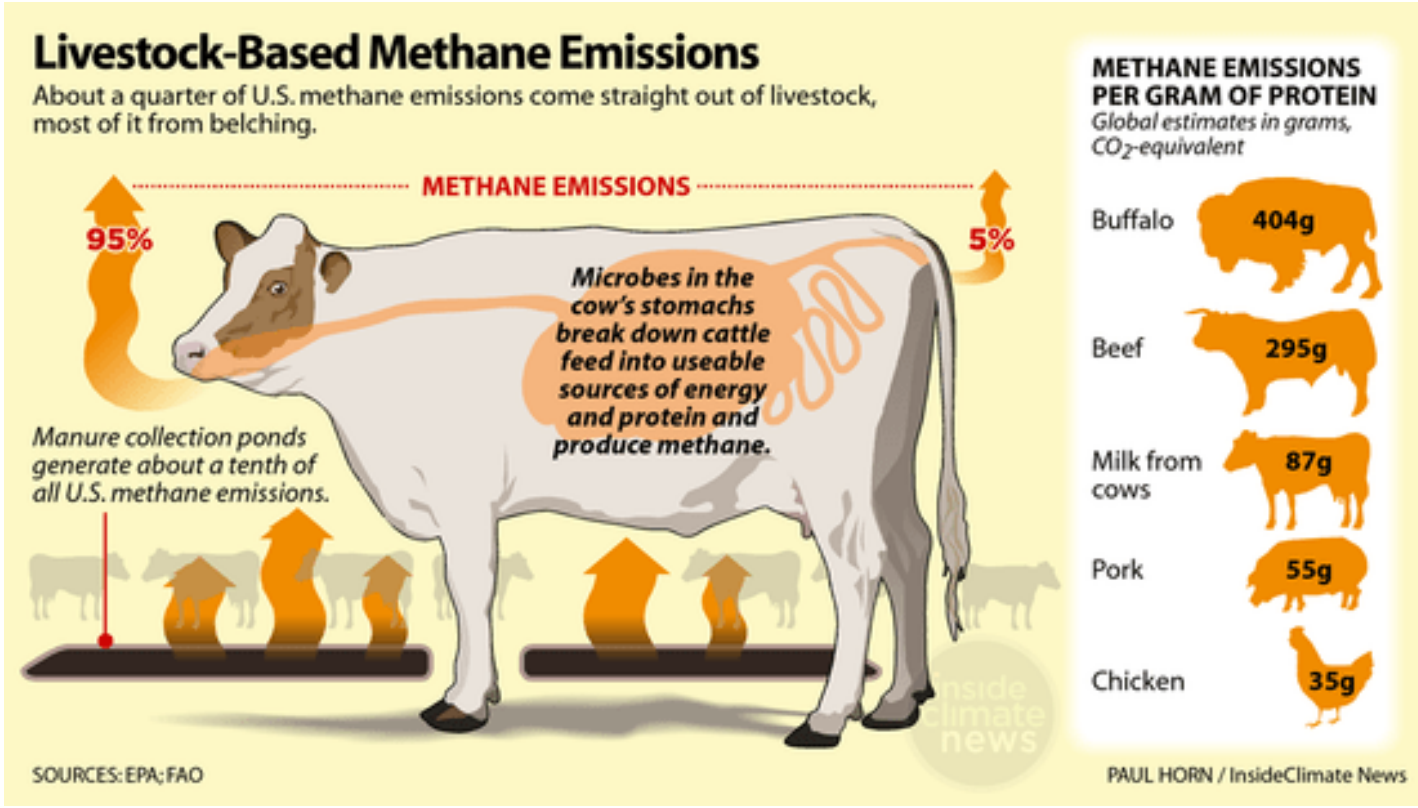
Minimalization of Animal Foods

- Nutrition
  - Decrease saturated fats
  - Minimize processed meats
    - High in sodium
- Ethical Concerns
- Sustainability

Sustainability Challenges

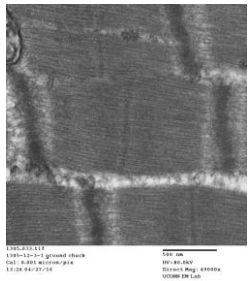
- Livestock Production Costs
  - Producing 1 lb meat costs
    - Beef = 5-20 lb feed
    - Pork = 3 lb feed
    - Chicken = 2 lb feed
    - Fish = 1.2 ?
  - Could use land for animal fed for human food
  - Methane – green house gas
    - Produced in rumen
    - Produced by manure processing

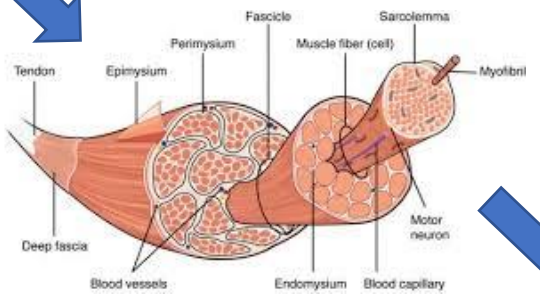


Plant Based Dairy Substitutes

- Can have lower energy density
  - Less sugar and protein
- Higher in Fiber
- Supplemented to provide nutritional profile similar to dairy
  - calcium and vitamins A, D &E
- Plant proteins have similar functionality to dairy proteins

Plant Based Muscle Foods Challenges

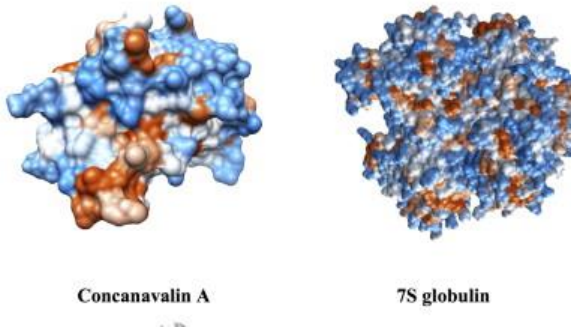




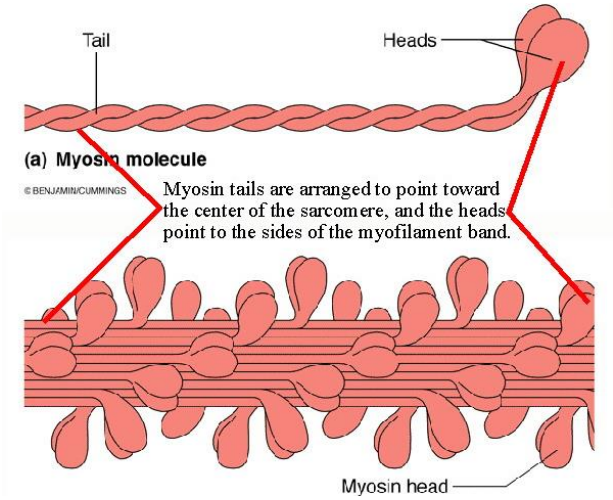
Meat Striation

Most plant proteins function as a reservoir of amino acids for the germinating seed, not as structural proteins.

