Jams,
Jellies and Marmalades
Cooking jams, jellies and marmalades using fruits, sugar, pectin and edible acids is one of the oldest food preserving processes known to mankind and presents a way of making food stable by increasing the content in soluble solids. The shelf-life of the products gained by this method depends on the following criteria as regards their stability to microbial spoilage:

- Perfect hygienic operating conditions, such as production units, filling and production system.
- Perfect hygienic raw materials and packaging materials.
- A high sugar content (min. 60% soluble solids in jams, jellies and marmalades), which causes a lowering of the free water by hydration.
- Sufficient pasteurization or chemical preservation of low-calorie fruit spreads, jams, jellies and marmalades (less than 60% soluble solids).
- A low pH-range (pH 2.6-3.2) when using high methylester pectins.
- Sufficient cooking time to achieve an inversion and exchange of sugar between the medium and fruits (otherwise the formation of low-sugar concentration zones may incur the risk of crystal formation or water exudation).

The quality criteria for jams and marmalades are decisively determined by the flavour, colour and consistency as well as state of preservation and distribution of fruits. These properties depend to a high degree on the raw materials used, with special importance given to the proper selection of suitable fruits. The characteristic nature of the finished product is further determined by the addition of sugars, pectin and edible acids.

The German Fruit Jams Regulation gives the following definition for the required condition of the raw materials:

Fruits:
Fresh, sound, not spoiled fruit, containing all its essential constituents, after cleaning and removal of blemishes and sufficiently ripe.

Chestnuts for the purpose of the regulation is the fruit of the sweet chestnut tree (Castanea sativa). The term “fruits” is extended for the purpose of the regulation also to:

- The edible parts of rhubarb stalks, ginger, e.g. parts of the ginger plant, tomatoes, cucumbers, melons, water melons, pumpkins, carrots and sweet potatoes.
- Stone fruits and kernel fruits are generally processed without stones, pits and cores and in unpeeled condition, citrus fruits are generally peeled when processed, part of the peels is frequently added.

The most important quality criteria for fruits used are:

- optimal state of ripeness
- full fruity flavour
- variety-specific colour
- no blemishes (no spots, no bruises)
- sufficient consistency (solidity of form)
- soluble solids content in agreement with quality standards
- perfect hygienic condition of raw materials and packaging

Fruit Pulp (pulp):
The edible part of the whole fruit, peeled or cored if necessary, which may be whole, sliced or chopped.

Fruit Purée (purée):
The edible part of the whole peeled or cored fruit, which has been reduced to purée by straining or a similar process.
Fruit Juice:
Products complying with the German Fruit Juice Regulation.

Aqueous Extracts of Fruits:
Aqueous extracts of fruits which contain all water-soluble constituents of the fruits except technically unavoidable losses.

Citrus Peels (peels):
Cleaned citrus peels with or without endocarp.

Fruit Constituents:
In fresh condition, fleshy-juicy fruits consist, as a rule, of 80-85% water. The main constituents, besides water, are carbohydrates, furthermore organic acids, polymer carbohydrates such as pectins and starches, nitrogenous compounds, minerals, vegetable phenols, flavours and vitamins.

The composition of the fruits underlies great deviations in dependence on type of fruit, degree of ripeness, conditions of cultivation and climate.

Fruit varieties used in the production of jams, jellies and marmalades have to be especially selected for their:

- **fruit owned pectin content:**
  The fruit owned pectin content is off less importance. Usually the cooking time does not suffice to let the pectin become soluble and with that be able to gel;

- **pH-value and titratable acid:**
  pH and titratable acid are indicators for the quantity of organic acids and its salts contained in a fruit. Both factors affect gelation. In the production of jams with high methylester pectins, the pH-range is usually set at about 2.8-3.2 with citric acid, since this pH-range is very favourable in view to gelation, flavour and shelf-life;

- **Calcium content:**
  Low methylester and amidated pectins gel in combination with calcium ions. Thus the fruit-owned calcium content is of great importance. Generally speaking, the insoluble parts of fruits are especially rich in calcium. However, the total calcium amount is not available to pectin, but only part of it, the so-called “free calcium”. The remaining calcium ions, or “bound calcium”, are solidly fixed to complexing agents.

The following table gives a summary of the average pectin contents as well as contents in titratable acids and calcium ions and the mean pH-range of the most important fruits in jam manufacture.

