

# 모짜렐라치즈의 이화학적 기능특성

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# Functionalities of Mozzarella Cheese

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## • What is Mozzarella cheese?

Categories	Mozzarella cheese
Color and texture	A creamy white appearance with a smooth plastic texture
Flavor	A mild, delicate milk flavor
Product forms	Both natural and process Mozzarella are available Blocks, loaves, shredded and diced forms
Performance	The variety of Mozzarella types offer many options for performance
Typical application	Pizza, sandwiches
Key benefits	Melt, stretch

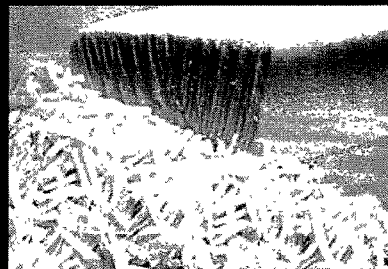
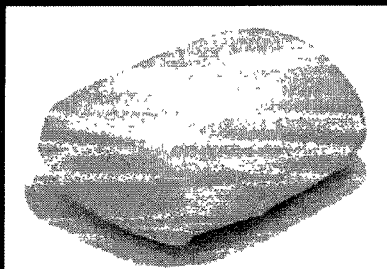
◦ Current cheese production in Korea (2002)

Category		Year total ( ton )
Natural cheese	Produced	9,508
	Imported	20,278
	Consumed	29,978
	Change (%)	6.6
Process cheese	Produced	11,198
	Imported	11,664
	Consumed	22,378
	Change (%)	-10.4

## Unique functional characteristics of Mozzarella cheese

### ■ Unmelted

- Shreddability
- Should be sufficiently firm to allow shredding



## Functional characteristics of Mozzarella cheese

### ■ Melted

- **Meltability** : capacity of cheese to flow
  - ▶ Distance cheese flow down a glass tube upon melting (McMahon, 1993)
- **Stretchability** : ability of cheese to form fibrous strands that deform without breaking under tension
  - ▶ Helical viscometry (Kindstet and Kiely, 1992)
- **Free oil** : separation of liquid fat at the surface from melted cheese
  - ▶ Modified Babcock test (Kindstet and Rippe, 1990)
- **Browning** : change of color at the surface after backing
  - ▶ Minolta colorimeter (Matzdorf and Cuppett, 1990)

## Caprine milk as a source for Mozzarella cheese ?

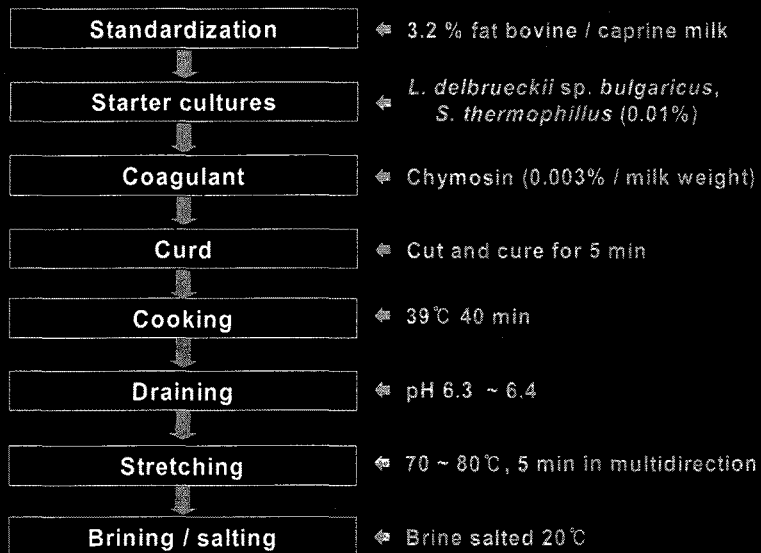
- **Healthy image**
- **High digestibility and lower allergy problem**
- **Any difference in functional characteristics ?**