Plant vs Muscle Protein



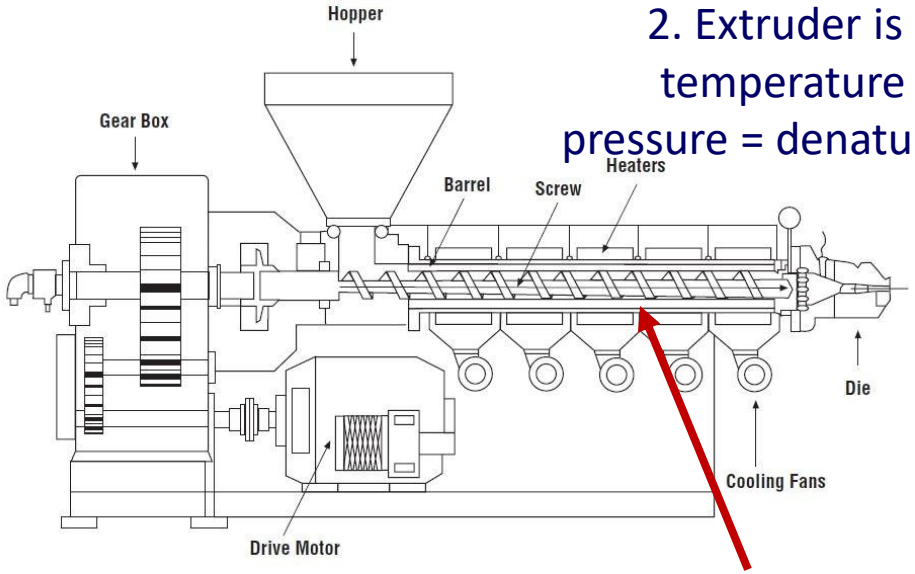
Soy Proteins



Myosin

Production of plant based meat substitutes

1. Protein isolate is mixed water in passed through extruder



2. Extruder is at high temperature under pressure = denatures proteins

- Product exits die
- Water flash evaporates to make fibrous structure
- Fibers are cut

3. Screw aligns denatured protein to make fibrous texture

Beyond Meat Ingredients

Flavor/flavor enhancers

Protein = structure

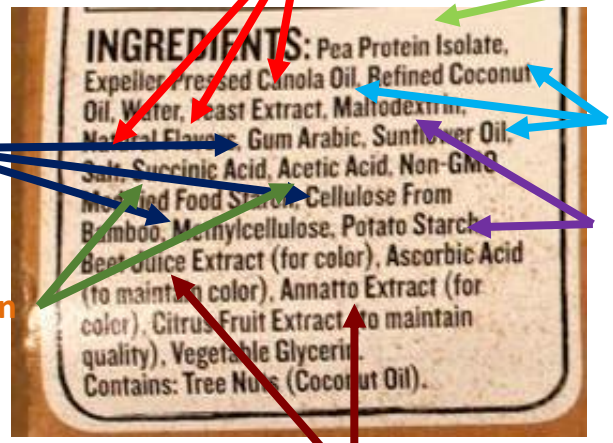
Gums/Cellulose
= structure/binding

Fat = moistness/lubrication

Starches= moisture binding

Acids = protein moification

Color



Are plant based animal substitutes the best way to sustainability and health?

- Replacement of animal proteins with plant proteins will increase sustainability
- Not always a healthier option

Is meatless fast food really healthier for you?

MarketWatch compared nutritional value and the cost of meat and meatless menu items at popular fast food chains

BURGER KING	IMPOSSIBLE WHOPPER	WHOPPER
Price	$5.19*	$4.19
Calories	630	660
Fat	34 grams	40 grams
Saturated fat	11 grams	12 grams
Sodium	1,240 milligrams	980 milligrams
Protein	25 grams	28 grams
MCDONALD'S	**MCVEGAN**	**BIG MAC**
Price	$5.80	$3.99
Calories	438	540
Fat	21 grams	28 grams
Saturated fat	1.9 grams	1 gram
Sodium	n/a	940 milligrams
Protein	7.5 grams	25 grams
WHITE CASTLE	**IMPOSSIBLE SLIDER**	**ORIGINAL SLIDER**
Price	$1.99	$0.72
Calories	210	140
Fat	11 grams	7 grams
Saturated fat	4 grams	2.5 grams
Sodium	550 milligrams	380 milligrams
Protein	11 grams	6 grams
DEL TACO	**BEYOND TACO**	**REGULAR DEL TACO**
Price	$2.49	$1.49
Calories	300	300
Fat	19 grams	18 grams
Saturated fat	10 grams	12 grams
Sodium	510 milligrams	410 milligrams
Protein	19 grams	18 grams

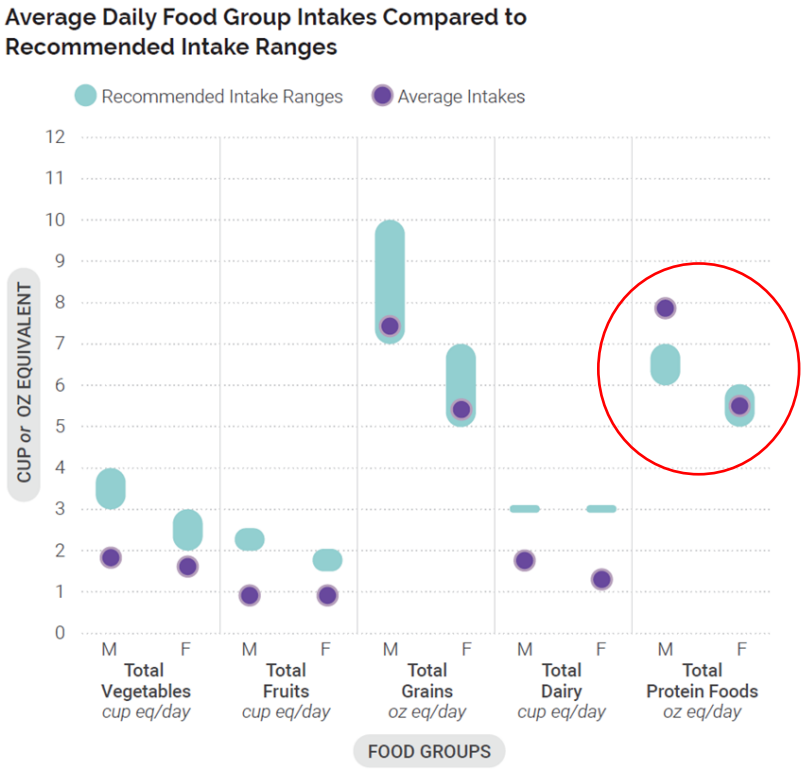
*Price varies per location

Source: MarketWatch reporting

By ultra-processed food definition, even though the plant based meats have similar or better nutrition value they would be less healthy than minimally processed meats

Are plant based animal substitutes the best way to increase sustainability and health?

