Biopolymer Films and Potential Applications to Meat and Poultry Products

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Potential Advantages

- Reduced dependence on petroleum sources
- Use of U.S. agricultural raw materials
- As a food contact layer to carry adjuncts
- Biodegradability
- Cost??

Definition of Biopolymer Packaging

- Packaging produced from renewable, biological material

Biopolymers for Packaging

from biomass	**Polysaccharides**	**Proteins**
	Cellulose	Casein
	Starch	Whey
	Gums	Gluten
	Chitosan/Chitin	Soy
		Egg/meat
synthesized	**Polylactate (PLA)**	**Other polyesters**
microbial	**Polyhydroxy-alcanoates (PHA) – butyrate (PHB)**	

Ref: Vibeke K Haugaard and Grete Bertelsen, Centre for Advanced Food Studies (LMC) The Royal Veterinary and Agricultural University, Copenhagen, Denmark

Biopolymer films-commercial materials

Material	Supplier	Trade name
PLA	Cargill Dow	NatureWorks PLA
	Hycail	
	Mitsui	LACEA
Starch	Novamont	Mater Bi
	Biotec	Bioplast
	Earth Shell	Earth Shell
PHB	Biomer	Biomer

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EarthShell
PACKAGING
Sandwich Wrap

Biodegradation

- Microbial
  - Aerobic→ compost or sludge
  - Anaerobic→ methane + hydrogen
- Animal feed
- Chemical

Optimal Packaging Requirements

Product	Shelf life	Barrier Needs			
		O_2	CO_2	H_2O	light
MAP raw meat	1-2 wk	✓	✓	✓	
Raw meat	1-2 wk			✓	
Cooked meat	1-4 wk	✓	✓	✓	
Cured Meat	1-6 mo	✓	✓	✓	✓

Biopolymer films-meat research

- 1949 – Pearce & Lavers – carrageenan
- 1952 – Klose et al – gelatin
- 1963 – Allen et al – alginates
- 1967 – Bauer et al – cellulose
- 1971 – Mullen – wheat gluten
- 1972 – Turbak – corn zein
- 1972 – Turbak – soy protein
- 1972 – Baker at al – albumen/soy/wheat protein
- 1980's and 1990's – numerous (mostly cast films)

Biopolymer films- applications

- Moisture/oxygen barrier
- Physical protection
- Oil barrier
- Breading adhesion
- Texture modifier
- Antimicrobial/Antioxidant carrier

Coating vs. Film

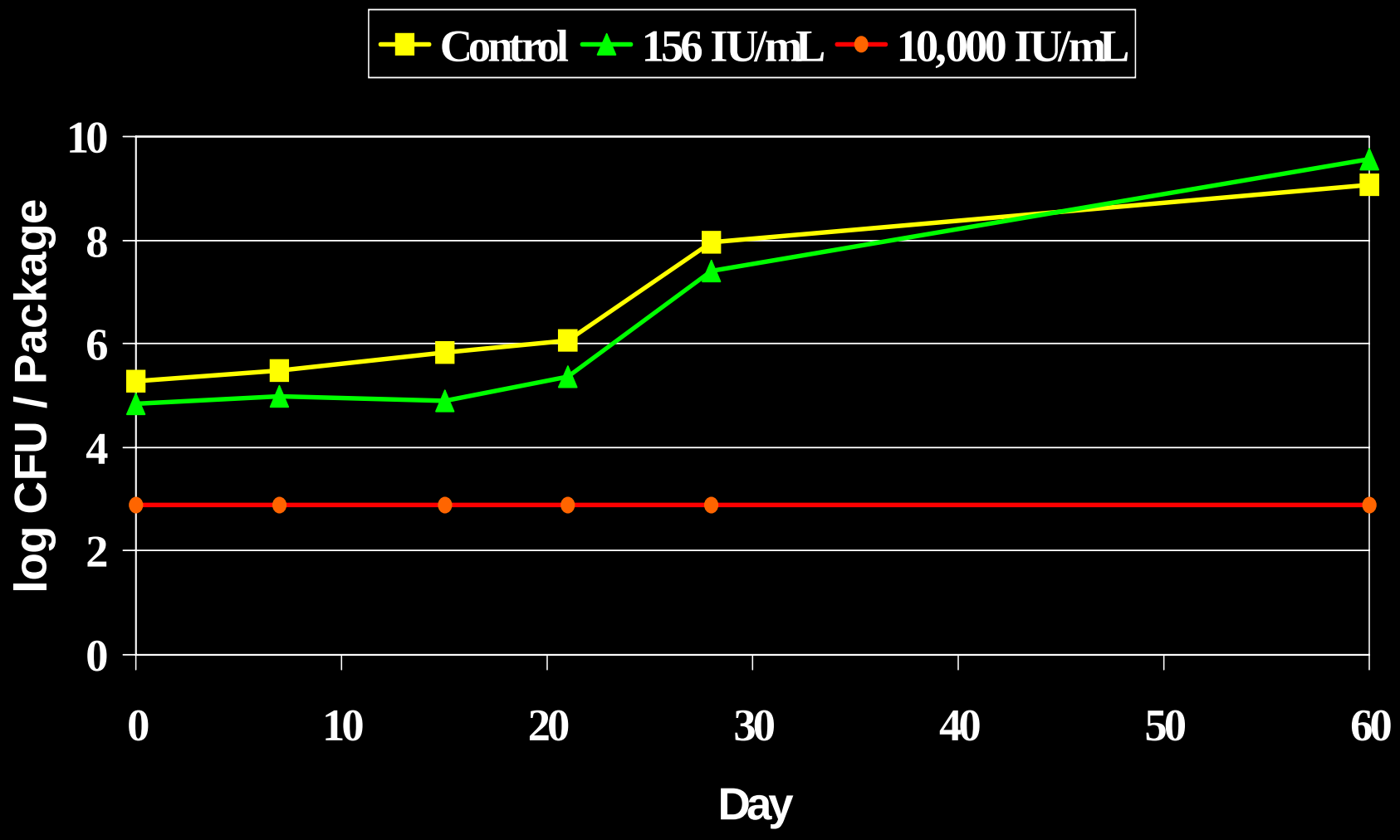
- Coating applied as a fluid
- Coating adheres to the food surface
- Coating is often consumed with the food

Meat coating applications

- Coatings reduce moisture loss in raw and cooked meat
- Antioxidants added to coatings to preserve cooked meat flavor
- Coatings used to reduce moisture loss/oxidation in frozen meat and fish

Nisin-coated cellulosic films applied to frankfurters

Research by Dr. Kay Cooksey, Clemson University



Biopolymer films- flexible films

- **Crosslinking required to form flexible film**
- ***Proteins and carbohydrates have the ability to crosslink and form a film matrix***

- **Two principal methods of forming**
  - **Casting**
  - **Thermal compression**

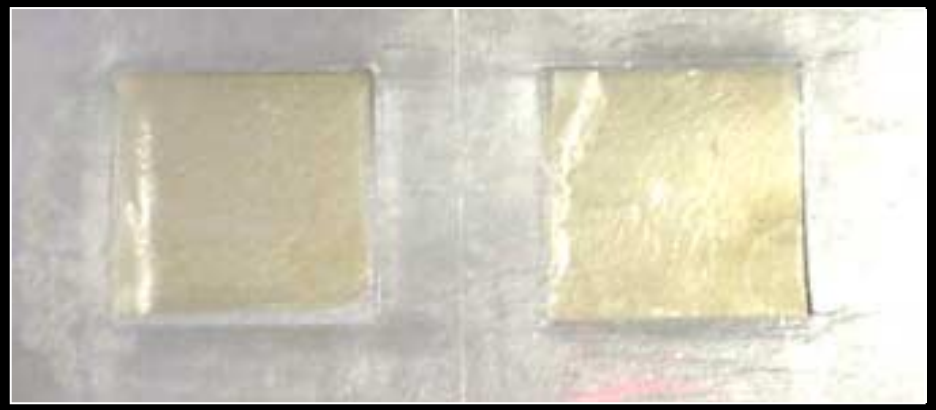
- **Extrusion methods**

Crosslinking Agents

- Formaldeyde
- Glutaraldehyde
- Cysteine
- Transglutaminase
- UV radiation
- Glyoxal

