

# صنایع لبنی 1

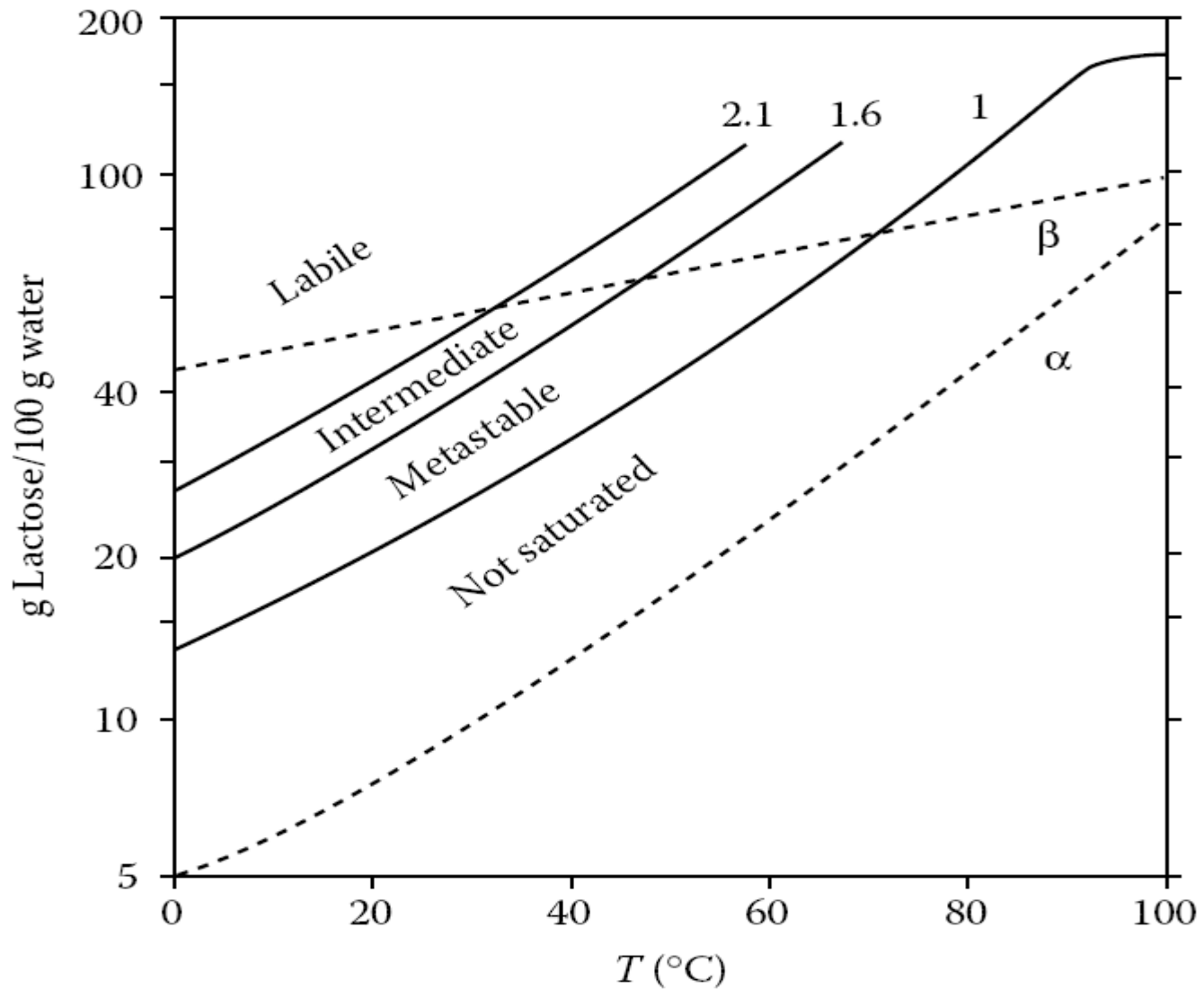
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**TABLE 1.2**  
**Properties of the Main Structural Elements of Milk**