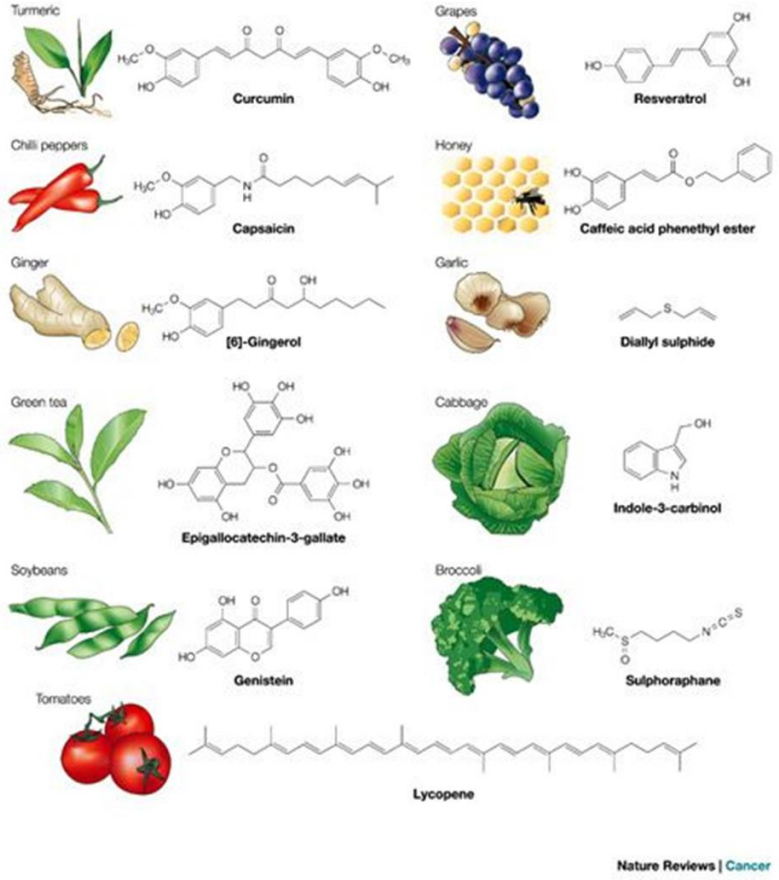
- Any decrease in animal foods will increase sustainability
- Should the focus be on plant proteins?
- Do we need more protein in the diet?



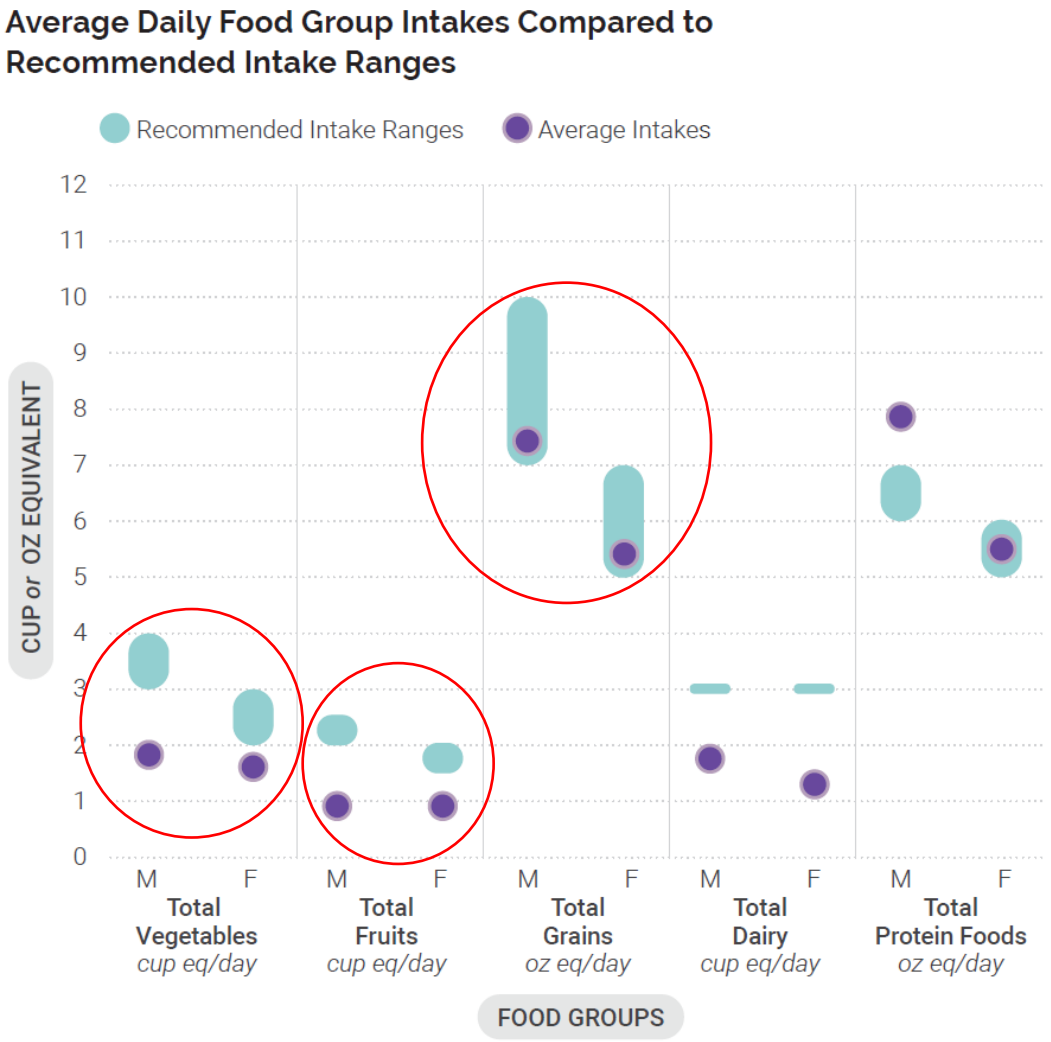
U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Dietary Guidelines for Americans, 2020-2025*. 9th Edition. December 2020. Available at DietaryGuidelines.gov.

