PROIZVODNJA ŽELATINA
Fig. 1.2 The Ancient Egyptians used glutin glues for furniture production. This glue is still produced today from the collagen of animal hides and bones in some countries, including Egypt.
Fig. 1.8 Advertisement for the “Kodak Nr. 1” camera which worked with rolls of film instead of plates. This made it possible to produce photos in an easy way and at reasonable cost.
Tropokolagen je osnovna molekulska jedinica kolagena, ima oblik štapića dužine oko 300 nm (280 nm prim.aut.) i dijametra 1,5 nm, to je najduža poznata belančevina, molekulske mase oko 3.000.000 Daltona. Molekul tropokolagena je sastavljen od tri polipeptidna lanca. Svaki lanac je pojedinačno uvrnut u α - heličnu konformaciju, a sva tri zajedno čine trostruki heliks ili "super" heliks, odnosno molekule tropokolagena koje se dalje međusobno povezju gradeći kolagen i kolagena vlakna."

Krajevi tropokolagena

Poprečna prugavost 64 nm
Lakunarna regija (praznine)

Zona preklapanja

280 nm

Lakunarna regija (praznine)

Zona preklapanja

64 nm

Tropokolagen

Fibril

Vlakno

Snop

10% ukupne dužine
Fig. 2.1 Collagen is comprised of linear, fiber-like structures. Left: Rat tail tendon collagen. Right: Kangaroo tail collagen (Source: Leibniz Research Center for Medicine and Biosciences, Borstel, Germany).
Fig. 3.54 At the beginning of the 19th century, Papin’s “Digestor” made it possible to manufacture gelatine economically as a food protein.
1682 The Frenchman Papin reports on a cooking process in which he tried to obtain a jelly-like mixture from bones.

1700 Gelatine (Latin: gelatus = stiff, frozen). The word gelatine is first used in Europe around 1700.

1754 The first patent in the adhesives sector is granted in England in 1754 for the manufacture of a joiner’s glue. The natural adhesive is manufactured on the basis of gelatine, among other things.

1871 Profound discoveries by the English doctor Richard Leach Maddox lead to the decisive breakthrough in photography. Doctor Maddox invents a dry plate with a bromide-silver-gelatine layer that is just as sensitive as the wet plates used until this time. Following further research Charles Bennett presents a satisfactory dry plate method. One of the main advantages of this new technology is that the exposure times during photography can be reduced considerably.

1875 This year is considered to be a milestone in modern gelatine manufacture. Thanks to the emergence of small factories, large quantities of gelatine can now be manufactured industrially.
**Fig. 2.20** The central layer of the cattle hide ("split") is an excellent source of collagen for the manufacture of gelatine.

<table>
<thead>
<tr>
<th>Hairs</th>
<th>Leather</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horn</td>
<td>Cutis Corium</td>
</tr>
<tr>
<td>Sebaceous Gland</td>
<td>Sweat Gland</td>
</tr>
<tr>
<td>Hair Root</td>
<td>Subcutis</td>
</tr>
</tbody>
</table>

**Fig. 2.21** The removal of pigskin, today's most important raw material for gelatine worldwide, from the fat layer is often still done by hand. However, machines are being increasingly used.
Table 1.7 Annual world gelatine production of all grades by areas in 1974–2005 (thousands of tons).