	Milk			
	Fat Globules	Casein Micelles	Plasma	
			Serum	
			Globular Proteins	Lipoprotein Particles
Main components	Fat	Casein, water, salts	Serum protein	Lipids, proteins
To be considered as	Emulsion	Fine dispersion	Colloidal solution	Colloidal dispersion
Content (% dry matter)	4	2.8	0.6	0.01
Volume fraction	0.05	0.1	0.006	$10^{-4}$
Particle diameter <sup>a</sup>	0.1–10 $\mu\text{m}$	20–400 nm	3–6 nm	10 nm
Number per ml	$10^{10}$	$10^{14}$	$10^{17}$	$10^{14}$
Surface area ( $\text{cm}^2/\text{ml}$ milk)	700	40000	50000	100
Density ( $20^\circ\text{C}$ ; $\text{kg} \cdot \text{m}^{-3}$ )	920	1100	1300	1100
Visible with	Microscope	Ultramicroscope		Electron microscope
Separable with	Milk separator	High-speed centrifuge	Ultrafiltration	Ultrafiltration
Diffusion rate (mm in 1h) <sup>a</sup>	0.0	0.1–0.3	0.6	0.4
Isoelectric pH	~3.8	~4.6	4–5	~4

*Note:* Numerical values are approximate averages.

<sup>a</sup> For comparison, most molecules in solution are 0.4 to 1 nm diameter, and diffuse, say, 5 mm in 1 h.  $1 \text{ mm} = 10^3 \mu\text{m} = 10^6 \text{ nm} = 10^7 \text{ \AA}$ .



**Solubilities of  $\alpha$ - and  $\beta$ -lactose, final solubility of lactose (curve 1), and supersaturation by a factor of 1.6 and 2.1, as a function of temperature.**

**TABLE 2.2****The Most Important Salts in Milk and Their Distribution between Serum and Casein Micelles**

Compound	Molar Mass (Da)	Range (mmol/kg)	Average (mg/100 g)	Fraction Present in Serum	In Micelles (mmol/g Dry Casein)
<b>Cations</b>					
Na	23	17–28	48	0.95	0.04
K	39.1	31–43	143	0.94	0.08
Ca	40.1	26–32	117	0.32	0.77
Mg	24.3	4–6	11	0.66	0.06
Amines	—	~1.3	—	~1	—
<b>Anions</b>					
Cl	35.5	22–34	110	1	—
CO <sub>3</sub>	60	~2	10	~1?	—
SO <sub>4</sub>	96.1	~1	10	1	—
PO <sub>4</sub> <sup>a</sup>	95	19–23	203	0.53	0.39
Citrate <sup>b</sup>	189	7–11	175	0.92	0.03
Carboxylic acids	—	1–4	—	~1?	—
Phosphoric esters <sup>c</sup>	—	2–4	—	1	—

<sup>a</sup> Inorganic only.<sup>b</sup> (CH<sub>2</sub>-COO<sup>-</sup>)-(COH-COO<sup>-</sup>)-(CH<sub>2</sub>-COO<sup>-</sup>).<sup>c</sup> Soluble.

**TABLE 2.3**  
**Approximate Distribution of Phosphorus in Milk**

Type	Location	Distribution (%)	Dialyzable against Water	Dialyzable at Low pH	Soluble in TCA <sup>a</sup>	Extractable with Ethanol/Ether
Esterified to casein	Casein micelles <sup>b</sup>	22	No	No	No	No
Esterified in phospholipids	Fat globules and serum	1	No	No	No	Yes
Various esters	Serum	9	Yes	Yes	Yes	Yes
Inorganic, 'colloidal'	Casein micelles	32	No <sup>c</sup>	Yes	Yes	No
Inorganic, dissolved	Serum	36	Yes	Yes	Yes	No

*Note:* Milk contains approximately 1 g phosphorus per kg.

<sup>a</sup> Final concentration 12% trichloroacetic acid.