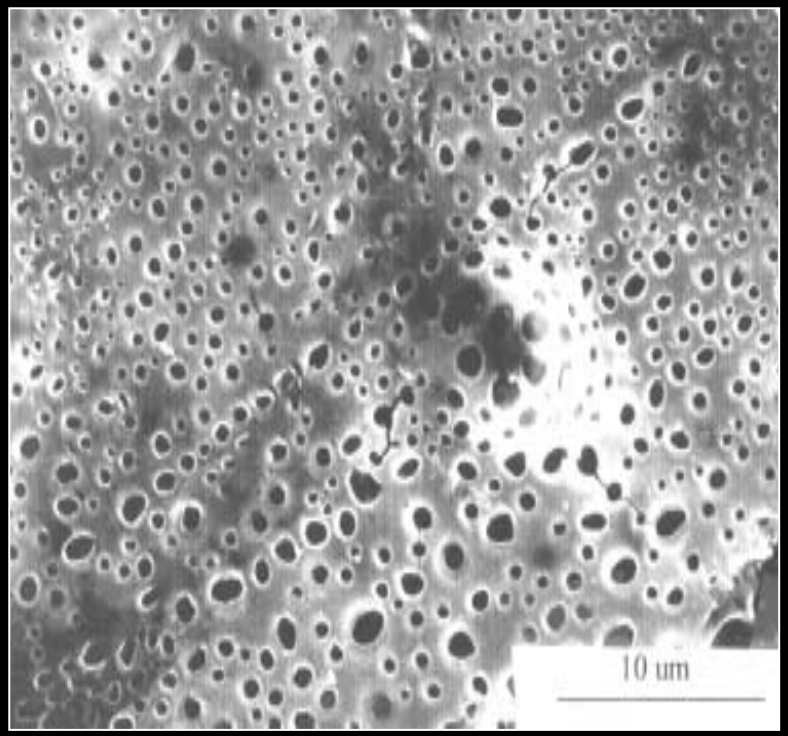
Batch Processing - Compression

BEFORE

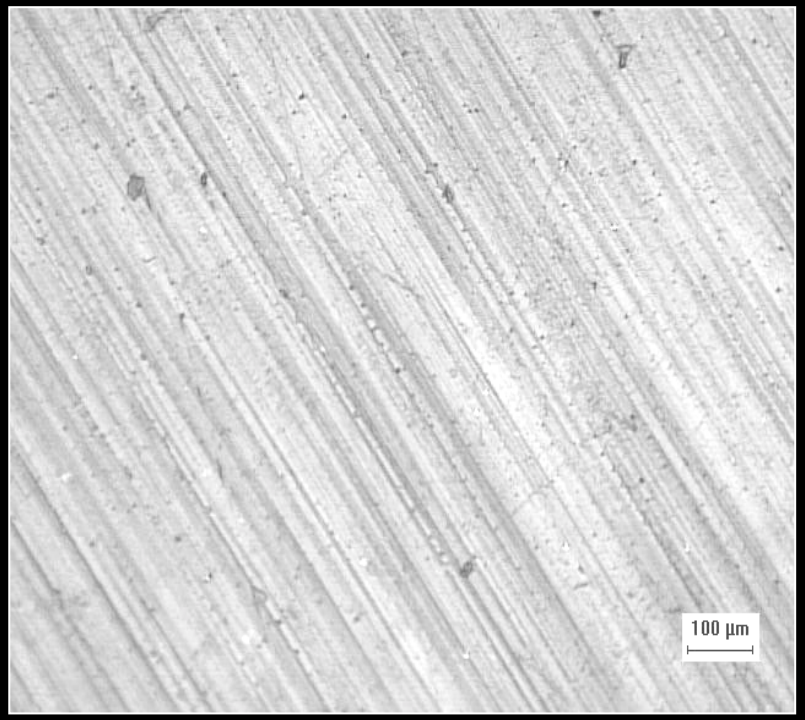


AFTER

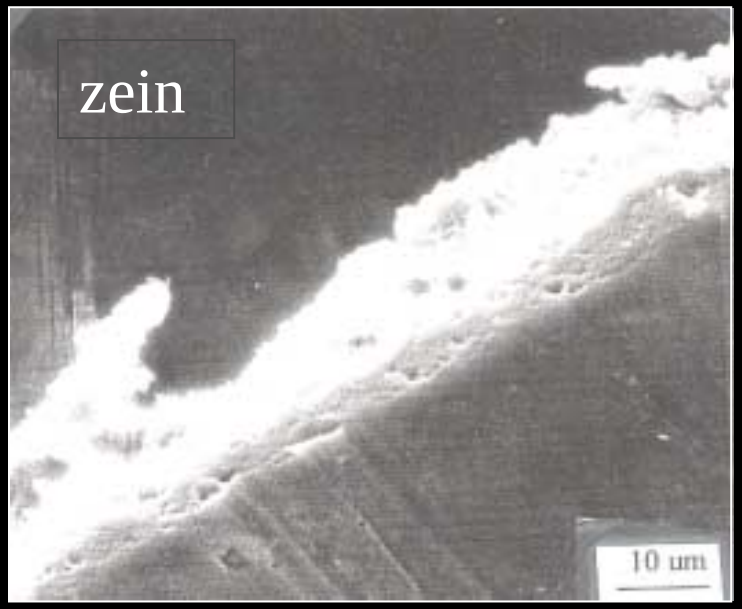
Biopolymer films- flexible films

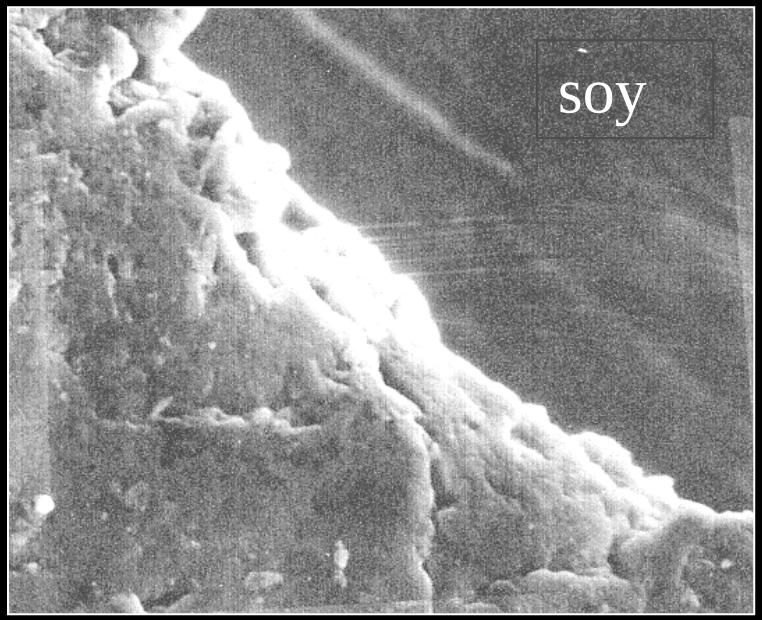


CAST

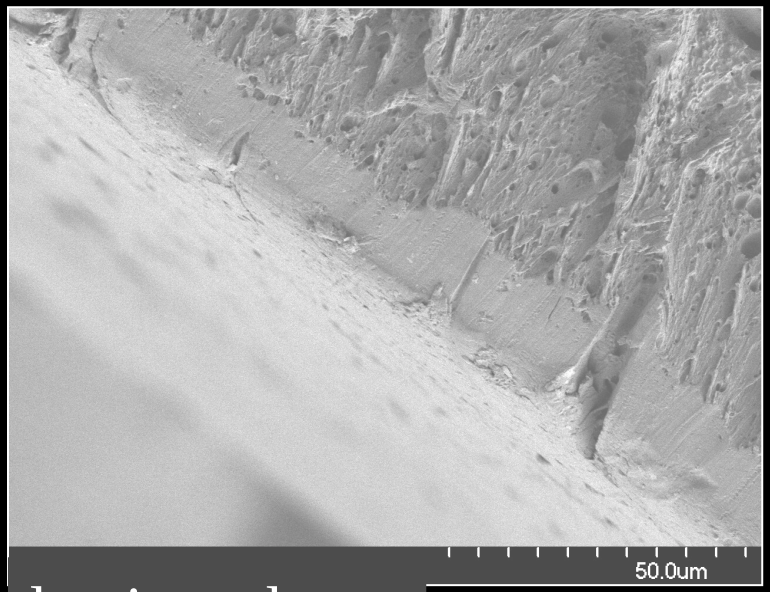


COMPRESSED