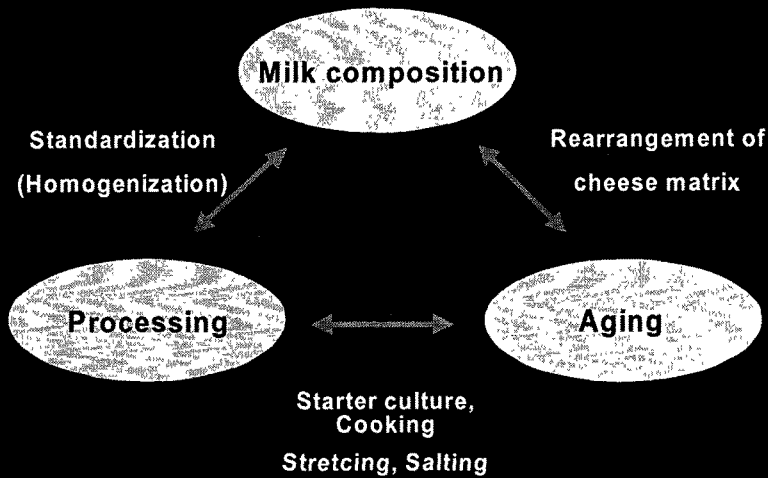
## Compositional standards for Mozzarella cheese in the U.S.

Type	Moisture (%)	Fat in dry matter (%)
Mozzarella	> 52 but ≤ 60	≥ 45
Low-moisture Mozzarella	> 45 but ≤ 52	≥ 45
Low-moisture part-skim Mozzarella	> 45 but ≤ 52	≥ 30 but < 45
Part-skim Mozzarella	> 52 but ≤ 60	≥ 30 but < 45

## Manufacture of Mozzarella cheese



## Whole picture of Mozzarella cheese functionality



## Major factors affecting functionality of Mozzarella cheese

### ■ Milk compositional side

- Moisture (47~52%)
  - ▶ Moisture ↑ ⇒ soften texture & meltability ↑
- Fat (36 ~ 38%)
  - ▶ FDB (fat on dry basis) ↑ ⇒ soft structure & free oil ↑
  - ▶ Homogenization pressure ↑ ⇒ free oil ↓
  - ▶ Milk fat with higher melting point fraction ↑ ⇒ free oil ↓



## Major factors affecting functionality of Mozzarella cheese

### ■ Processing side

#### • Starter culture (coagulant)

- ▶ Rod to coccus ratio  $\Rightarrow$  proteolysis  $\Rightarrow$  browning
- ▶ Heat tolerance

#### • Cooking

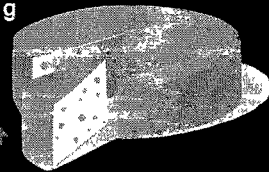
- ▶ Temperature  $\uparrow$   $\Rightarrow$  meltability  $\downarrow$  / hardness  $\uparrow$

#### • pH

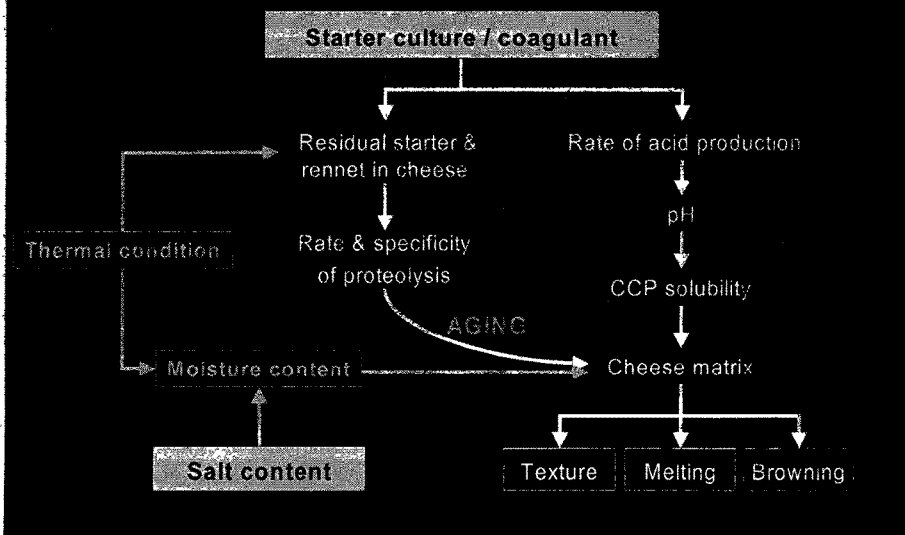
- ▶ Whey drainage pH  $\downarrow$   $\Rightarrow$  demineralization  $\uparrow$  / melting  $\uparrow$
- ▶ Stretching pH  $\uparrow$   $\Rightarrow$  structured texture  $\uparrow$  / aging time  $\uparrow$