Replace animal foods with fruits, vegetables and whole grains

- Sustainable
- Caloric density is low
  - Depends on preparation
- Nutrient density is high
  - Kale, chocolate, potatoes, berries, whole grains, etc
- Bioactive food components
- Very strong link to better health outcomes
  - Obesity, Heart Disease, Diabetes and Cancer



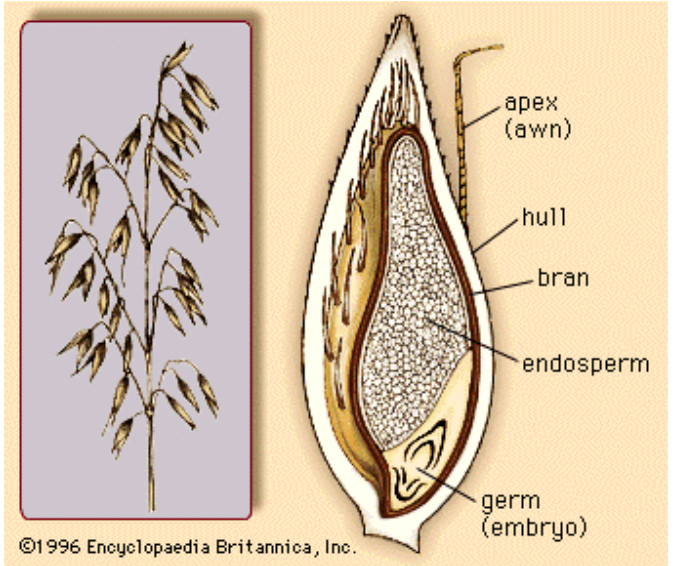
Fruits, Vegetables and Whole Grains are Under Consumed



Why is it so Hard to Increase Consumption of Healthy Fruits, Vegetables and Whole Grains?

Biology of Fruits

- Fruits = sweet and fleshy product of a tree or other plant that contain seeds and can be eaten as food.
  - Evolution developed fruits with flavor, color and aroma so they were eaten
  - Seeds are indigestible so the animal moves the seeds to a new location
- Grains are similar in that the husk/hull makes the seed indigestible



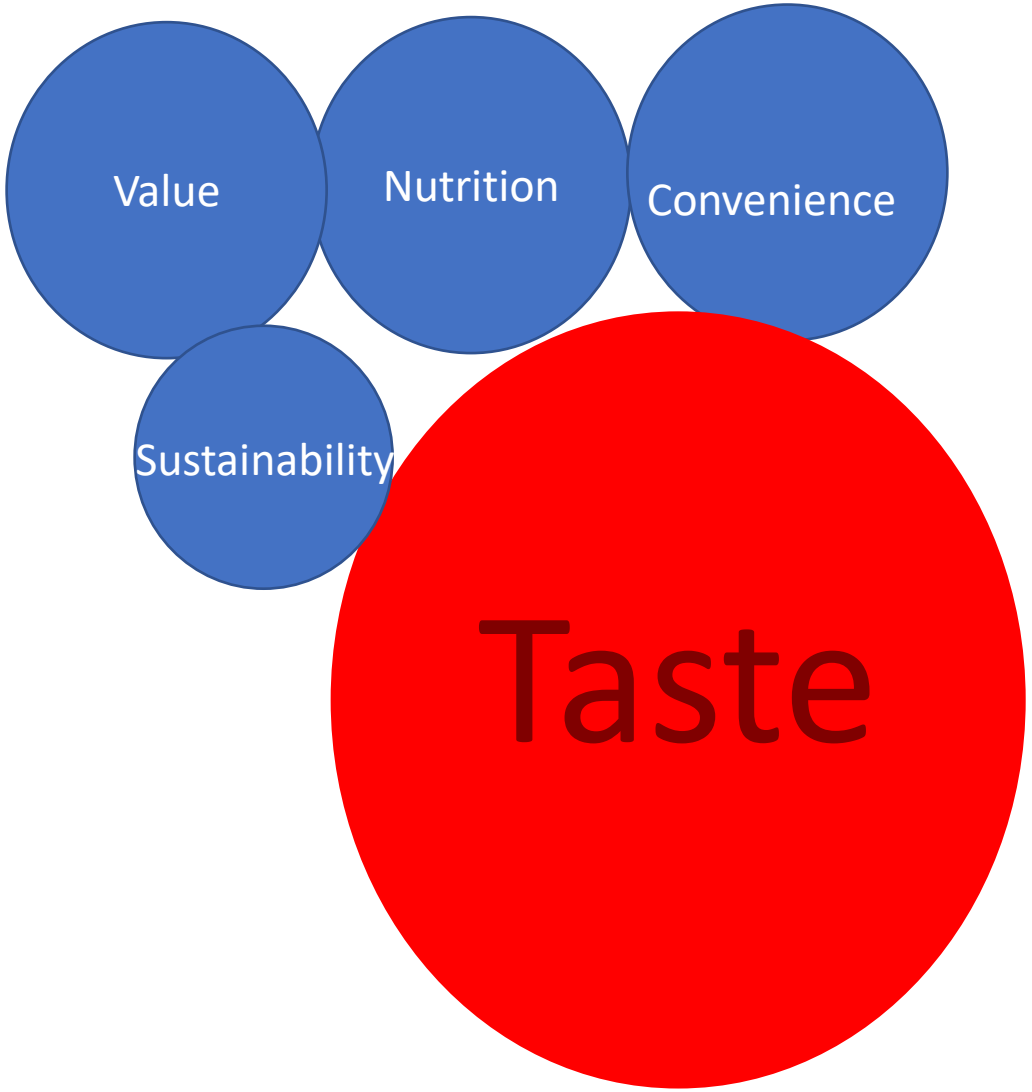
Biology of Vegetables

- Vegetables - the edible portion of a plant including leaves (lettuce), stems (celery), roots (carrot), tubers (potato), bulbs (onion) and flowers (broccoli).
- These parts of a plant function to help in the production of seeds so if they are eaten, the plant does not regenerate
- Vegetables have evolved a series of defenses to keep from being eaten
  - Antinutritional compounds
  - Off-flavors and aromas

Plant Antinutritional compounds

- Plants minimize the ability of animals to obtain nutrients as a strategy to not be eaten
  - Digestive enzyme inhibitors – protease and amylase
    - Destroyed by cooking
  - Mineral sequestrants
    - Oxalic acid – calcium - rhubarb
    - Phytic acid – iron – many plants
  - Decreases mineral bioavailability
    - Iron absorption from spinach = 2% vs 20+% for meat

Drivers of Food Purchases

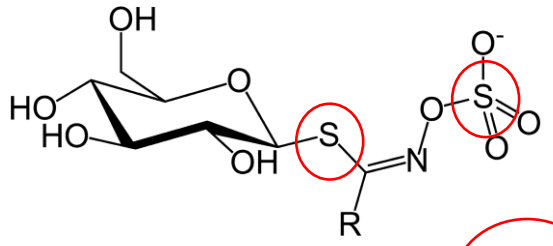


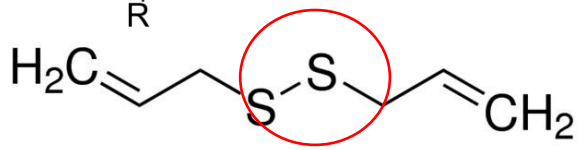
Fruits vs Vegetables

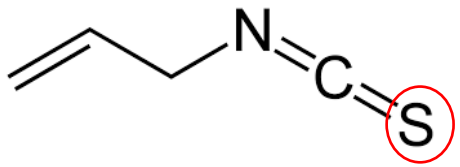
- Because of their biology, fruits are more expectable to most people
  - Still not eating much
  - Fruits 12% of recommendation, Vegetable 9% of recommendation
- Retail fruit flavor not optimal
  - Varieties chosen for yield, size and durability
  - Harvest unripe and ripening often uneven
    - Honeydew melons