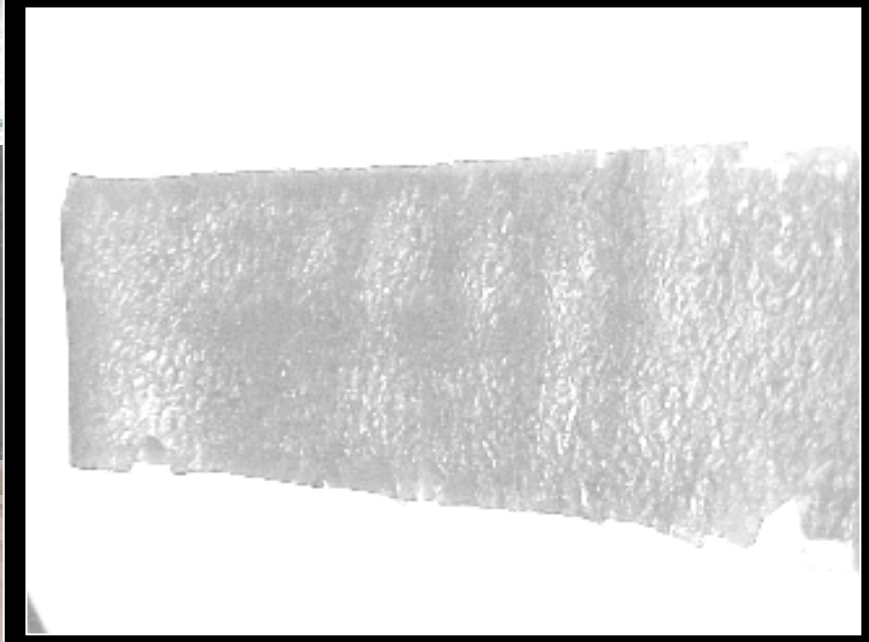


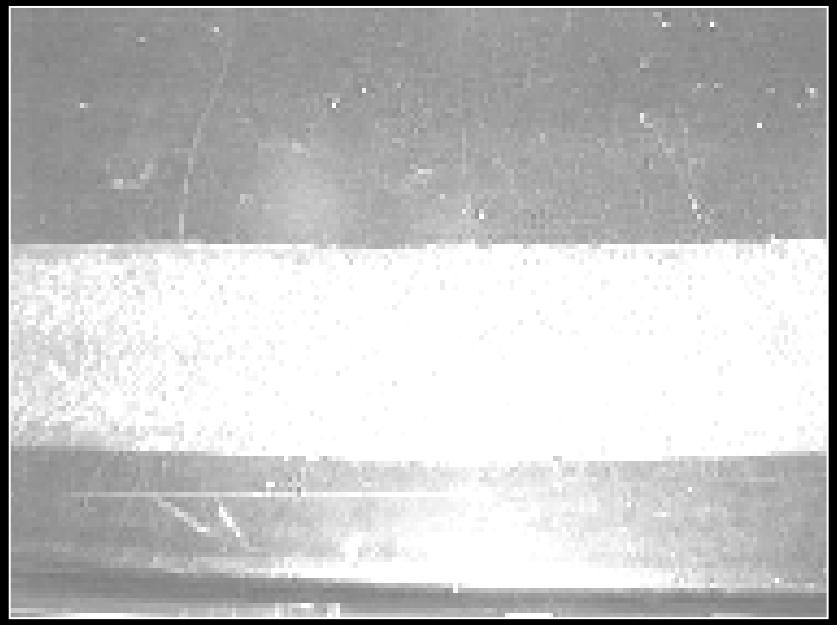
press



laminated

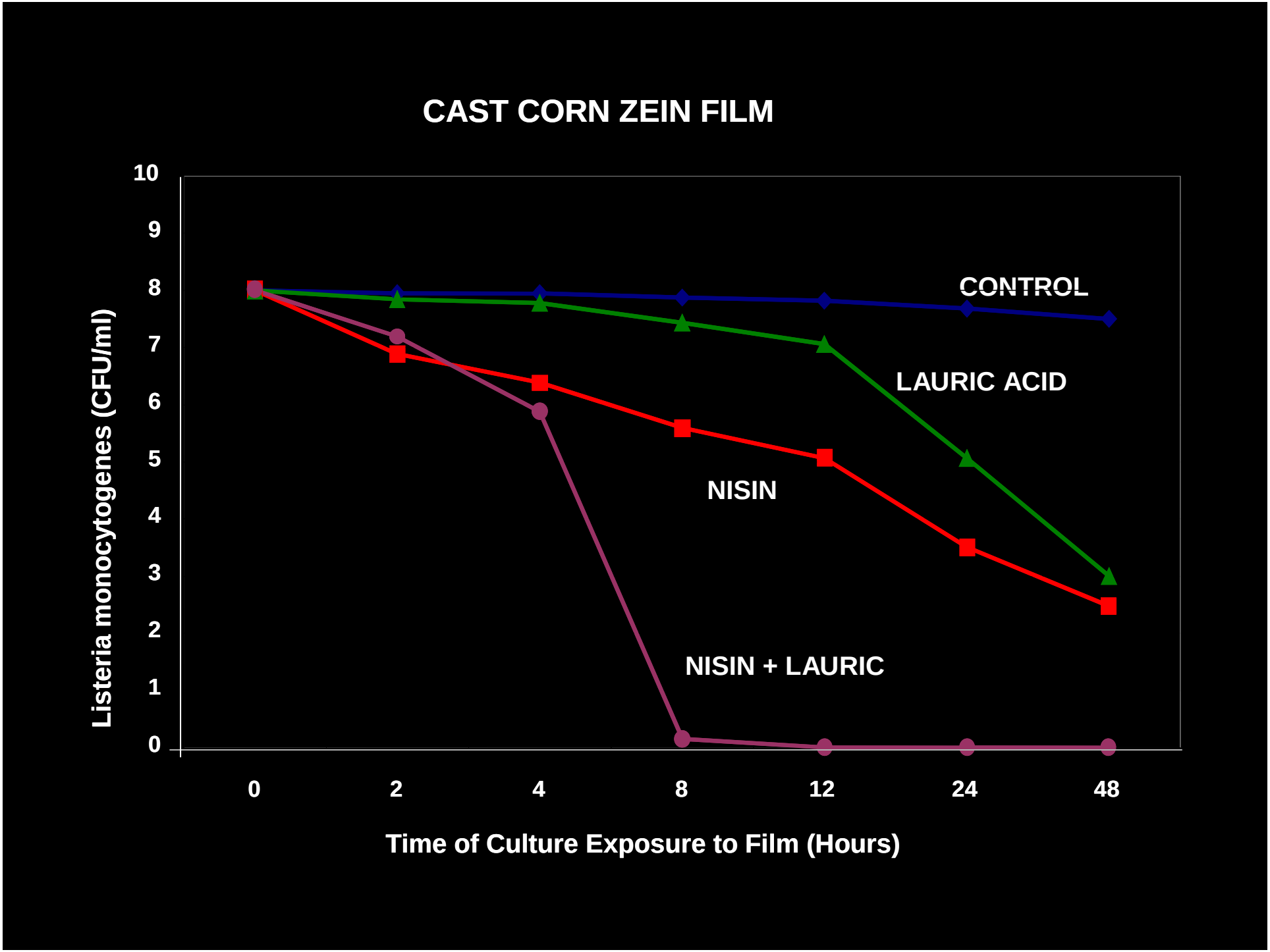
Continuous Processing

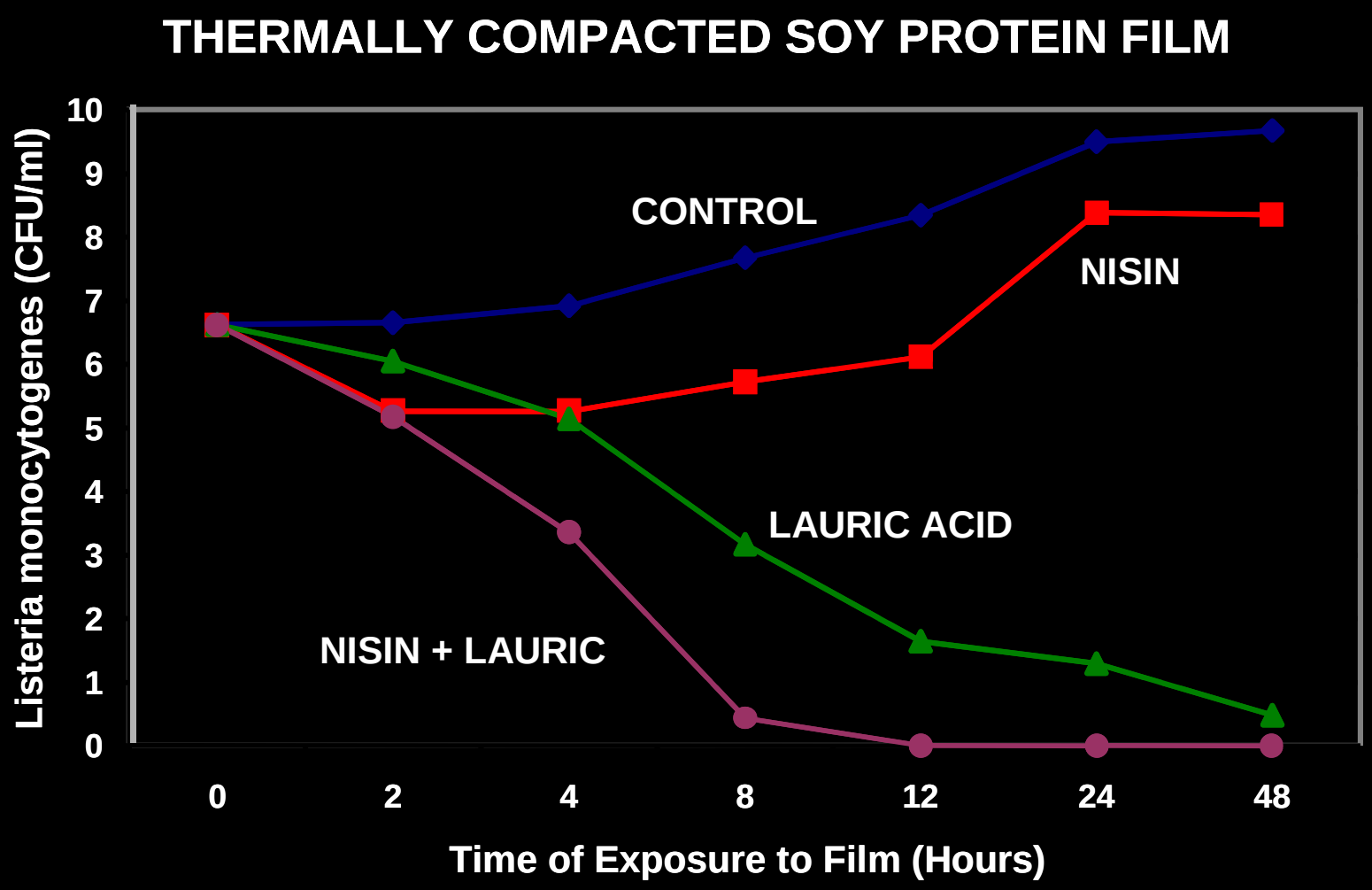




Physical properties of films

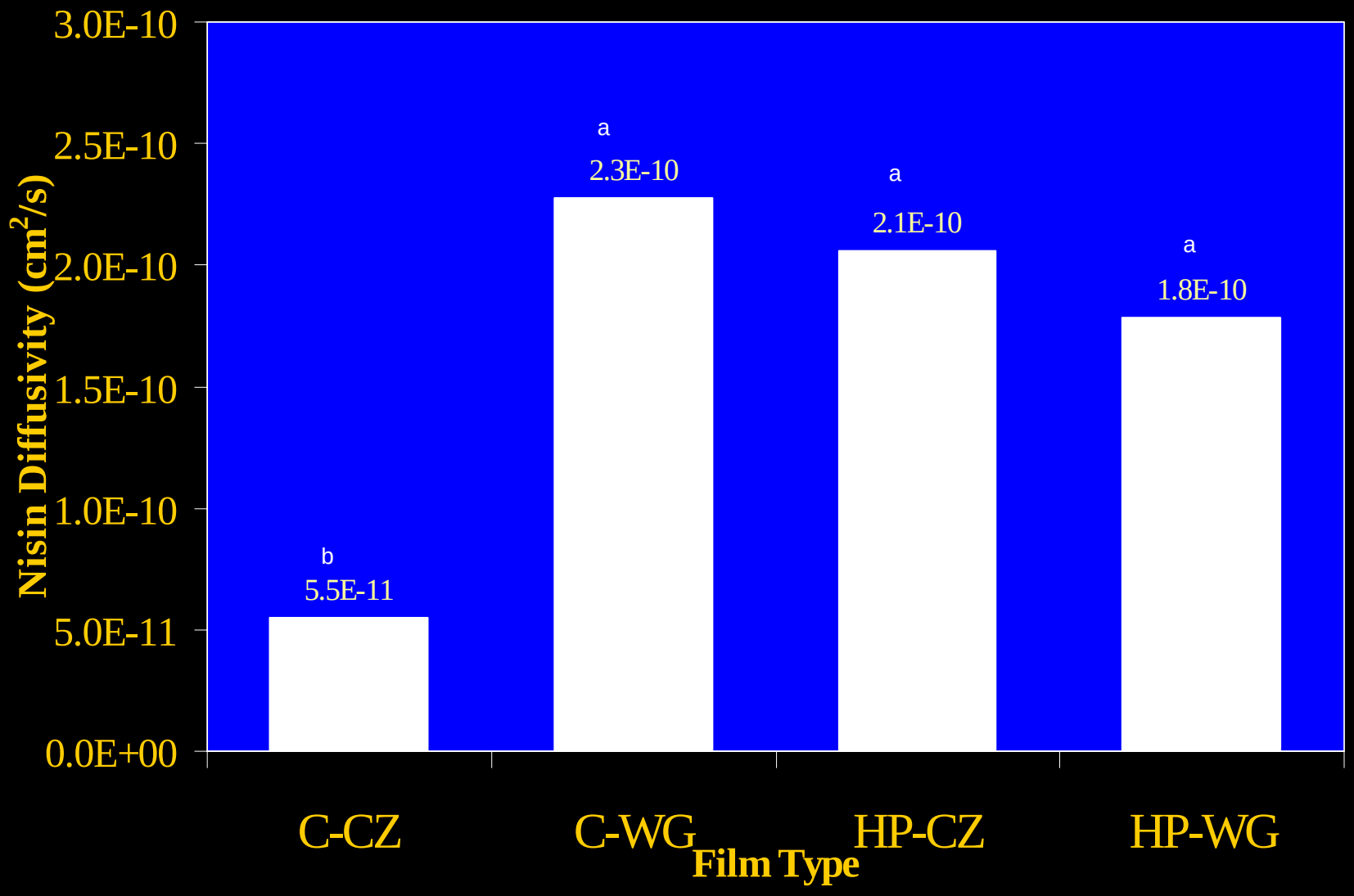
Film type	Thickness (mil)	Tensile Strength (MPa)	Elongation (%)
Heat-press soy protein	11.8	5.0	123
Cast wheat gluten	3.98	2.6	276
Cast whey protein/glycerol	4.33	13.9	31
Cast soy protein/glycerol	NA	37	4.0
Cast corn zein	3.5	0.4	<1.9
cellophane	14.17	114	20
High density PE	0.98	17.3-34.6	300
Low density PE	0.98	8.6-17.3	500
0.75%chitosan/LDPE	4.48	9.2	60