#### • Salting

- ▶ Salt content  $\uparrow$   $\Rightarrow$  free oil & meltability  $\uparrow$



## Interrelationship & complexity of Mozzarella cheese functionality





## Functionality and physicochemical characteristics of bovine and caprine Mozzarella cheese

### : A comparative study

#### Chemical composition of bovine and caprine milk

• Proximate composition					• Composition of casein				
	Protein (%)	Fat (%)	Lactose (%)	Ash (%)	Caseins (%)				
					$\alpha_{s1}$ -	$\alpha_{s2}$ -	$\beta$ -	$\kappa$ -	
Bovine	3.7	4.3	4.6	0.8	Bovine	38	12	36	14
Caprine	3.3	3.5	4.9	0.7	Caprine	5.6	19.2	54.8	20.4

(Adapted from Jenness, 1980)

(Adapted from Remeuf and Lenoir, 1986)

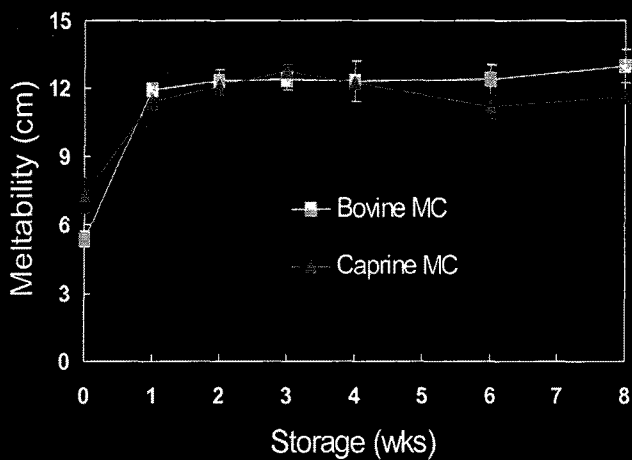
## Mean composition of Mozzarella cheese produced either from bovine or caprine milk.

(Imm et. al., 2003, J. Dairy Sci.)

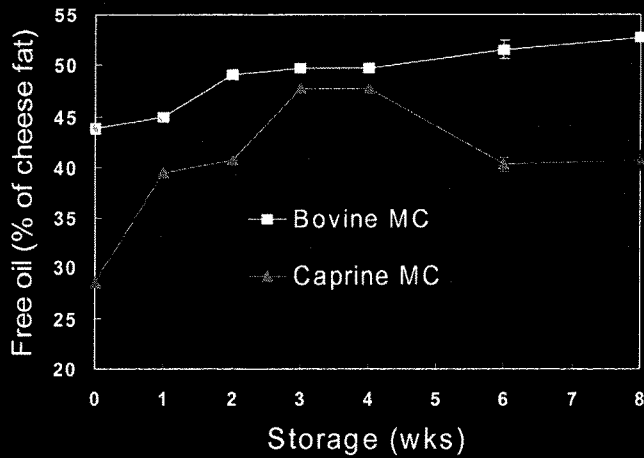
Milk source for MC <sup>a</sup>	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	MNFS <sup>b</sup> (%)	FDM <sup>c</sup> (%)
Bovine	48.42	21.13	26.07	4.38	61.39	40.97
Caprine	47.55	21.50	27.25	3.70	60.57	40.99

<sup>a</sup>: Mozzarella cheese, <sup>b</sup>: moisture in non-fat, <sup>c</sup>: fat in dry matter.

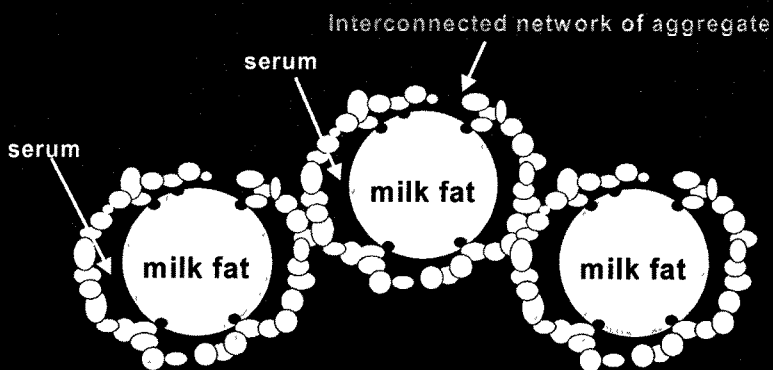
## Changes in meltability of Mozzarella cheese during storage