<table>
<thead>
<tr>
<th>Type of fruit</th>
<th>1) mgCa2+/100g</th>
<th>1) + 2) pectin [%]</th>
<th>2) pH</th>
<th>2) titratable acid [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>apples</td>
<td>7</td>
<td>0.70</td>
<td>3.2-3.5</td>
<td>0.52 (M)</td>
</tr>
<tr>
<td>sweet cherries</td>
<td>17</td>
<td>0.36</td>
<td>3.4-3.7</td>
<td>1.36 (M)</td>
</tr>
<tr>
<td>plums</td>
<td>14</td>
<td>0.76</td>
<td>3.1-3.4</td>
<td>2.21 (M)</td>
</tr>
<tr>
<td>peaches</td>
<td>8</td>
<td>0.54</td>
<td>3.4-3.8</td>
<td>0.62 (M)</td>
</tr>
<tr>
<td>apricots</td>
<td>16</td>
<td>0.96</td>
<td>3.6-3.8</td>
<td>1.13 (M)</td>
</tr>
<tr>
<td>strawberries</td>
<td>26</td>
<td>0.81</td>
<td>3.2-3.5</td>
<td>1.11 (C)</td>
</tr>
<tr>
<td>raspberries</td>
<td>40</td>
<td>0.40</td>
<td>3.1-3.6</td>
<td>1.35 (C)</td>
</tr>
<tr>
<td>blackberries</td>
<td>44</td>
<td>0.48</td>
<td>3.3-3.6</td>
<td>1.09 (C)</td>
</tr>
<tr>
<td>red currants</td>
<td>29</td>
<td>0.93</td>
<td>3.0-3.1</td>
<td>2.14 (C)</td>
</tr>
<tr>
<td>gooseberries</td>
<td>29</td>
<td>0.62</td>
<td>2.7-3.1</td>
<td>2.37 (C)</td>
</tr>
</tbody>
</table>

Table 1:
M: calculated as malic acid
C: calculated as citric acid

2) K. Herrmann: Obst, Obstduerwaren und Obstzeugnisse, Verlag Paul Parey 1966

Types of sugar:
All sugars listed in the “German Regulation on Certain Sugars Destined for Human Consumption” (Zuckerarten-Verordnung vom 23.10.2003 [BGBl. I.S. 2096] in the actual edition) may also be used in solution and in any mixing ratio.

Sugars are one of the main constituents of jams, jellies and marmalades and influence the shelf-life of these products decisively through the soluble solids content. At the same time they provide taste, flavour, consistency and colouring.

For jam production, mostly refined sugar or white sugar (sucrose) is used. During cooking, sucrose is partially inverted. This intended chemical reaction (splitting of sucrose into glucose and fructose by binding water) is influenced by:

- the pH-value
- the temperature
- the time
Sugar Substitutes:
Sugar substitutes form a group of substances which may be used to substitute sucrose in food products. Similar to sugars they provide some or all of the sweet taste, flavor and aw-value in the finished product may be influenced by suitable combinations with other sugars. When high dosages (more than 20g per person and day) are consumed, polyols may sometimes have a laxative effect.

Polyols or sugar alcohols form the main group of sugar substitutes. The physiological benefit of these sugar substitutes is their suitability for diabetics (insulin independent metabolism) as well as their partially anti-cariogenic effect and lower calorific value.

Fructose (fruit sugar) is a monosaccharide which is naturally present in practically all fruits. Its relevance as a sugar substitute consists in its insulin independent metabolism and digestion, which makes it suitable for dietetic food products for diabetics. The calorific value of fructose is determined at 17KJ/g (or 4kcal/g), equal to sucrose or glucose. The sweetening power of fructose is higher than that of sucrose. Fruit sugar is normally traded as fruit sugar syrup with 70% ss.

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  - For all sugar alcohols a uniform physiological calorific value of 10kJ/7g is fixed.

<table>
<thead>
<tr>
<th>Sweetener</th>
<th>Sweetening Power Relative to Sucrose</th>
</tr>
</thead>
<tbody>
<tr>
<td>acesulfame-k</td>
<td>130-200 *</td>
</tr>
<tr>
<td>aspartame</td>
<td>200-250 *</td>
</tr>
<tr>
<td>cyclamate</td>
<td>30-40 *</td>
</tr>
<tr>
<td>saccharine</td>
<td>450-500 *</td>
</tr>
<tr>
<td>sucralose</td>
<td>approx. 600 *</td>
</tr>
</tbody>
</table>

Table 3: * the figures indicate the factor by which the sugar replacer in question tastes sweeter than sucrose.

