Light Impact on Quality of Milk

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Light Energy Causes Chemical Changes

Photosensitizers

- Riboflavin
- Chlorophyll
- Flavonoids

Intersystem Crossing (ISC)

Sensitizer (singlet state)

Excitation

Fluorescence

Sensitizer (triplet state)

Phosphorescence

Reaction with oxygen, lipids, proteins

Change in volatile chemistry
Limited Controls from Farm to Processing

Milk Composition
- Photosensitizers
- Other oxidants
- Antioxidants
- Susceptible molecules

Milk Processing
- Fat content
- Pasteurization process
- Other ingredients (flavorings?)

Freshly processed milk flavor: ‘bland, neutral flavor profile, pleasantly sweet, no aftertaste other than the natural richness due to milkfat and milk solids.’ (Alvarez, 2009)
Light Affects Milk Quality

- Alters milk odor and flavor
- Degrades nutrients

Odor: ‘wet-cardboard, wet paper, burnt hair or plastic, chemical-like note’.

Flavor: ‘burnt, burnt protein, burnt feathers, cabbage-like, medicinal, chemical-like.’ (Alvarez, 2009)
Decisions in Packaging and Retail can Control Quality

**Packaging**
- Material
- Barrier properties
  - Light
  - Oxygen

**Light Conditions**
- Intensity
- Wavelength spectrum
- Duration
- Temperature

*Processing warehouse*  *Retail*
Whose Responsibility?

- Quality
- Image
- Brand
- Marketing
- Consumer perception
Where are the Milk Lovers?

Figure 1
Per capita, daily fluid milk consumption declining

Notes: Whole milk has a fat content of at least 3.25 percent. Lower fat milk includes products with less milk fat than whole like 2-percent, 1-percent, and skim milk.


- Increasing use of plastic pkg
- Negative health messages
- Competitive beverage market
Light affects freshness perception

- Flavor: ‘lacks freshness’ or worse
What is freshness?

- Dairy farmer: Doesn’t get any fresher than this!
- Dairy processor: Processed quickly! Fresh!
- QC Lab Tech: Low bacteria! Fresh!
- Dairy retailer: In our store – Fresh!
- Nutritionist/Media: More nutrients – Fresh!
- Consumer: I want fresh foods for you!
What is freshness?

‘fresh milk is best consumed within three days of opening. It is a common misconception that milk will stay fresh as long as it is consumed prior to the expiration date. In reality, the expiration date on a milk pack only reflects the end date of an unopened carton of milk will be able to retain its freshness and quality.’
‘Freshness’ – Meaning to Consumers

Freshness

- Time since pasteurization/packaging
- Fresh milk flavor

Factors contributing to consumers’ judgement of freshness

(Cardello and Schutz, 2003)
Freshness – influence on consumer purchasing behavior?

Purchasing behavior influenced by:
- Sensory perception of product attributes
- Pre-existing attitudes and beliefs

Loss of fresh flavor during storage

- Loss of aroma compounds inherent to ‘fresh’ but contribute little to basic character of food
- Loss of desirable characterizing aroma compounds
- Formation of off-flavors that mask desirable aroma compounds

(Reineccius, 2003)
Change in ‘freshness’ volatiles—packaging and lighting influence

• High density polyethylene packaging
• Fresh – volatiles in freshly processed, packaged milk before retail
• E-nose detects volatile differences between fresh and aged samples
• Both fluorescent and LED lighting rapidly alters volatiles
• Even light-protected pkg has different volatiles than fresh

(Amin, Duncan, Johnson, 2016; unpublished data)
Change in ‘freshness’ volatiles-packaging and lighting influence

- PET packaging – oxygen barrier
- E-nose detects volatile differences between fresh and aged samples under fluorescent conditions
- LED lighting effects not as extreme

(Potts, Duncan, Johnson, 2016; unpublished data)
Influence of packaging and retail lighting on consumer acceptability

(Potts et al., 2017)
Influence of packaging and retail lighting on consumer acceptability

(Potts et al., 2017)
Freshness Perception of Milk Affected by Retail Lighting (4 hrs)

(Potts et al., 2017)
Aftertaste Perception of Milk Affected by Retail Lighting (4 hrs)

(Potts et al., 2017)
Retail Dairy Manager Knowledge and Training about Lighting

- Do you receive any training or educational information about milk quality as related to light or packaging?
  - 10% Yes
- Are there any specific actions that are standard operating practices for protecting milk quality from light?
  - 15% identified ‘low-quality light’; they defined as ‘low light intensity’
- Practices for managing lighting in cases and coolers were highly variable
  - 35% - lighting on continuously
  - Coolers – lights on/off manually

Phillips, Duncan, Amin, Potts, 2016
Retail Dairy Manager Estimates for Fluid Milk Duration in Store

- Delivery to stores occurred
  - Every 2 weeks to 4x/week
  - 70% had 2-4 deliveries/week
- Turnover
  - Defined as amt of time in case before refilled
  - 35% estimated 30 minutes to 4 hrs
  - Others estimated 8 hrs – 7 days
- Ambient (in store) lighting is most often fluorescent, though changing
  - Influence on products

Phillips, Duncan, Amin, Potts, 2016
10 stores had LED; 10 stores had fluorescent

15% of managers stated their cases were on timers, 25% stated they had motion sensors, and 60% stated the lights were on continuously.
Opportunities for Positively Affecting Fluid Milk Consumption

- *Freshness* is ultimately defined by the consumer
- LED lighting and packaging (oxygen barrier; light barrier) potentially extend fresh flavor, nutrient protection/health
- SOPs for retail handling can help extend milk freshness
- Focusing on delivering freshness creates a better consumer experience
  - economic value
  - consumer perception + behavior
Acknowledgements