## Changes in free oil formation of Mozzarella cheese during storage

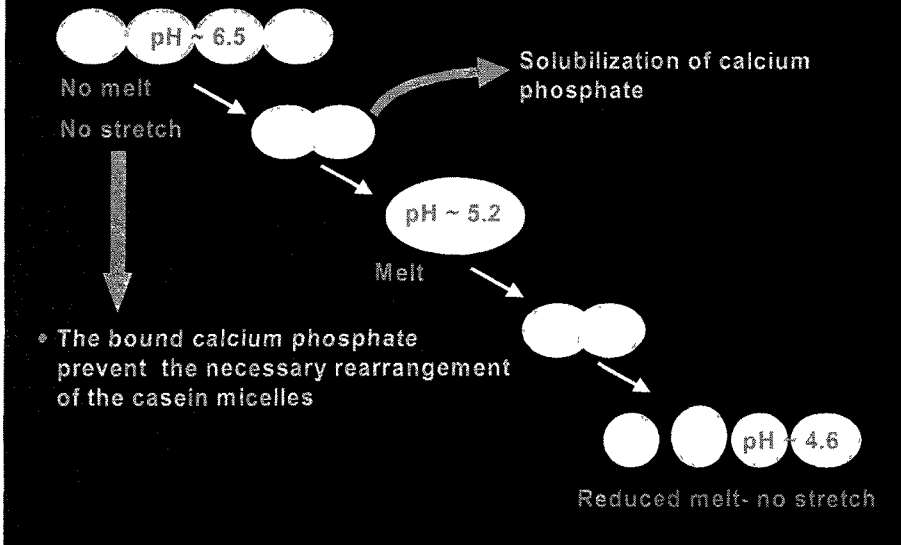


## The chemistry of melt and stretch

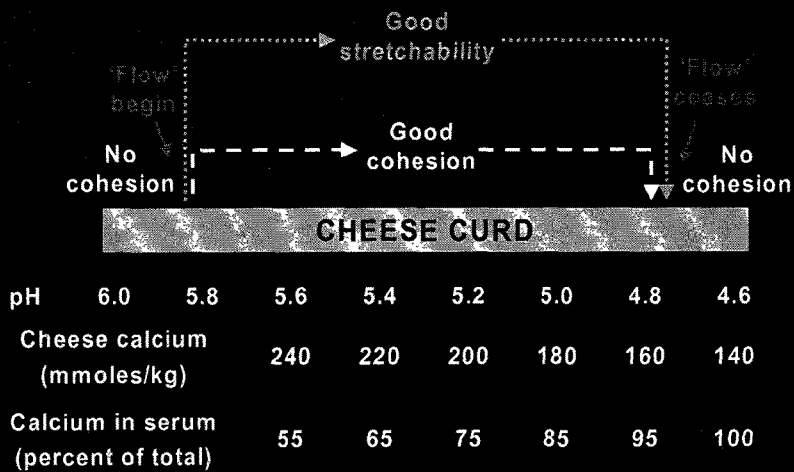


- The fewer the interactions, the greater the melt
- Stretch requires an intact, interconnected casein network

## Rearrangement of casein network

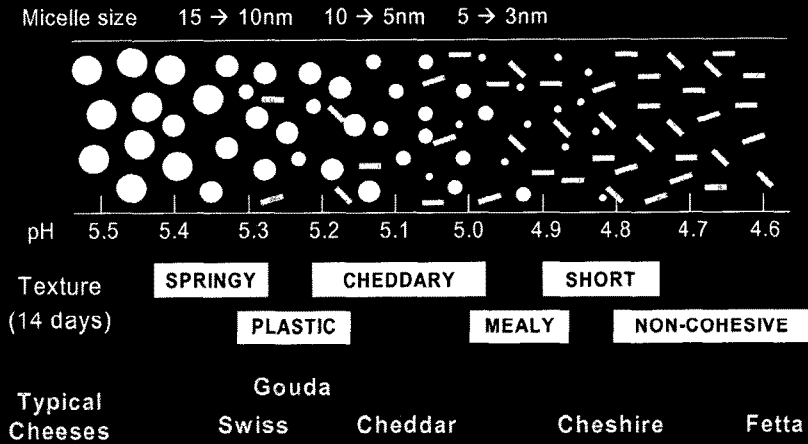


## Relationship between pH and stretchability



(Adapted from Creamer, 1985)