Sugar Substitutes:
Sugar substitutes form a group of substances which may be used to substitute sucrose in food products. Similar to sugars they provide food with “bulk” or “body” and a physiological calorific value. Their sweetening power is comparable to sucrose or less.

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Sweeteners:
Sweeteners are natural or synthetic compounds which have no or, compared to their sweetening power, only a negligible calorific value. Their sweetening power is by far greater than that of sucrose.
Sweeteners are not insulin dependent in their metabolism and thus suitable for diabetics. Since they are generally used in small amounts, they neither influence texture nor body of the sweetened food product.

The various sweeteners differ in their characteristics, such as profile in taste, stability in acidified food and during heating. In composition they may sometimes yield a positive synergistic effect.

**Sweeteners:**
De-ionized fruit juice concentrates and fruit extracts are increasingly used as natural sweeteners. Herbasweet apple extract is a high-quality sweetener with a soluble solids content of 70-72°Bx resp. 78°Bx, which is produced from the fruit extract of juice-extracted and carefully dried apples.

By state-of-the-art technologies minerals, fruit acids and natural colours are extracted from the concentrated fruit extract. What remains is the concentrated sweetness of the apple, which may be universally used to sweeten food products instead of sugar or starch-saccharification products.

According to the German Fruit Jams Regulation, these sweeteners (different sugars gained from fruits) are allowed. They are of great interest for the so-called “all fruit products”, which consist only of ingredients from fruits.

In multi component systems like jams, jellies and marmalades, pectin is a texture provider. The optimal formation of a gel is directly linked to the volume ratio in which the ingredients fruits, sugars, water, acid and pectin are present. The addition of pectin, which is produced from fruits, must be considered as naturally enhancing the inherent pectin content of the fruits used for the jam production. Additionally there are the acid resistance of pectin and the fact, that it has no specific odour or flavour, that it is an excellent flavour carrier as well as the possibility to control consistency and setting rate.

**Pectin:**
The gelling agent pectin, a constituent of the vegetable cell structure, strengthens and supports as “bonding substance” the structure of the plant tissue.

Any vegetable raw material with a high pectin content is suitable for the production of pectins.

Different amounts of pectin may be extracted from various raw materials:
- Pomace 10-15%
- Sugar beet chips 10-20%
- Citrus peels 20-35%

Apples and citrus fruits have always been of superior importance for the production of pectin destined for the manufacture of jams, jellies and marmalades. The highly valuable pectin substances are present in the pulp and, in especially high concentration, the cell walls. This explains why the press residues from the production of apple and citrus juice are so valuable for large-scale extraction of high-quality pectins.

In the plant cell, pectin molecules are so tightly linked to the other molecules in the cellular wall that they cannot be extracted by water. This water-insoluble form is called protopectin.

Protopectin becomes soluble by acid hydrolysis and is then extracted with hot water. The pectin-rich extract is mechanically cleaned and carefully concentrated. Pectin is then precipitated with alcohol from the liquid extract.

Alcohol-insoluble pectin substances in pure form are obtained by this alcohol precipitation. They are subsequently dried and ground to powder. The gel strength of pectin as a natural substance differs due to the raw material used and is standardized by blending with dextrose or other sugar types.

The molecular structure of pectins is composed of D-galacturonic acid molecules, which are linked to each other in alpha-1,4-glycosidic formation to polygalacturonic acid. Part of the carboxyl groups is methoxylated with methanol. Neutral sugars like arabinose, galactose and xylose, which are linked as side chains to the pectin macromolecule, as well as the interruption of the main chain by rhamnose make pectin a heteropolysaccharide.
Therefore often neutral polysaccharides like galactane, araban and also starch are concomitant substances of isolated pectin. However, the specific composition depends on the raw material. The gelling power of pectin is mainly based on its molecular weight, i.e. the number of chain links a pectin molecule boasts, which is kept intact by extremely sensitive production process.

If all carboxyl groups of the polygalacturonic acid are free, i.e. not methoxylated, one gets pectic acid, its salts are called pectates.