<sup>b</sup> A small part in the serum, especially at low temperature.

<sup>c</sup> Partly dialyzable against an excess of water.

**TABLE 2.7**  
**Fatty Acids in Milk Fat**

Acid	Notation <sup>a</sup>		Melting Point (°C)	Solubility <sup>b</sup> (g/l)	Composition (in mol %) of			
	<i>x</i>	<i>y</i>			Neutral Glycerides <sup>c</sup>	Phospholipids	Free Fatty Acids <sup>d</sup>	Percentage in 3-Position
Saturated:					69 (57–80)	45	72	
Butyric	4	0	–8	Miscible	8.5 (7–14)	0.0	14.5	97
Caproic	6	0	–4	174	4.0 (2–7)	0.0	4.5	84
Caprylic	8	0	16	58	1.8 (1–3.5)	0.2	2	45
Capric	10	0	31	17	3.0 (1.5–5)	0.2	2	33
Lauric	12	0	44	5.6	3.6 (2.5–7)	0.5	2	26
Myristic	14	0	54	1.6	10.5 (8–15)	3	9	17
Palmitic	16	0	63	0.49	23.5 (20–32)	19	21	12
Stearic	18	0	70	0.14	10.0 (6–13)	12	13	22
Odd-numbered					2.5 (1.5–3.5)	4.5	2.5	7
Branched					1.1 (0.7–1.8)	0.7	1	
Other					0.7 (0.3–2)	5		
Monoene:					27 (18–36)	41	23	
Palmitoleic	16	1 $\Delta^9$ <sup>e</sup>			1.4	?	1?	23
Oleic	18	1 $\Delta^9$ <sup>e</sup>	16	0.42	21 (13–28)	38	20	32
Other					5.5	3	3.5	
Diene:					2.5 (1–4.3)	8		
Linoleic	18	2 $\Delta^9,12$ <sup>e</sup>	–5		1.8	8	2.3	20
Other					0.7	0.2		

Polyene:				0.8 (0.4–2)	4			29
$\alpha$ -Linolenic	18	3 $\Delta$ 9,12,15 <sup>e</sup>	-12	0.4	2			
Other				0.4	2			
Keto				0.3	?			
Hydroxy				0.3	?			
Fatty alcohol				0.01	0.15			
Fatty aldehyde				0.02	0.01			
Unclassified					2		1	

*Note:* Properties, approximate average fatty acid composition of some lipid classes, and average percentage of each fatty acid residue esterified in the 3-position of the triglycerides.