## Relationship between pH and texture



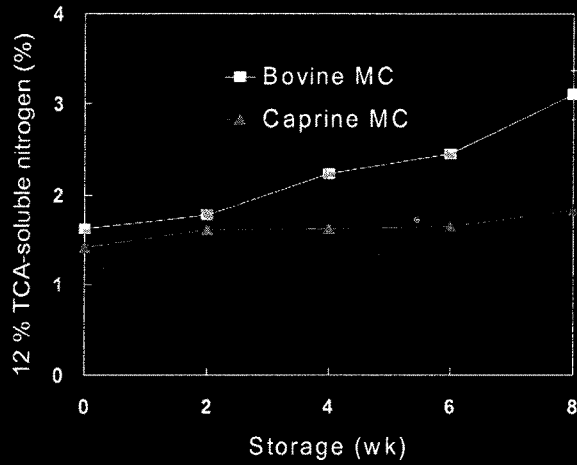
## Mean diameter ( $d_{vs}$ ), range, and specific surface area (SSA) of particles in milk.

(Attaie and Richter, 2000, J. Dairy Sci.)

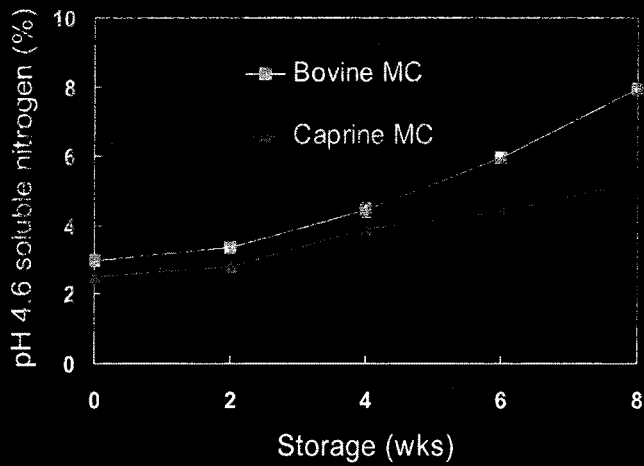
	Whole milk				
	$d_{vs}$ ( $\mu\text{m}$ )	SEM	Range ( $\mu\text{m}$ )	SSA ( $\text{cm}^2/\text{ml}$ )	SEM
Bovine	3.51 <sup>a</sup>	0.08	0.92 ~ 15.75	11,117 <sup>b</sup>	550
Caprine	2.76 <sup>b</sup>	0.07	0.73 ~ 8.58	21,778 <sup>a</sup>	476

<sup>a, b</sup> Means in the same column without common superscripts differ ( $P < 0.005$ ).

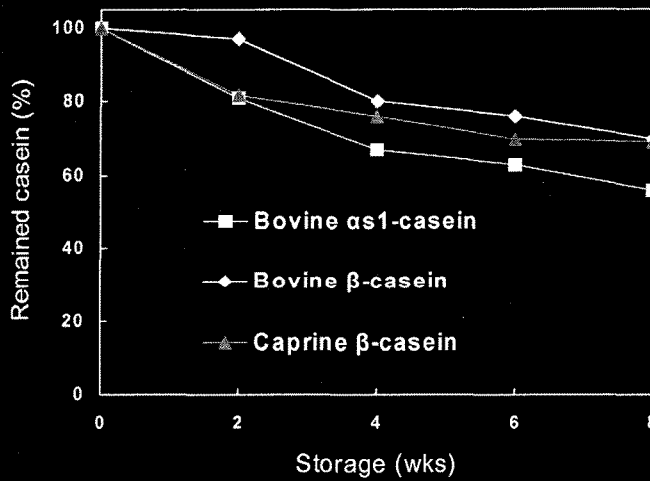
### Changes in 12% TCA soluble nitrogen content of Mozzarella cheese during storage