<table>
<thead>
<tr>
<th>Year</th>
<th>Total production</th>
<th>Western Europe</th>
<th>Eastern Europe &amp; Russia</th>
<th>NAFTA</th>
<th>South America</th>
<th>Asia</th>
<th>Oceania &amp; Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>305</td>
<td>119</td>
<td>7</td>
<td>61</td>
<td>52</td>
<td>59</td>
<td>7</td>
</tr>
<tr>
<td>2004</td>
<td>290</td>
<td>119</td>
<td>6</td>
<td>62</td>
<td>48</td>
<td>49</td>
<td>6</td>
</tr>
<tr>
<td>2003</td>
<td>278</td>
<td>118</td>
<td>5</td>
<td>60</td>
<td>43</td>
<td>46</td>
<td>6</td>
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<tr>
<td>2002</td>
<td>276</td>
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<td>4</td>
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<td>2001</td>
<td>264</td>
<td>117</td>
<td>4</td>
<td>58</td>
<td>39</td>
<td>40</td>
<td>6</td>
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<tr>
<td>2000</td>
<td>258</td>
<td>118</td>
<td>4</td>
<td>57</td>
<td>35</td>
<td>38</td>
<td>6</td>
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<tr>
<td>1999</td>
<td>252</td>
<td>111</td>
<td>7</td>
<td>54</td>
<td>38</td>
<td>36</td>
<td>6</td>
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<tr>
<td>1998</td>
<td>253</td>
<td>113</td>
<td>7</td>
<td>55</td>
<td>38</td>
<td>34</td>
<td>6</td>
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<tr>
<td>1997</td>
<td>248</td>
<td>110</td>
<td>8</td>
<td>52</td>
<td>35</td>
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<td>1996</td>
<td>232</td>
<td>102</td>
<td>9</td>
<td>51</td>
<td>31</td>
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<td>5</td>
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<tr>
<td>1995</td>
<td>226</td>
<td>101</td>
<td>10</td>
<td>46</td>
<td>30</td>
<td>35</td>
<td>4</td>
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<tr>
<td>1994</td>
<td>224</td>
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<td>37</td>
<td>4</td>
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<tr>
<td>1993</td>
<td>212</td>
<td>93</td>
<td>12</td>
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<td>33</td>
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<td>4</td>
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<tr>
<td>1992</td>
<td>206</td>
<td>91</td>
<td>12</td>
<td>39</td>
<td>27</td>
<td>33</td>
<td>4</td>
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<tr>
<td>1991</td>
<td>200</td>
<td>90</td>
<td>13</td>
<td>37</td>
<td>24</td>
<td>32</td>
<td>4</td>
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<tr>
<td>1990</td>
<td>193</td>
<td>83</td>
<td>10</td>
<td>35</td>
<td>21</td>
<td>38</td>
<td>6</td>
</tr>
<tr>
<td>1989</td>
<td>190</td>
<td>81</td>
<td>12</td>
<td>36</td>
<td>20</td>
<td>35</td>
<td>6</td>
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<tr>
<td>1988</td>
<td>185</td>
<td>78</td>
<td>13</td>
<td>36</td>
<td>19</td>
<td>33</td>
<td>6</td>
</tr>
<tr>
<td>1988</td>
<td>185</td>
<td>79</td>
<td>13</td>
<td>35</td>
<td>19</td>
<td>33</td>
<td>6</td>
</tr>
<tr>
<td>1987</td>
<td>186</td>
<td>77</td>
<td>13</td>
<td>37</td>
<td>17</td>
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<tr>
<td>1986</td>
<td>183</td>
<td>72</td>
<td>13</td>
<td>38</td>
<td>18</td>
<td>36</td>
<td>6</td>
</tr>
<tr>
<td>1974</td>
<td>130</td>
<td>62</td>
<td>12</td>
<td>31</td>
<td>5</td>
<td>15</td>
<td>5</td>
</tr>
</tbody>
</table>
Table 1.6  Gelatine production in the different areas in 2005 (thousands of tons).

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Western Europe</th>
<th>Eastern Europe &amp; Russia</th>
<th>NAFTA</th>
<th>South America</th>
<th>Asia</th>
<th>Oceania &amp; Africa</th>
<th>Total</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigskin</td>
<td>81</td>
<td>1</td>
<td>36</td>
<td>5</td>
<td>14</td>
<td>0</td>
<td>137</td>
<td>44.9%</td>
</tr>
<tr>
<td>Beef hide</td>
<td>11</td>
<td>4</td>
<td>10</td>
<td>47</td>
<td>6</td>
<td>7</td>
<td>85</td>
<td>27.9%</td>
</tr>
<tr>
<td>Bones</td>
<td>27</td>
<td>2</td>
<td>15</td>
<td>0</td>
<td>39</td>
<td>0</td>
<td>83</td>
<td>27.2%</td>
</tr>
<tr>
<td>Total</td>
<td>119</td>
<td>7</td>
<td>61</td>
<td>52</td>
<td>59</td>
<td>7</td>
<td>305</td>
<td></td>
</tr>
</tbody>
</table>
SIROVINA

KOŽICE

- priprema i usitnjavanje
  - obrada bazama ili kiselinama
    - neutralizacija
      - ispiranje nabubrelih kožica

- EKSTRAKCIJA ŽELATINA
  - filtriranje
    - koncentrovanje
      - sušenje, oblikovanje i pakovanje želatina

KOSTI

- pripremanje i usitnjavanje
  - tehničke masti
    - mineralno stočno hranivo
      - demineralizacija
      - ispiranje i neutralizacija oseina
Proizvodnja želatina iz kožica

1. Priprema sirovina

Kožice se defrostiraju u bazenu i istovremeno peru cede na perforiranim postoljima

Usitnjavaju na vuku do ujednačenih kockica ~ 3cm
2. Obrada kožica

SIROVINA - KOŽICE

Defrostacija

Pranje

Ispiranje

Potapanje u rastvor kреča. Kреč - sirovina 1:10; Rastvor-sirovina 1:1.