Vegetable Flavors – Love Them or Hate Them

- Cabbage family
  - Glucosinolates
- Garlic Family
  - Diallyl disulfide
- Ginger and Horseradish – volatile spicy
  - Gingerol and allyl isothiocyanate
- Beets
  - Geosmin – dirt flavor
- Wheat bran
  - Tannins
- Sensitivity varies with age
- Sensitivity improves as a function of the diets of pregnant and breast feeding women



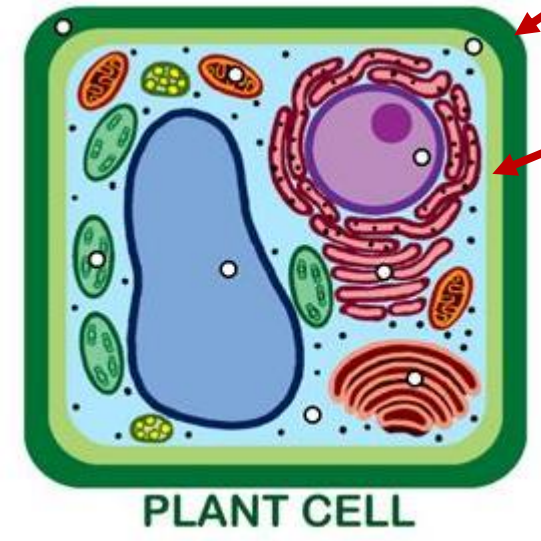


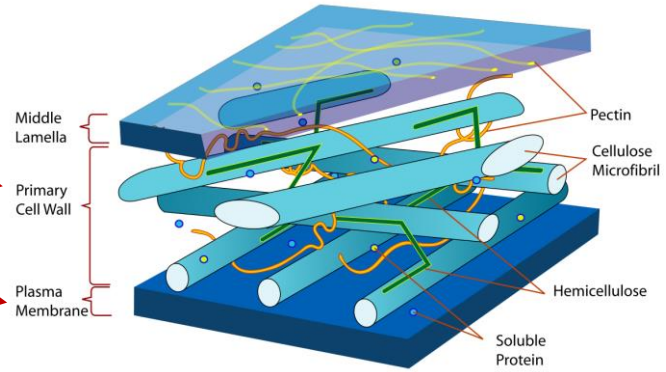


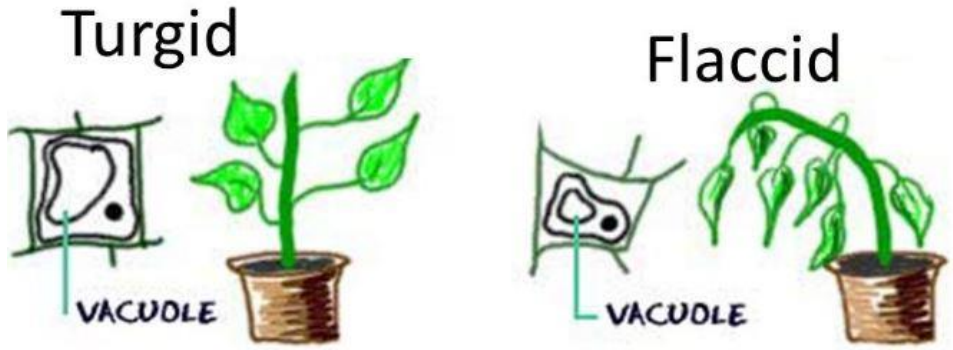
Fiber and acceptability

- Fruits, vegetables and whole grains are important sources of dietary fibers
- Dietary fibers are not digested by human enzymes
  - Large amounts of undigested fiber will bind water and cause diarrhea
- Dietary fibers can be digested by the microbiome
  - Digestion in the microbiome produces gas (carbon dioxide) that causes flatulence
- Oligosaccharides in beans and cabbage are also a source of microbial carbon dioxide
  - Beano

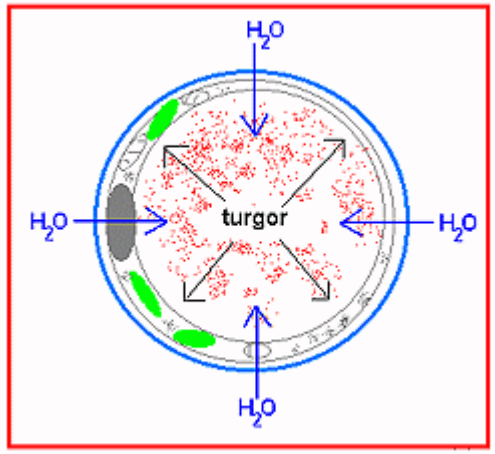
Texture and Acceptability







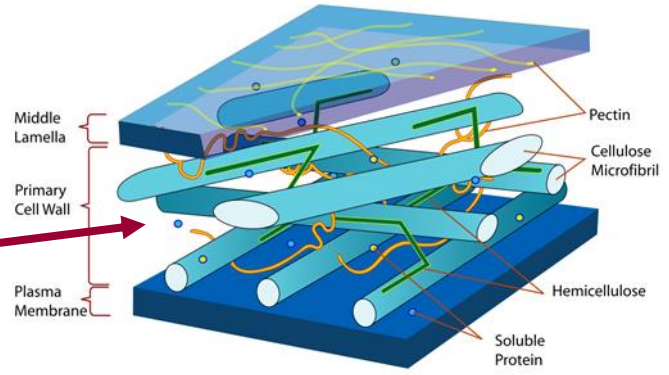
Turgor Pressure



Creates Crip Texture

Destruction of cell wall (turgor) creates positive and negative textures

- Positive
  - Soften texture during fruit ripening
    - Enzyme degradation of pectin
  - Soften texture during cooking
    - Asparagus, brussels sprouts, green beans, broccoli, etc
- Negative
  - Softening during cooking
    - Makes it difficult to heat preserve = lettuce
    - Can minimize with calcium
  - Softening during freezing
    - Large ice crystals burst cell wall