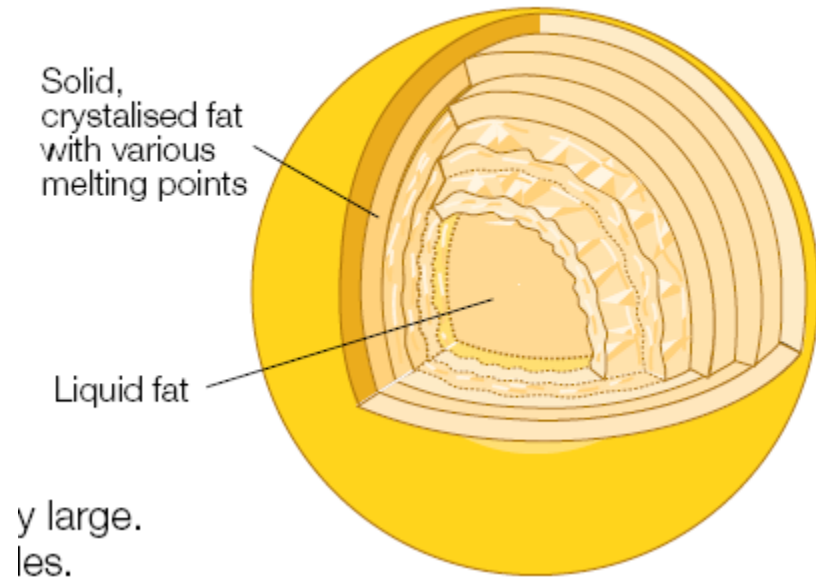
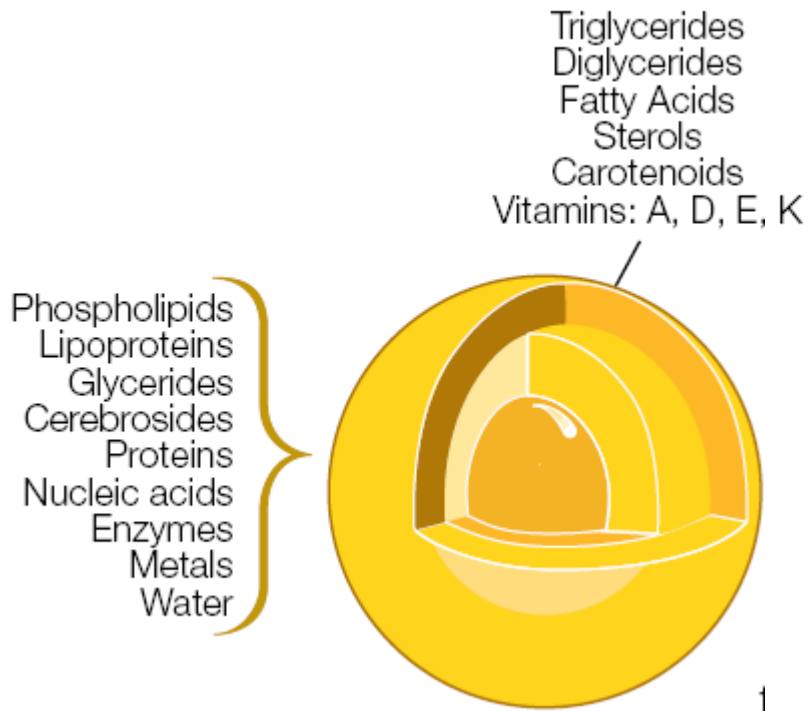
<sup>a</sup>  $x$  = number of C atoms;  $y$  = number of double bonds;  $\Delta$  refers to the position in the carbon chain:  $\Delta$ 9, 12, for instance, indicates that the two double bonds occur at the 9th and 12th bonds, counting from the carboxyl group.

<sup>b</sup> Critical micellization concentration in the presence of  $\text{Na}^+$  ions.

<sup>c</sup> In parentheses is the approximate range.

<sup>d</sup> Free fatty acids liberated by the action of milk lipase.

<sup>e</sup> All *cis*.



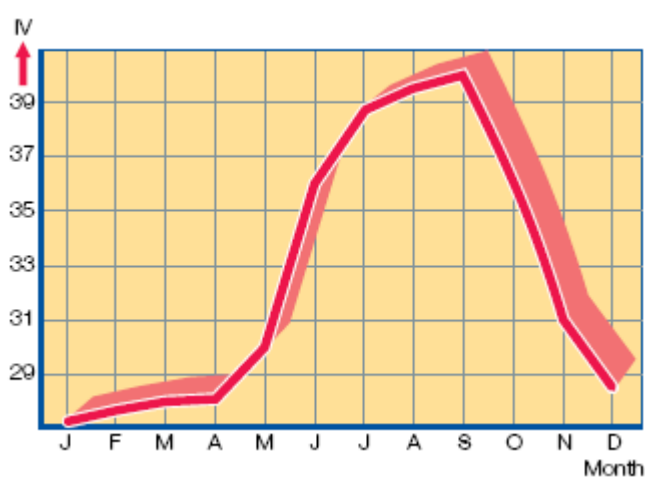
**The composition of milk fat. Size 0.1 – 20 mm.  
Average size 3 – 4 mm.**