Bubrenje pri pH 12-12,5, nekoliko dana ili nedeļa.

Ispiranje do postizanja pH oko 6.

Neutralizacija sa blagim rastv. sone kис. do postizanja pH oko 8.

Kolagen prelazi u rastorljiv oblik i omogućava ekstrakciju.

Sličica 64. ŠEMA ALKALNE OBRADE KOŽICA.
• Stariji i znatno sporiji ali se može primeniti na sve sirovine

• U bazenima sa krećom po nekoliko nedelja pa i meseci na 17°C

• Krečno mleko se menja svakih 8 dana i meša jednom u 24h

• Nakon ispiranja se cede i prenose u kotao za ekstrakciju
Do pH 2 za 20-30h
Ispiranje krećnim mlekom radi neutralizacije do pH 5,5 pa vodom

Sl. 65. LINIJA OBRADE I PRERADE SIROVINE PO KISELOM POSTUPKU. 1-uredjaj za doziranje kiseline, 2-bazeni za obradu sirovine u kiseloj sredini, 3-pumpa za tečnu fazu-hidrolizat, 4-prijemnik rastvora baza za neutralizaciju 5-kondenzator, 6-prijemnik hidrolizata, 7-sušnica sa tri sekcije, 8-vakum kotao-uparivač, 9-cilindrična sušnica sa raspršivanjem, 10,11-odstranjivanje suvišne vlage iz ostatka, 12-mlevenje osušenog ostatka.
3. Ekstrakcija želatina

Dovršava se kidanje veza polipeptidnih lanaca kolagena započetih bubrenjem

• dodaje voda t 55°C u odnosu 1:1

• meša se uz održavanje temp (kolagen prelazi u rastvor) 7h

• Odvaja mast u tankom sloju sa površine rastvora

• rastvor odstrani (najčvršći želatin) iz kotla pa doda nova voda t 60°C  

• nastavlja do ključanja i sa svakom novom frakcijom sve lošiji kvalitet želatina sa sve većom količinom stranih čestica tj. suve materije
Ekstrakcija
3. Filtriranje želatina

Rastvor se propušta kroz centrifugalni separator 7.000 o/min (kako bi se izdvojila zaostala mast)

Filter prese sa aktivnim materijama za odstranjivanje bojenih i dr materija na temp 50 °C, eventualno jono izmenjivačke smole
4. Koncentrisanje rastvora

Uparavanje u vakuum uparivačima ne temp 30 °C do s.m. 20-40%
5. UHT sterilizacija (140°C 5 sec)
6. Sušenje

Oblikuje u pakuje u vidu pločica, ljuspica, granula ili praha
Proizvodnja želatina iz kostiju

1. Sortiranje kostiju
cevaste kosti ekstremiteta
kične karlice i rebara
glave

oslobađaju mesa, tetiva, ligamenata itd.
event. lak term tretm u kotlu
Usitnjavanje kostiju
Obezmašćivanje

1. topom vodom
2. parom
3. isparljivim rastvaraćima
Demineralizacija

1/3 organske materije (kolagen 35%)
2/3 neorganske soli koje treba odstraniti (Ca30%, P15%)

u vidu nerastvorljivog tri kalcijum fosfata koji se dejstvom kiselina 1:1 na t 16 °C prevodi u rastvorljiv bi kalcijum fosfat koji se taloži i odstranjuje.
Demineralizacija
### g amino acid per 100 g pure gelatine

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Gelatine</th>
<th>Milk (100g)</th>
<th>Bread (100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alanine</td>
<td>11.3</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Arginine*</td>
<td>9.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspartic Acid</td>
<td>6.7</td>
<td>0.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Glutamic Acid</td>
<td>11.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glycine</td>
<td>27.2</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>Histidine*</td>
<td>0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proline</td>
<td>15.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydroxyproline</td>
<td>13.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydroxylysine</td>
<td>0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isoleucine*</td>
<td>1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leucine*</td>
<td>3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lysine*</td>
<td>4.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methionine*</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phenylalanine*</td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serine</td>
<td>3.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threonine*</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tryptophan*</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tyrosine</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valine*</td>
<td>2.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Essential Amino Acid

### The chemical analysis

- **84–90% protein**
- **1–2% mineral salts**
- The rest is water.