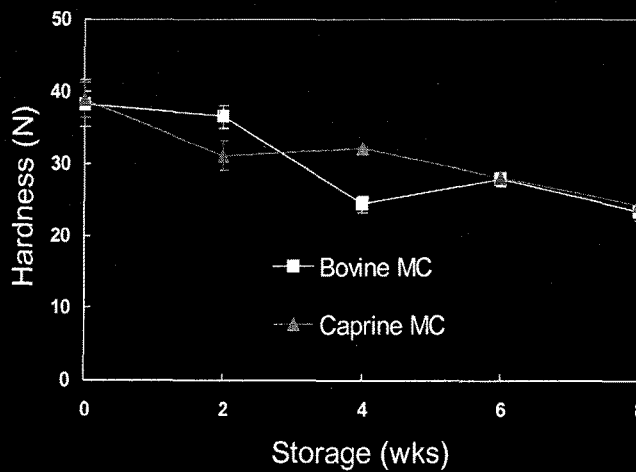
### Changes in pH 4.6 soluble nitrogen content of Mozzarella cheese during storage



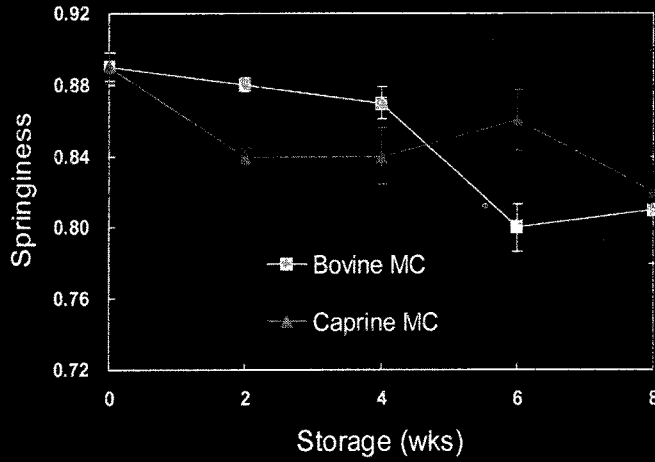
### Degradation of major caseins in Mozzarella cheese during storage



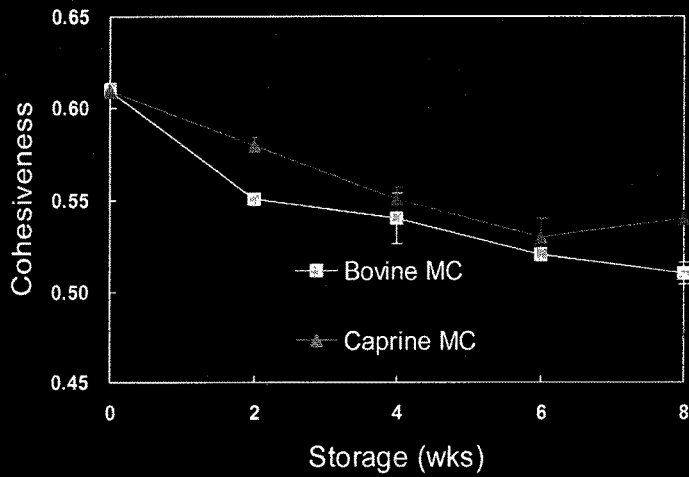
### Changes in TPA hardness of Mozzarella cheese during storage



### Changes in TPA springiness of Mozzarella cheese during storage



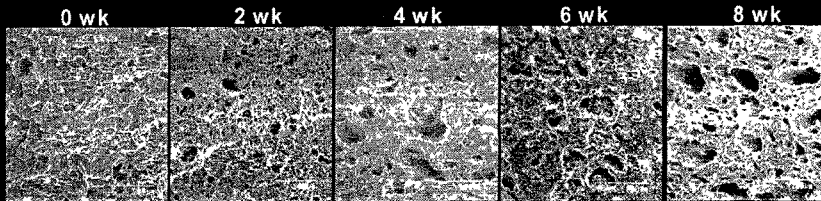
### Changes in TPA cohesiveness of Mozzarella cheese during storage