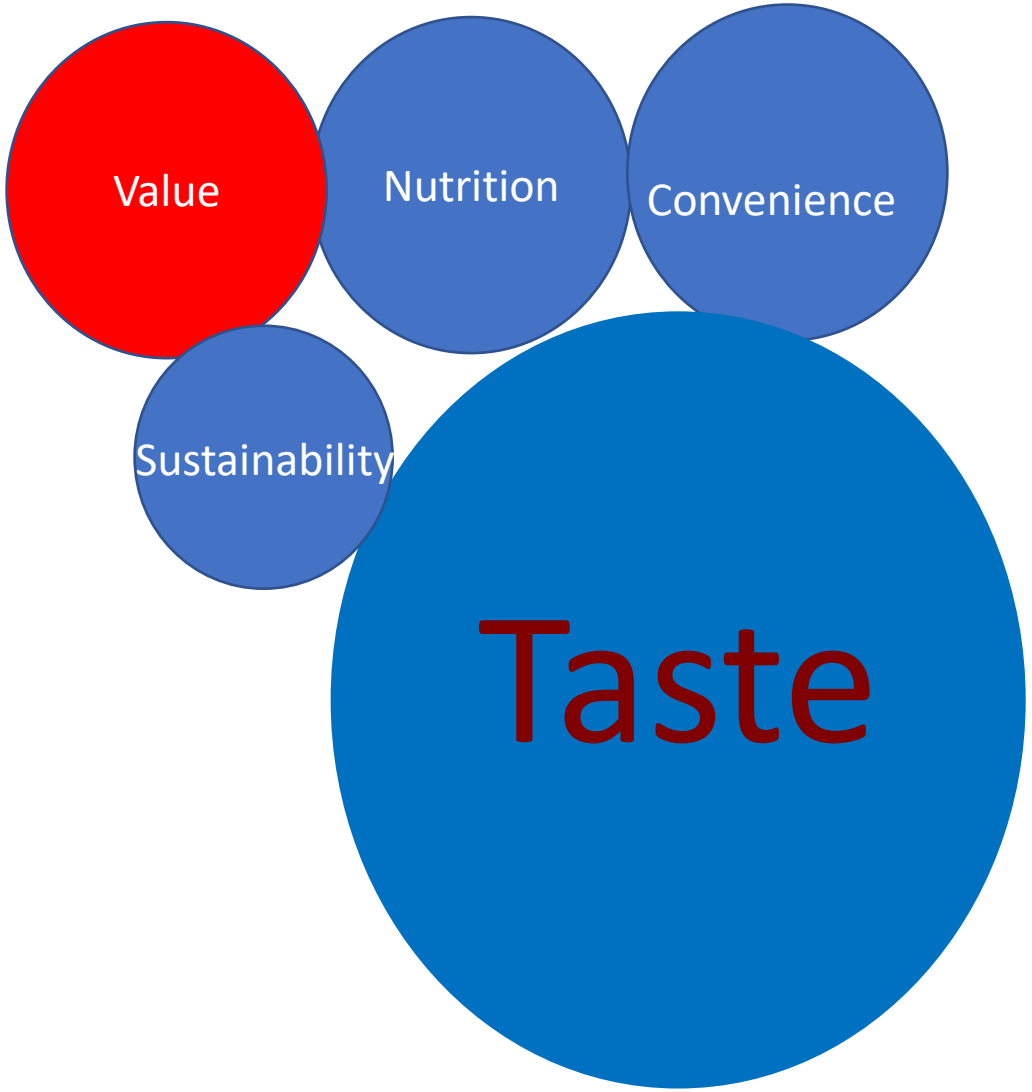


Freezing fruits and vegetable can alter turgor pressure

- Frozen water is less dense (bigger) than liquid water
- When freezing fruits and vegetable, the ice crystal gets larger and can burst the plant cell
- When the cell is damage this decreases turgor pressure
  - Frozen green beans
- Rapid freezing makes small ice crystals and superior quality
- Individually quick frozen foods

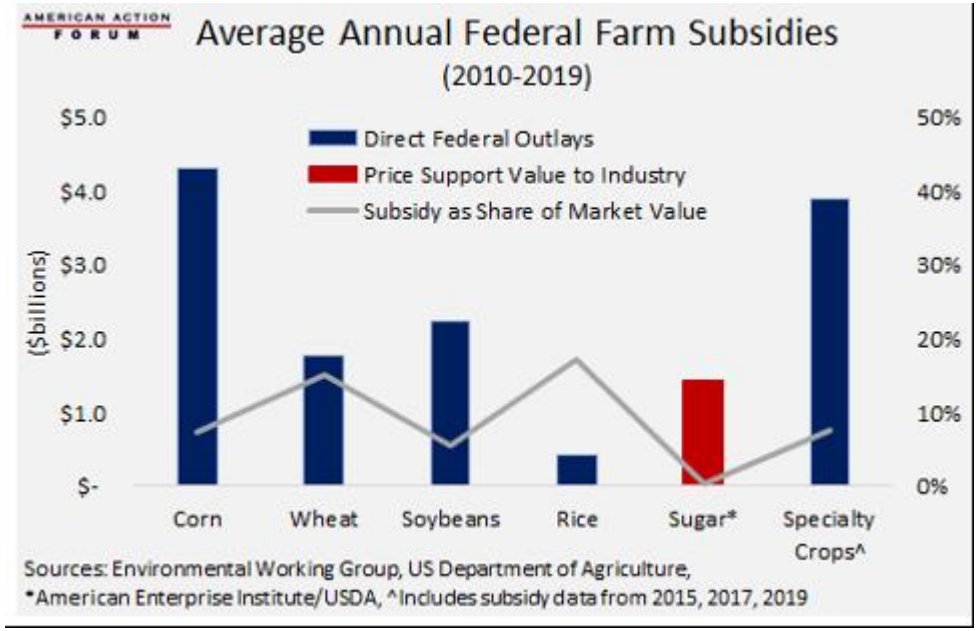
- Must keep frozen at all times
  - Refreezing makes large crystals

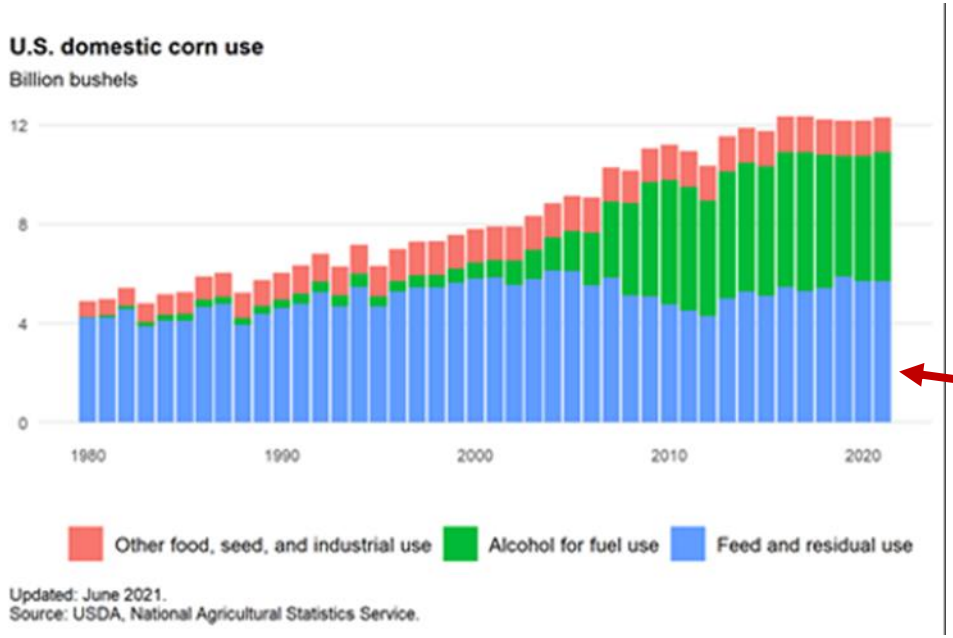
Drivers of Food Purchases



Economics of Fruits, Vegetables and Whole Grains

- Fresh fruits, vegetables and whole grains are expensive
  - Lack of government subsidies for fruits and vegetable