**Sectional view of a fat globule**

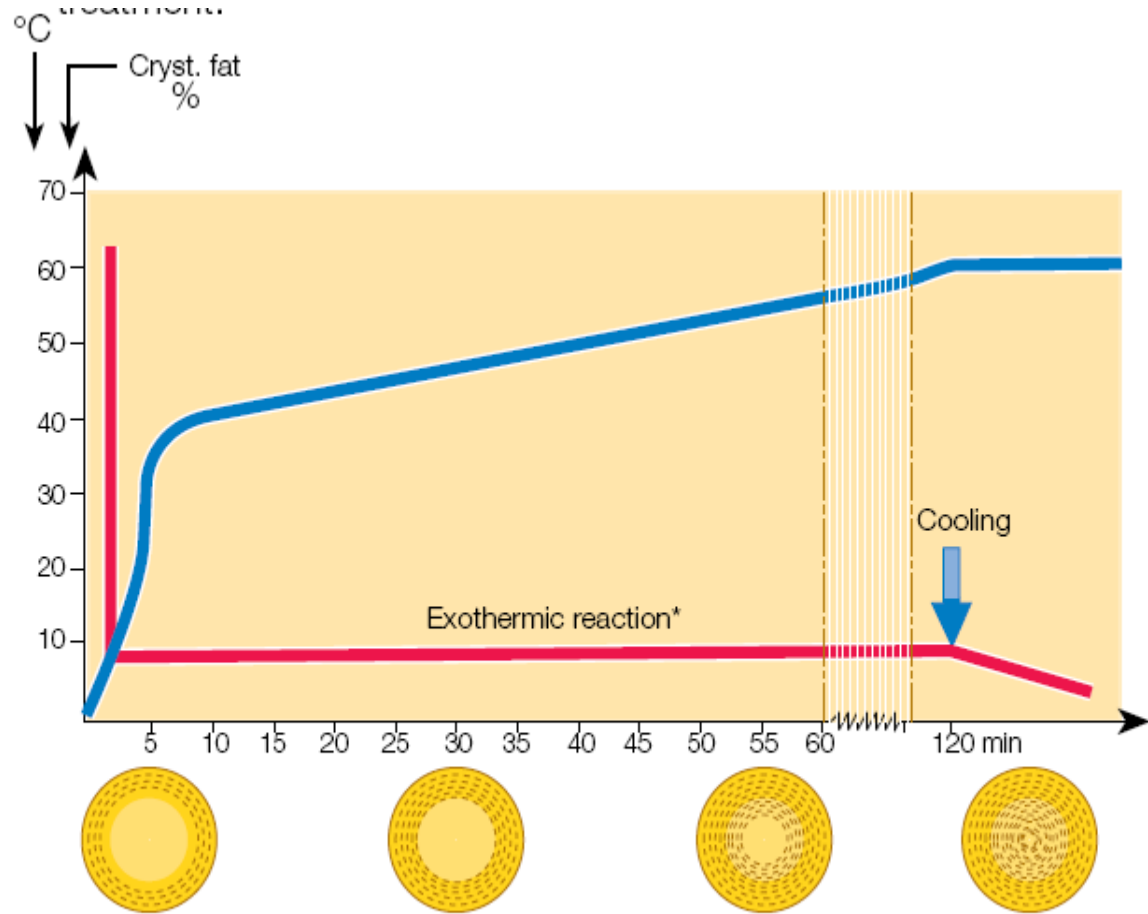
- v: particle velocity
- d: particle diameter
- $p_d$ : discrete phase density
- $p_c$ : continuous phase density
- r: rotation axis radius
- $\omega$ : angular velocity
- $\mu$ : continuous phase viscosity

$$v = \frac{d^2 (p_d - p_c) r \omega^2}{18\mu}$$





***Iodine value at different times of the year. The iodine value is a direct measure of the oleic acid content of the fat.***



\* Exothermic = a chemical reaction accompanied by development of heat. (Heat of fusion)

***Milk fat crystallisation is an exothermic reaction, which means that the chemical reaction is accompanied by evolution of heat. The crystallisation curve is based on analysis made by the NMR method.***