Gelatine does not contain any preservatives or other additives. It is free of cholesterol and purines (uric acid compounds).
The same amount of the amino acid glycine is contained in:

- 10 g gelatine
- 2.8 L milk
- 160 g meat
<table>
<thead>
<tr>
<th>Application</th>
<th>Gelatine type</th>
<th>Concentration</th>
<th>Principal function</th>
<th>Secondary function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desserts</td>
<td>200–260 Bloom</td>
<td>1.5–3.0%</td>
<td>Gel formation</td>
<td>Texture, transparency, brilliance</td>
</tr>
<tr>
<td>Fruit gummies</td>
<td>200–280 Bloom</td>
<td>6.0–10.0%</td>
<td>Gel formation</td>
<td>Texture, elasticity, transparency, brilliance</td>
</tr>
<tr>
<td>Marshmallows</td>
<td>160–260 Bloom</td>
<td>1.0–3.0%</td>
<td>Foam formation</td>
<td>Foam stabilizer, gel formation</td>
</tr>
<tr>
<td>Nougat</td>
<td>180–220 Bloom</td>
<td>1.5–3.0%</td>
<td>Foam formation</td>
<td>Foam stabilizer, gel formation</td>
</tr>
<tr>
<td>Pastilles</td>
<td>160–220 Bloom</td>
<td>1.0–2.0%</td>
<td>Binding agent</td>
<td>Texture, improvement of melting properties in the mouth, prevents disintegration</td>
</tr>
<tr>
<td>Caramels</td>
<td>140–200 Bloom</td>
<td>0.5–2.5%</td>
<td>Emulsifier, foam stabilizer</td>
<td>Chewability</td>
</tr>
<tr>
<td>Yogurt</td>
<td>220–260 Bloom</td>
<td>0.2–1.0%</td>
<td>Syneresis stabilizer</td>
<td>Texture, creaminess</td>
</tr>
<tr>
<td>Foamed milk dessert</td>
<td>180–240 Bloom</td>
<td>0.3–3.0%</td>
<td>Foam formation</td>
<td>Texture, stabilization</td>
</tr>
<tr>
<td>Jellied milk dessert</td>
<td>180–240 Bloom</td>
<td>1.0–2.0%</td>
<td>Gel formation</td>
<td>Texture, creaminess</td>
</tr>
<tr>
<td>Sandwich spread (without meat)</td>
<td>240–280 Bloom</td>
<td>0.3–1.5%</td>
<td>Emulsion stabilizer</td>
<td>Texture, creaminess</td>
</tr>
<tr>
<td>Meat and sausages</td>
<td>220–260 Bloom</td>
<td>0.5–2.0%</td>
<td>Emulsion stabilizer</td>
<td>Water binder</td>
</tr>
<tr>
<td>Broths and canned meats</td>
<td>220–260 Bloom</td>
<td>0.5–2.0%</td>
<td>Binding agent</td>
<td>Texture, sliceability</td>
</tr>
</tbody>
</table>
Fig. 3.1 Market share of the most important hydrocolloids for food applications.
Fig. 1.6 Gelatine sponges are available in a variety of shapes to stanch surgical bleeding in different areas of the human and animal bodies.

Fig. 1.7 Blood plasma substitutes based on gelatine are widely used for the temporary replacement of blood in the circulatory system after surgery or accidents.

Fig. 3.71 Gelatine hard shell capsules are produced in a wide variety of sizes and colors.
Fig. 2.14 Cereal bars with low water and low sugar content are produced with gelatine or gelatine hydrolysate as a binding agent.

Fig. 3.68 Gelatine hydrolysate, when added to dough, renders bread softer and delays staling during storage. Therefore, the consumer need not shop so frequently.
Fig. 3.95 Collagen and its derivatives play a major role in skin and hair care cosmetics.

Fig. 3.108 Gelatine gel corresponds closely to the density of muscle tissue. In this way, for example, in forensic medicine, conclusions can be drawn about the behavior of projectiles in animal or human tissues.
Fig. 3.114  Gelatine is a proven agent for decontaminating buildings containing asbestos.

Fig. 3.106  Playing cards are given their high-quality surface by technical gelatine.
Fig. 3.105 One well-known application of the adhesive properties of gelatine is the manufacture of matches.

Fig. 3.109 Gelatine coatings can protect the surfaces of metals from corrosion in a very environmentally friendly way.
Fig. 3.110 Gelatine used as a buffer layer between the roots of the plant and a plant pot made of renewable materials improves the resistance of the pot to moisture and provides the plant with a natural reservoir of water and – after biodegradation – of nitrogen.