CAST CORN ZEIN FILM
Listeria monocytogenes (CFU/ml)
10
9
8
7
6
5
4
3
2
1
0
CONTROL
LAURIC ACID
NISIN
NISIN + LAURIC
0
2
4
8
12
24
48
Time of Culture Exposure to Film (Hours)


THERMALLY COMPACTED SOY PROTEIN FILM
Listeria monocytogenes (CFU/ml)
10
9
8
7
6
5
4
3
2
1
0
CONTROL
NISIN
LAURIC ACID
NISIN + LAURIC
0
2
4
8
12
24
48
Time of Exposure to Film (Hours)

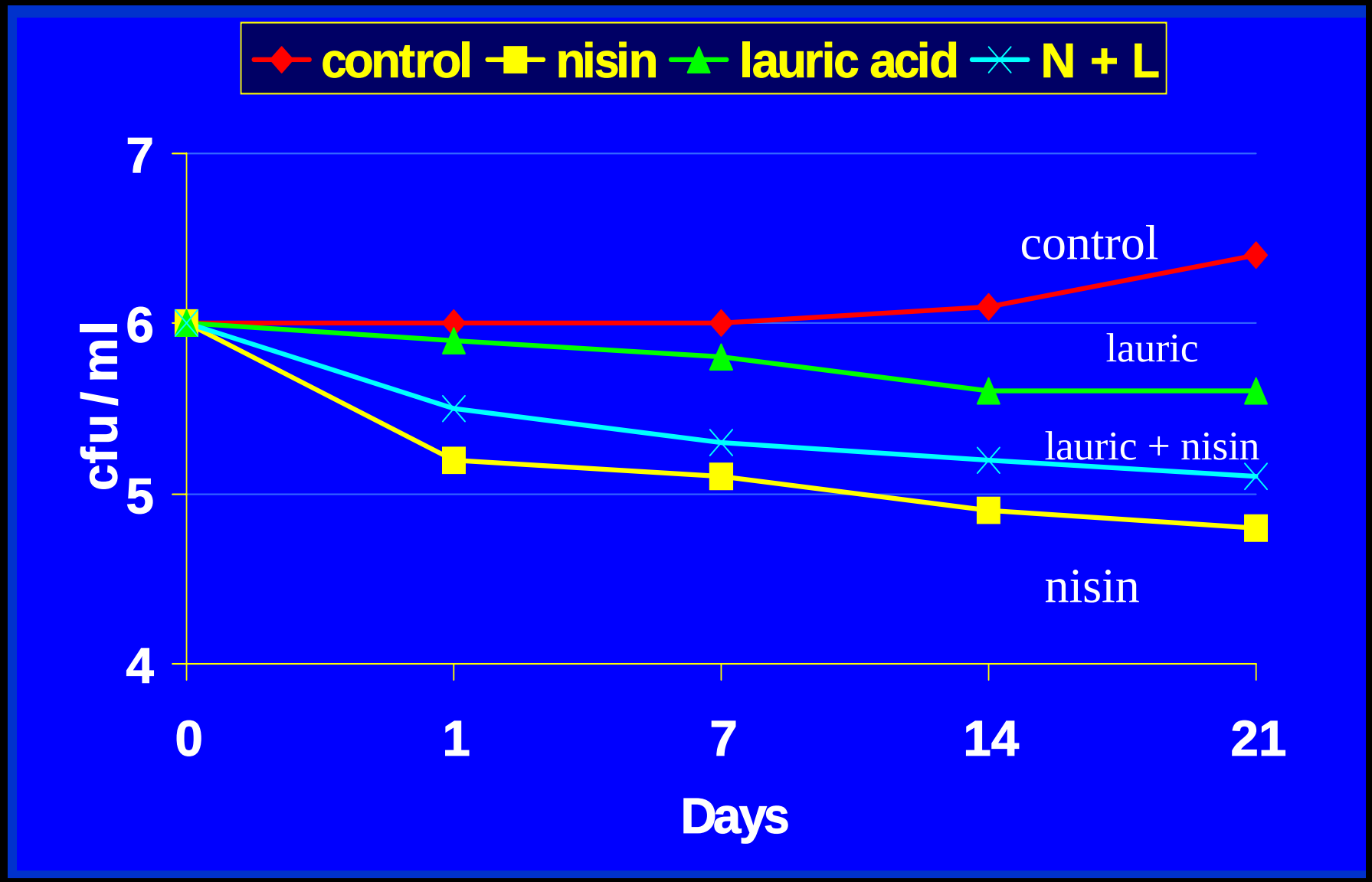
Protein Films

Comparison of nisin diffusivity