Animal Feed

Economics of Fruits, Vegetables and Whole Grains

- Fresh fruits, vegetables and whole grains are expensive
  - Lack of government subsidies for fruits and vegetable
  - Short shelf life = ↑ food waste = ↑ price
    - bananas, avocados, berries, green beans, tomatoes, greens
  - Transportation costs can be high if not local
  - Whole wheat and rancidity
  - Supply and demand
  - Difficult to preserve by processing = longer shelf-life = lower price

= $4.99

= $8.30

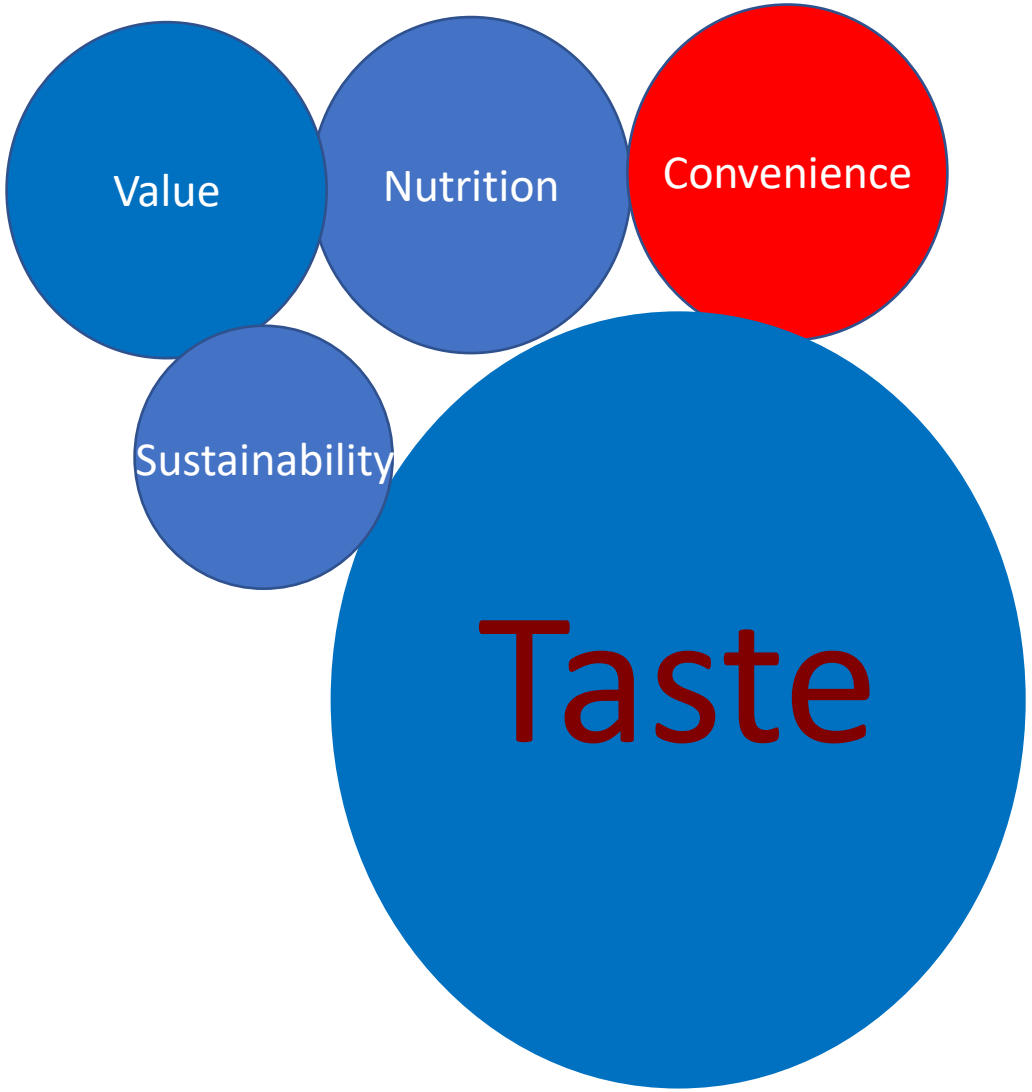
How important is cost vs taste

Most purchased vegetables	Value- Cost/serving
1. Potato	$0.06/serving
2. Tomato	$0.21/serving
3. Onion	$0.12/serving
4. Corn	$0.21/serving
5. Green beans	$0.13/serving
18 Asparagus	$0.66/serving
30. Kale	$0.19/serving