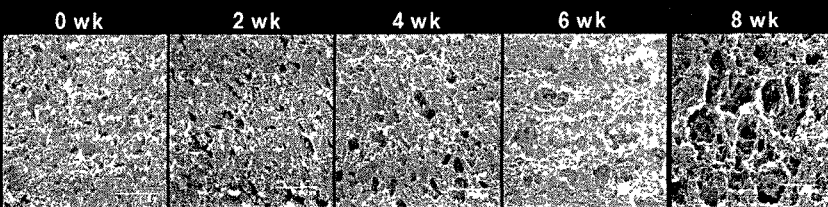


## Changes in microstructure of Mozzarella cheese during storage

- Bovine Mozzarella cheese



- Caprine Mozzarella cheese



## Changes in Hunter color values of bovine and caprine Mozzarella cheese during storage

Storage (wks)	L*		a*		b*	
	B-MC <sup>1</sup>	C-MC <sup>2</sup>	B-MC	C-MC	B-MC	C-MC
0	79.6 <sup>abc</sup>	81.0 <sup>a</sup>	-4.3 <sup>bc</sup>	-3.7 <sup>a</sup>	17.4 <sup>bc</sup>	14.9 <sup>d</sup>
2	79.4 <sup>abc</sup>	79.9 <sup>ab</sup>	-4.6 <sup>cd</sup>	-4.3 <sup>b</sup>	18.1 <sup>a</sup>	15.9 <sup>cd</sup>
4	78.5 <sup>bc</sup>	79.6 <sup>abc</sup>	-4.8 <sup>d</sup>	-4.5 <sup>bc</sup>	18.2 <sup>a</sup>	17.0 <sup>bc</sup>
6	77.8 <sup>c</sup>	78.5 <sup>abc</sup>	-5.2 <sup>e</sup>	-4.8 <sup>bc</sup>	21.0 <sup>a</sup>	16.9 <sup>c</sup>
8	74.7 <sup>d</sup>	78.2 <sup>bc</sup>	-5.9 <sup>f</sup>	-3.7 <sup>a</sup>	22.1 <sup>a</sup>	14.9 <sup>d</sup>

Color indices were determined after cooking at 240 °C for 2min.

<sup>1</sup>: B-MC = bovine Mozzarella cheese, <sup>2</sup>: C-MC = caprine Mozzarella cheese

<sup>a-f</sup>: Means within the same color indices with different superscript differ significantly (P<0.05).

## Correlation coefficients between physiochemical characteristics of bovine Mozzarella cheese

	Meltability	TCA soluble N	pH 4.6 soluble N	TPA Hardness	TPA Springiness	TPA Cohesiveness	L*	a*	b*
Free oil	0.67	0.76	0.80	-0.70	-0.60	-0.88	-0.63	-0.74	0.62
Meltability		0.53	0.59	-0.55	<b>-0.32</b>	-0.77	-0.35	-0.59	0.58
TCA soluble N			0.91	-0.78	<b>-0.48</b>	-0.72	-0.74	-0.88	0.71
pH 4.6 soluble N				-0.76	-0.55	-0.79	-0.80	-0.91	0.77
TPA Hardness					0.51	0.58	0.41	0.62	-0.50
TPA Springiness						0.59	0.59	0.67	-0.59
TPA Cohesiveness							0.59	0.75	-0.64
L*								0.71	-0.49
a*									-0.86

*Values in green (P<0.05)*

## Correlation coefficients between physiochemical characteristics of caprine Mozzarella cheese

	Meltability	TCA soluble N	pH 4.6 soluble N	TPA Hardness	TPA Springiness	TPA Cohesiveness	L*	a*	b*
Free oil	0.85	0.54	0.49	-0.58	-0.65	-0.69	-0.11	-0.49	0.39
Meltability		0.65	0.51	-0.62	<b>-0.66</b>	-0.72	-0.22	-0.44	0.29
TCA soluble N			0.80	-0.74	-0.59	-0.67	-0.54	-0.11	-0.17
pH 4.6 soluble N				-0.81	-0.60	-0.81	-0.45	-0.04	-0.08
TPA Hardness					0.54	0.68	0.33	0.02	-0.03
TPA Springiness						0.36	0.25	0.08	-0.03
TPA Cohesiveness							0.41	0.46	-0.42
L*								-0.06	-0.21
a*									-0.72

*Values in green (P<0.05)*

## CONCLUSION

(Bovine vs. caprine Mozzarella cheese study)

- No difference in meltability
- Free oil formation of caprine Mozzarella cheese was improved by aging for 3 to 4 wks.
- The difference in free oil formation between bovine & caprine Mozzarella cheese was ascribed to intrinsic difference of fat and protein matrix rather than total fat and moisture content present in cheese.
- Bovine Mozzarella cheese resulted in greater proteolysis and subsequently had faster changes of microstructure and texture characteristics during storage.
- The extent of proteolysis also affected cooked color formation.

## PROPOSED FURTHER STUDY

- The relationship between casein micelle integrity and cheese *microstructure*
- The relative contribution of plasmin during aging
- The relationship between fat globule size (distribution), fatty acid profiles and melting characteristics
- Sensory attributes of caprine Mozzarella cheese