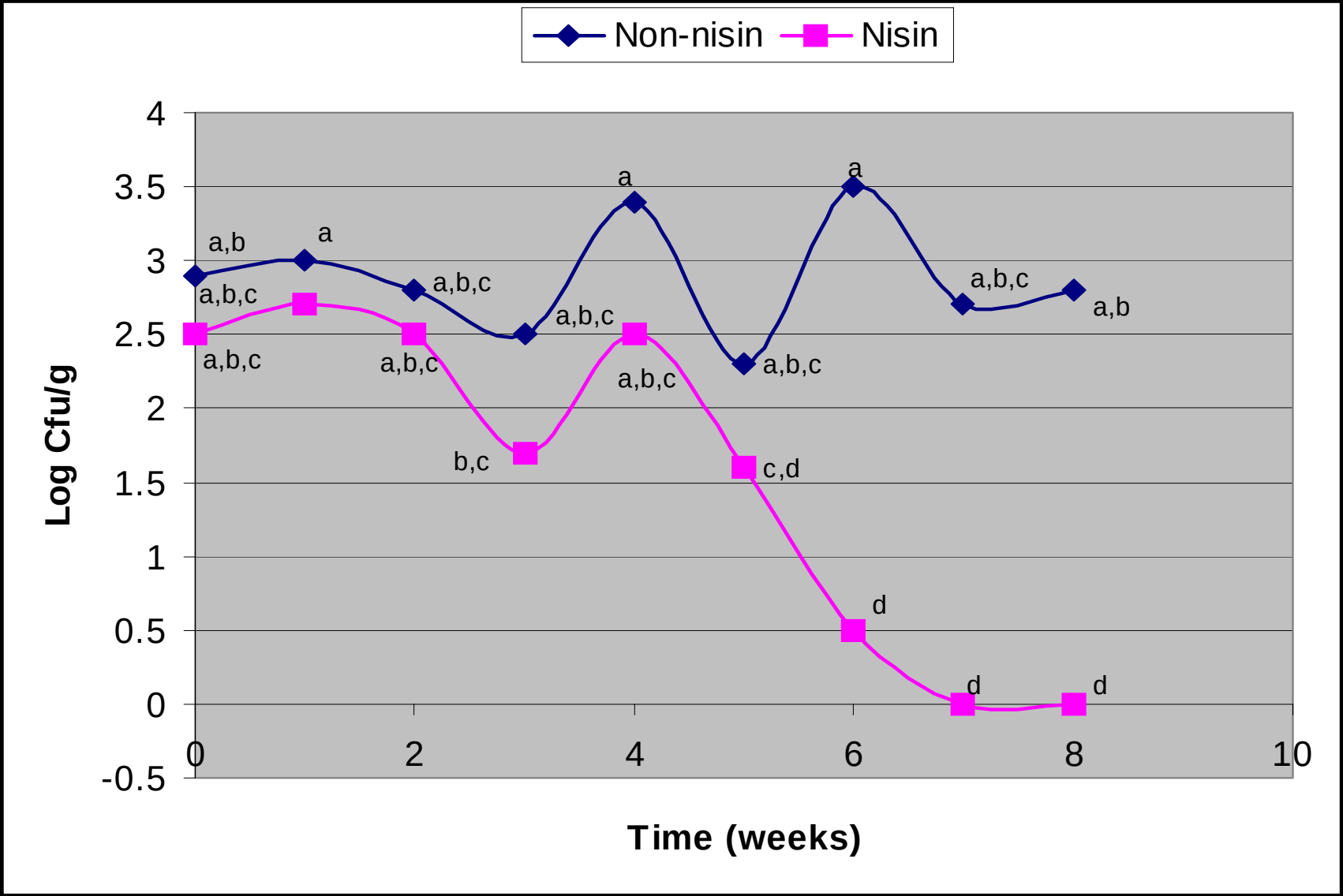


Application on bologna

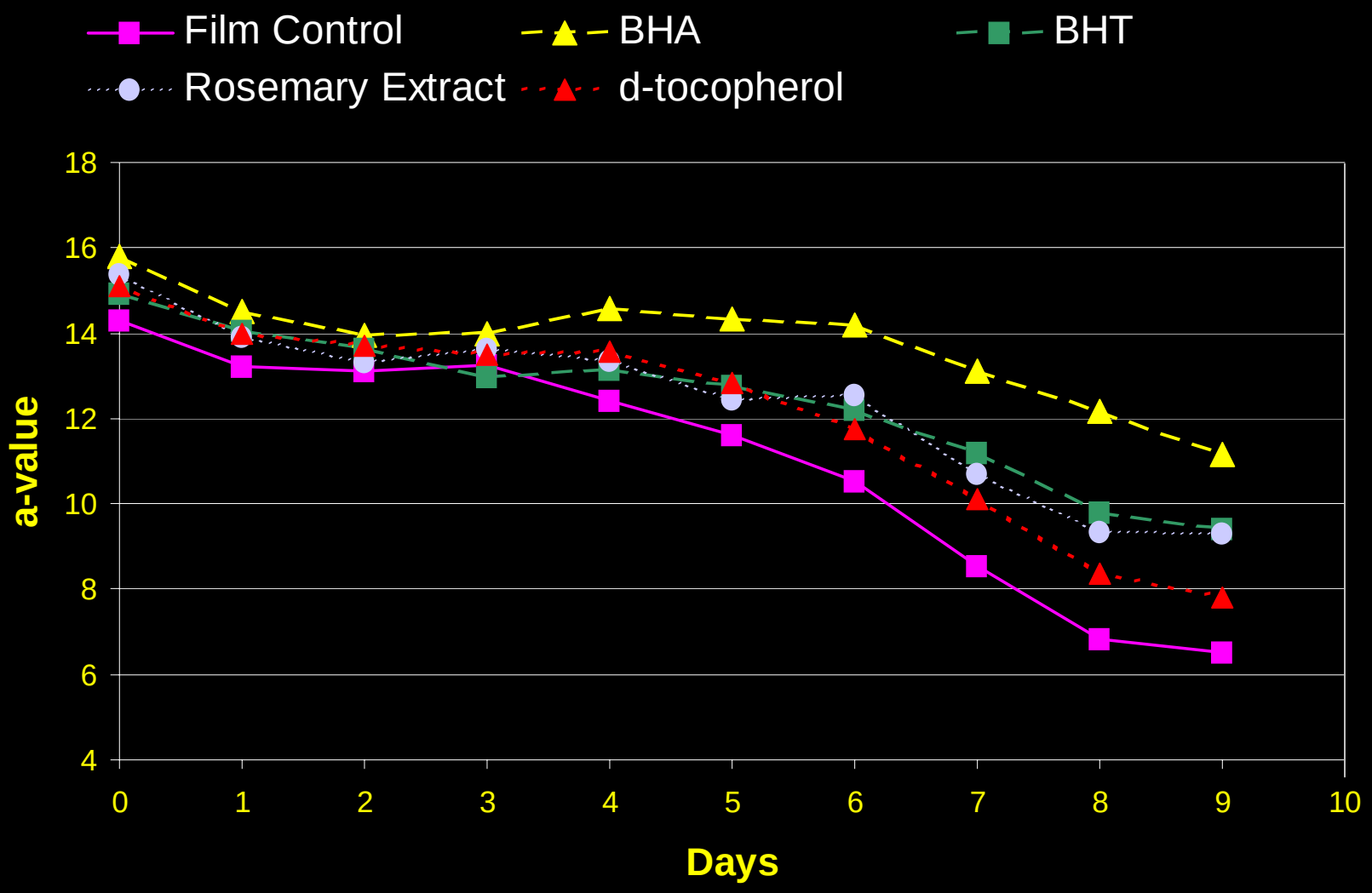
L. monocytogenes-inoculated turkey bologna exposed to biocide-impregnated soy films



Turkey bologna inoculated with L. monocytogenes and packaged with nisin in wheat gluten film

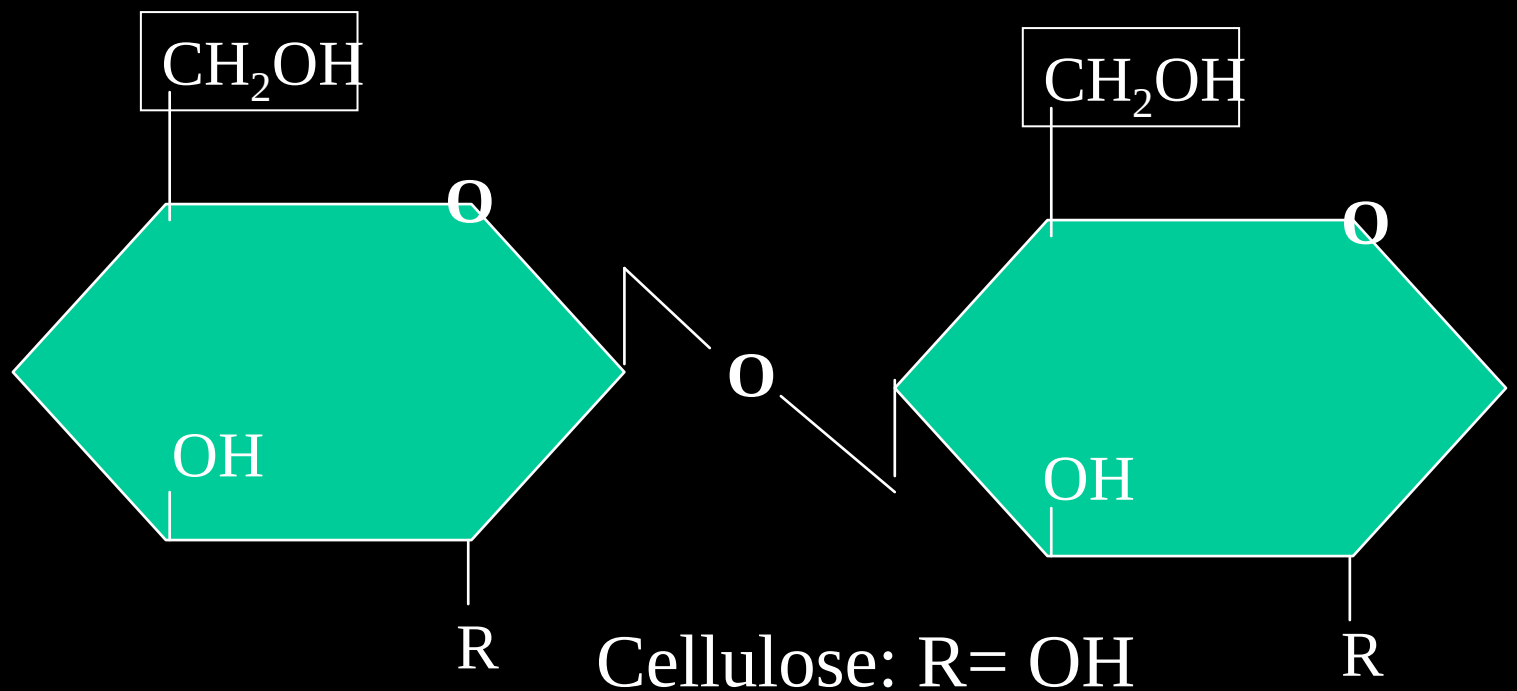


CIE a-value Results for Steaks Allowed to Bloom Prior to Packaging with Antioxidant Films