Suggests that value and taste are large drivers of vegetable choices

Challenges with Whole Grains

Drivers of Food Purchases



Processing to Increase Ease of Preparation

Wheat

Cracked

Cooked and Dried

Farro = 40 min

Cracked Wheat = 20 min

Bulgar= 12 min

Processing to Increase Ease of Preparation

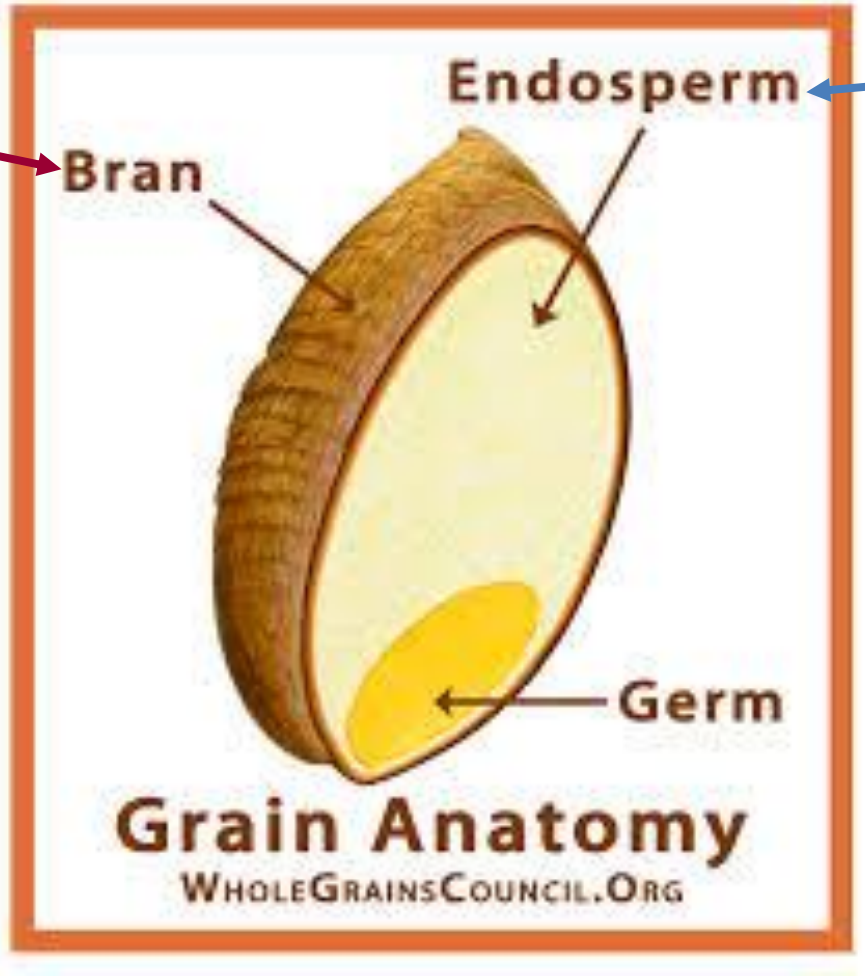
Pre-Gelatinization

- Pre-cook grain and then dry
- Dried grain is more porous allowing for rapid absorption of water and quicker cooking
- Usually fortified with minerals and vitamins lost during processing

Roles of Whole Grains Components on Food Quality

Endosperm

Insoluble fibers, flavonoids, proteins



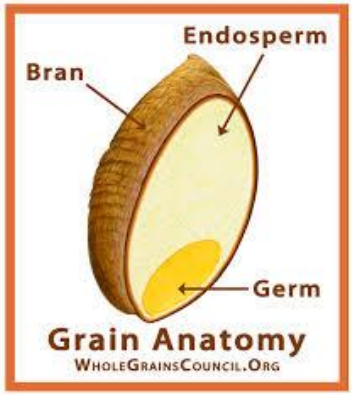
Starch (84%), fiber (3%) and protein (11%)

This is the major key to wheat functionality attributes because it's the source of gluten and starch.

- **Gluten provide dough elasticity = volume**
- **Starch provides crumb = moistness**

The additional components in whole wheat flour decrease the concentration of gluten and starch which changes functionality

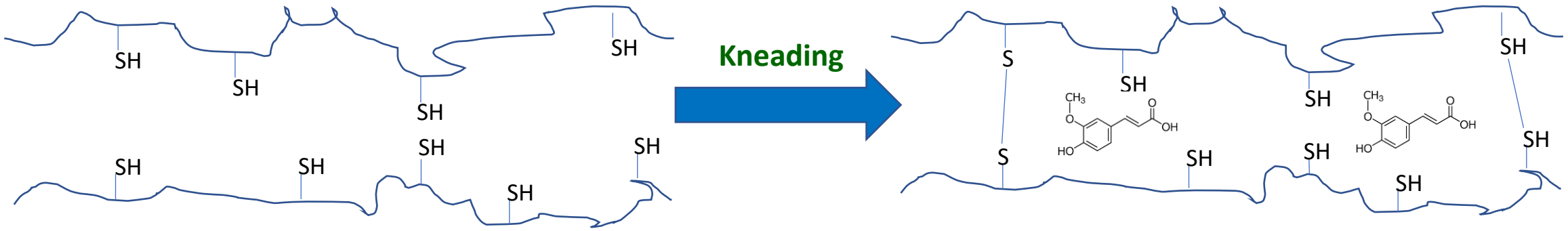
Impact of Bran on Bread Preparation and Taste



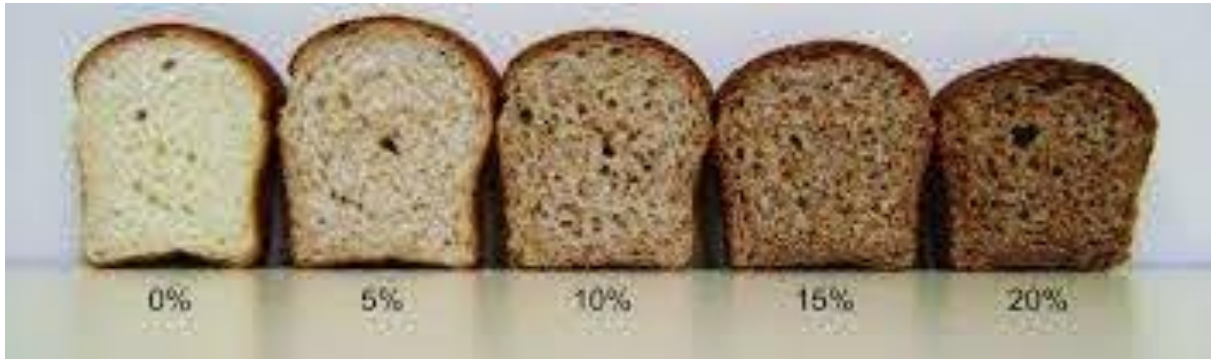
- Fibers compete with starch for water
  - More water needed to make dough
  - Dough production longer due to increased hydration time
  - Can produce different texture and staling due to different water binding properties
- Flavonoids produce astringency
  - A feeling of dryness in the mouth: e.g. tea and unsweetened chocolate
  - Mainly caused by flavonoids forming complexes with saliva proteins
  - Can be masked with sweetness
- Flavonoids also alter gluten functionality

Whole Wheat Bread Production

Flavonoids inhibit disulfide bonds formation



Gluten



Addition of Wheat Fiber to Bread: Hemdane et al., 2015

Improving the Functionality of Whole Wheat Bread

- Enzyme Treatments - Xylanase
  - Breakdown fiber to improve dough properties by reducing water absorption
- Emulsifiers – Monoglycerols, lecithin, Datem (tartaric + acylglycerols)
  - Decrease staling and increase loaf volume
- Mold inhibitors – Propionic and sorbic acids
  - All breads are susceptible to mold growth
  - Whole wheat breads can have higher moisture content making them more susceptible to mold growth
  - Sometimes refrigerated to decrease mold but this increases staling

What can be done?

- Change government subsidies
- Genetics
  - Flavor, flatulence, ripening, functionality
  - Work with your suppliers
    - Heirloom
    - GMO
    - GMO Heirloom
- Culinary solutions that don't add calories
  - Off-flavor masking
  - Flavor enhancement – umami and acid
  - Low fat frying
  - Optimize texture -calcium
- Stealth
  - Blended products
    - Meat patties
    - Baked goods and fruit purees
  - Dishes with small amounts of proteins and mostly veggies