Color Differences - Antioxidant Discs within Packaged Steaks

Chitosan tested as a coating and film

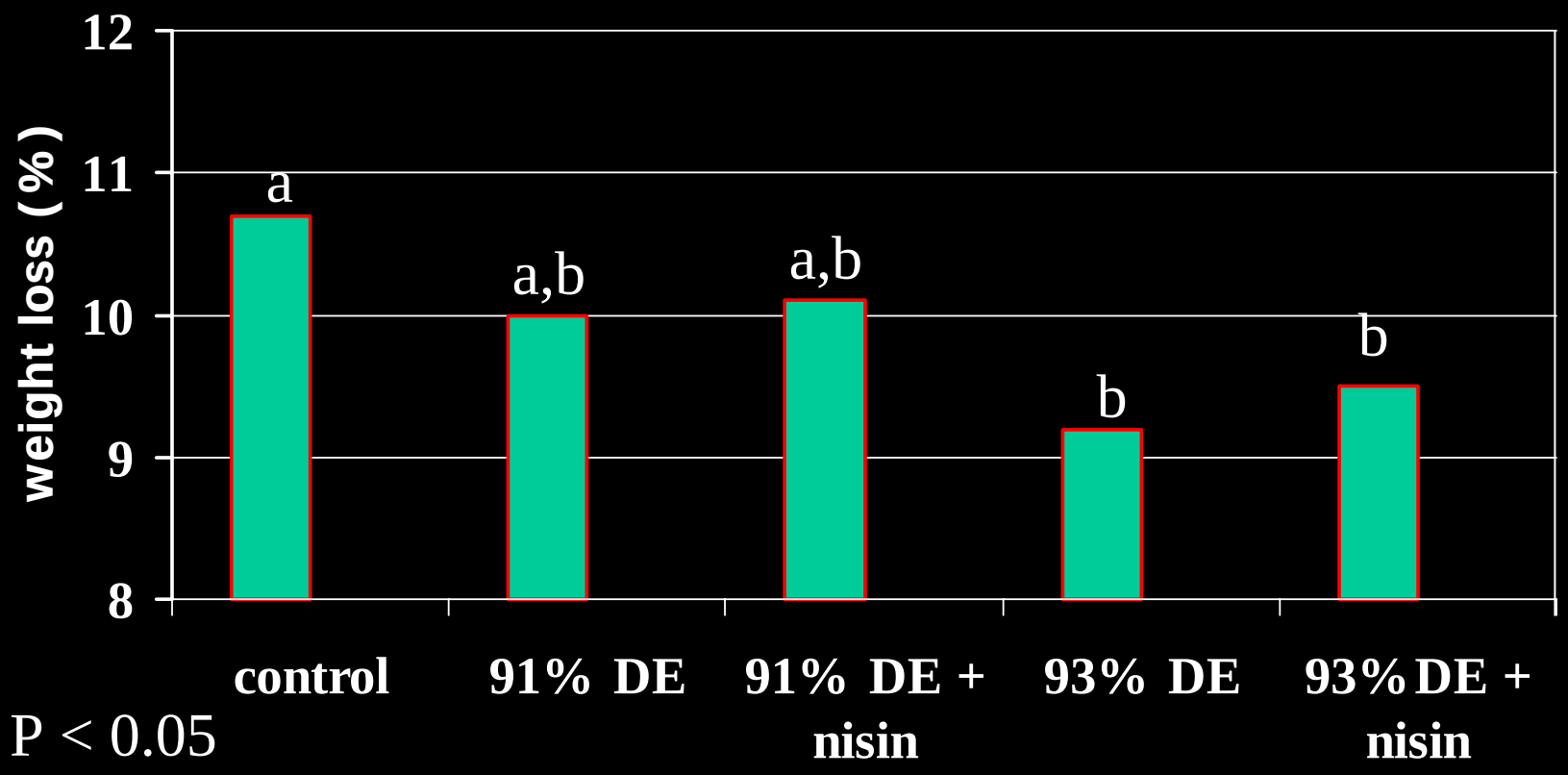


Cellulose: R= OH

Chitin : R=$NHCOCH_3$

Chitosan : R=NH_2

Chitosan coated onto drumsticks

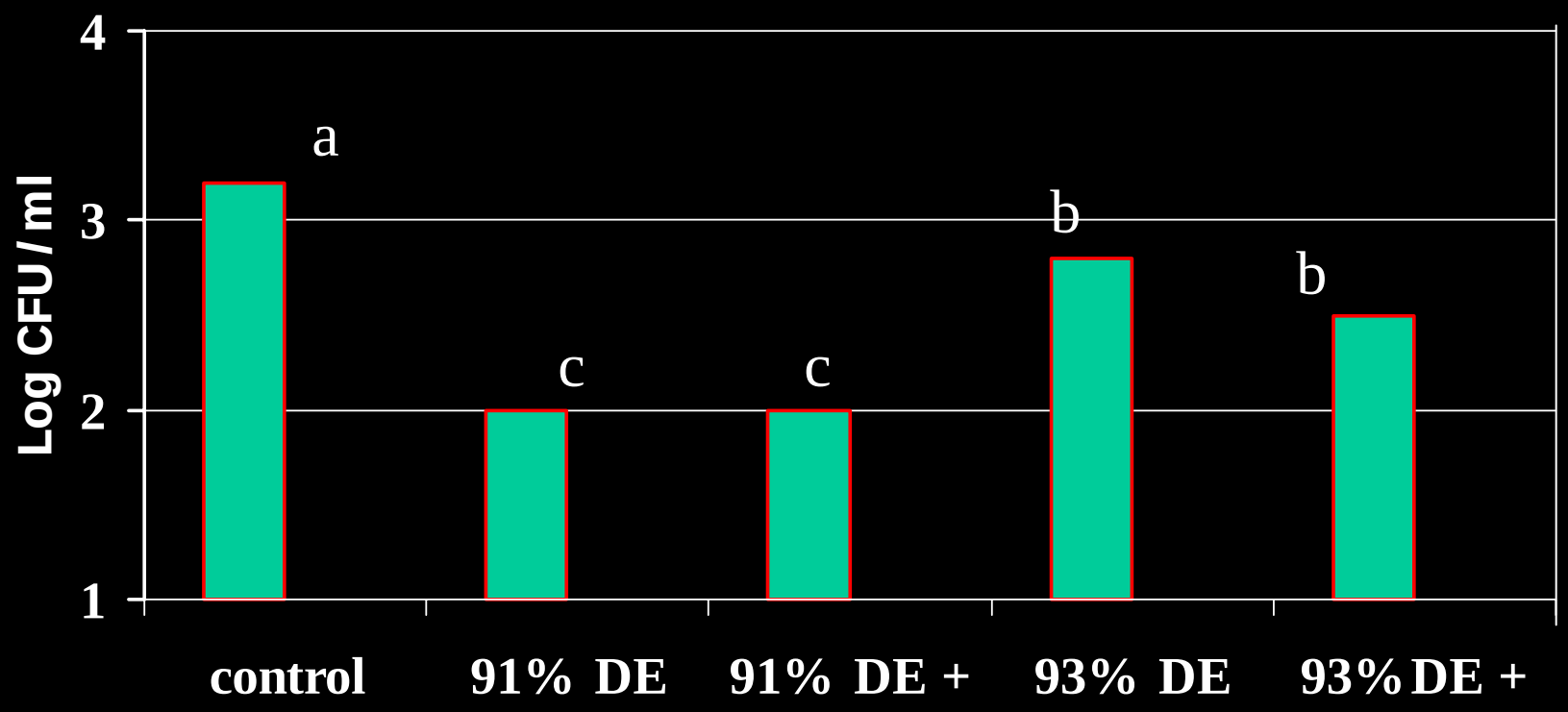


$P < 0.05$

SEM = 0.7

n = 6

Chitosan coated onto drumsticks

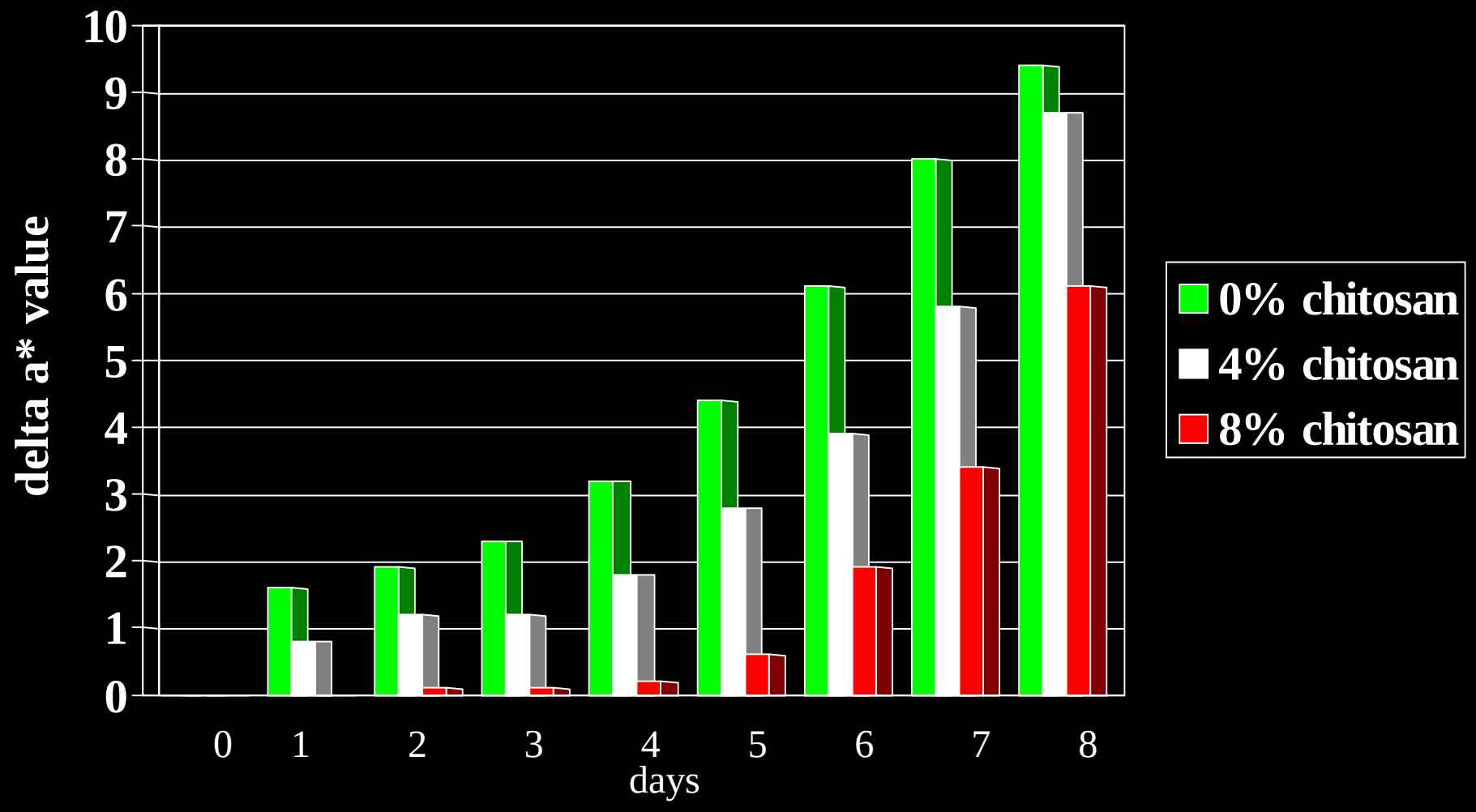


$P < 0.05$

SEM = 0.4

n = 6

8% chitosan within LDPE films - steak surface



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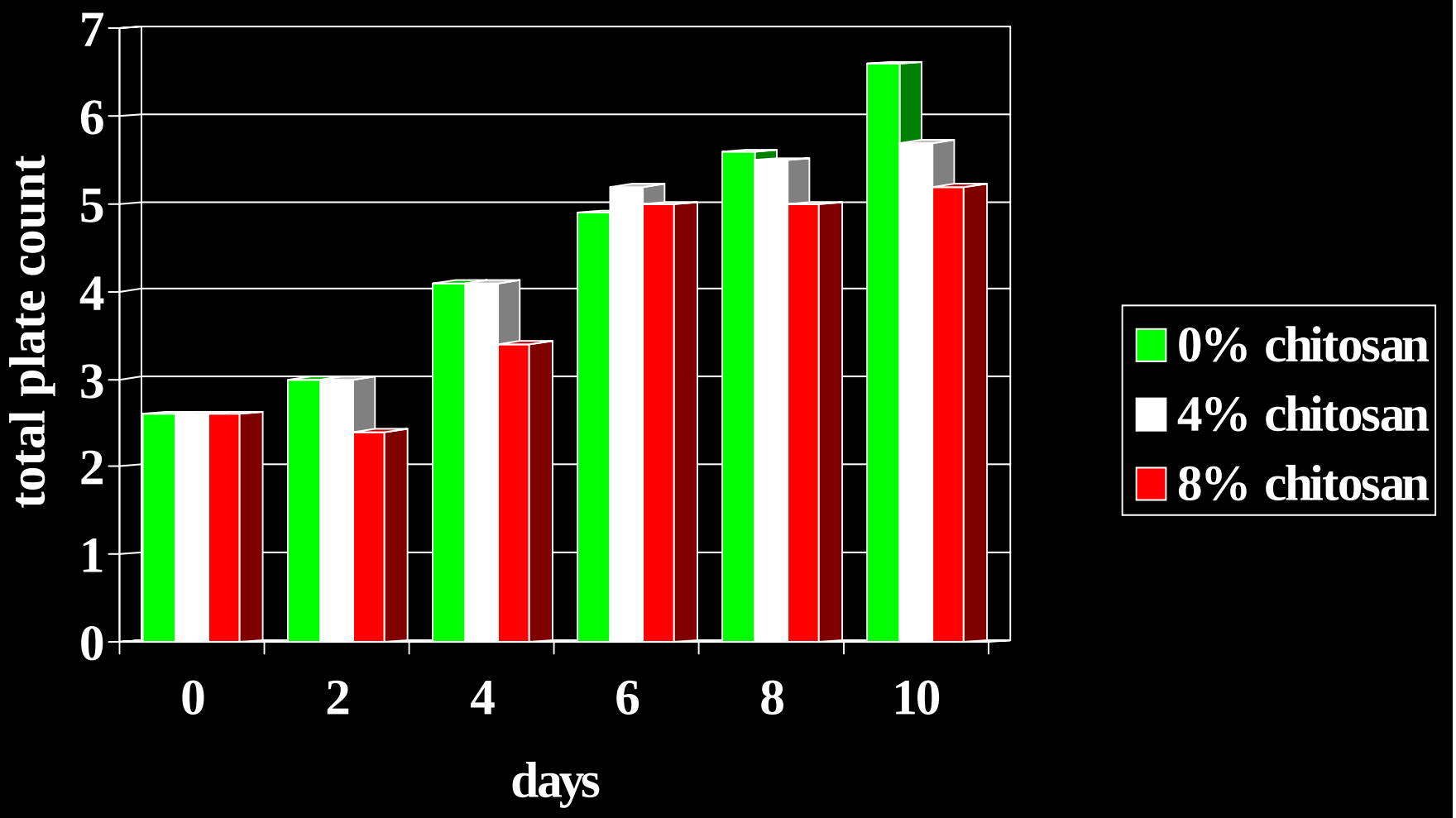

Future

- Coatings will still be developed for specific applications
- Biopolymer films will eventually enter the market as **cost** and functionality get near that of synthetic polymers
- Requirements for meat packaging make this one of the most difficult areas for biopolymers to meet