Pectic acid in nature is methoxylated (or esterified) in different degrees with methanol and thus becomes pectin. If the degree of esterification is higher than 50%, it is called high methylester pectin, with less than 50% it is called low methylester pectin.

**Gelling Mechanisms:**

The association of pectin chains leads to the formation of three-dimensional networks, that means to gel formation. Two or more chain segments bond together and start to interact. These are longer segments of regular sequence, which are ruptured by the incorporation of rhamnose or by the branching of the chain.

Different types of chain associations exist which are determined by the degree of esterification. For high methylester pectins, two decisive factors initiate gel formation:

1. The addition of sucrose or other sugars has a dehydrating effect on the pectin molecules, which facilitates the approach of the polymer chains and enables a cross linkage of the hydrogen bridges.

2. A lowering of the pH in the medium suppresses the dissociation of free carboxyl groups and thus reduces the electrostatic repulsion between the chains. The mechanism described above is referred to in literature as “sugar-acid-gelling mechanism”.

Recent studies, however, have shown that high methylester pectins are stabilized in the gel by a combination of hydrophobic interactions and hydrogen bridge bondings, which means that the term “sugar-acid-gelling mechanism” requires a closer definition.

Methylester groups are the hydrophobic part of a pectin molecule. Hydrophobic forces push them into aggregate formations, while they are constantly striving to keep the contact surface with water as small as possible. Moreover, hydrogen bridges are formed, e.g. between non-esterified carboxyl groups, at a sufficiently low pH-value in the gel and the dissociation of the carboxyl groups is largely suppressed.
According to Oakenfull and Scott (1984), the hydrogen bridge bondings are the responsible factor in the stabilization of a pectin network, but without the hydrophobic interaction of the methylester groups, gelation would not occur for energetic reasons.

The higher the degree of esterification, the greater the impact of hydrophobic forces in the gelation. The number of hydrogen bridges over free, non-methoxylated carboxyl groups decreases and if the pH is too high, the number of interfering factors (-COO⁻) decreases as well (in case of a too high product pH, dissociated carboxyl groups interfere with the network formation). This affects the gelling-pH-range. If the degree of esterification is extremely high, the suppression of dissociation does not matter anymore.
The higher the degree of esterification, the higher also the pH-value is, at which gelation sets in. Completely methoxylated pectins (100% degree of esterification) thus do not require any acid for gelation (Deuel et al., 1950).

The required high sugar concentration for the gelation of high methylester pectins could be explained, according to Oakenfull, by the fact that certain sugars have an additionally stabilizing effect on the hydrophobic interactions.

Low methylester pectins also gel according to the mechanism described above. However, they may form a gel even in relative independence from soluble solids content and pH-value if multivalent cations, e.g. calcium ions, are present. The following model has been used to describe this gelling mechanism:

Pectins chains cluster during the gelation process. Due to their bent shape they create cavities between them, which become occupied by carboxyl and hydroxyl groups. Both the formation of cavities and the carboxyl and hydroxyl groups favour the association of pectin chains by calcium gelation.

As regards low methylester, amidated pectins, additional links by hydrogen bonds are created due to the presence of amid groups. The more amid groups are present, that means the more links are possible, the firmer the resulting gels will be.

For low methylester, amidated pectins, the clustering of the pectin chains happens more controlled than for low methylester, non amidated pectins, as the formation of the gel network is, due to the hydrogen bonds between the amid groups, more slow than the reaction of low methylester pectins with calcium ions.

High Methylester Pectins – Gelling Behaviour:

Soluble Solids and pH-Value:
The chart on page 15 (setting range of high methylester pectins, mod., Pilnik, 1980) in principal shows the setting ranges of sugar-acid-gels with high methylester pectins. Certain solids/pH areas are identified in which pre-gelling or no gelling (liquid) occurs. Pre-gelling means that at the given filling temperature, the products have already started setting. Pumping, stirring or depositing during filling destroys this incipient gel structure, the formation of a homogeneous gel is not more possible. Therefore the texture of a pre-gelled product is mushy with a reduced gel strength.

The chart also explains that sugar and acid may substitute each other within certain limits in their contributions to the gel strength. A lower sugar content requires for proper gelation a lower pH-value. Higher pH-values are feasible with a higher sugar content. If the sugar content remains constant, gels with lower pH-values will be firmer and more brittle, the same applies if the pH stays the same and the amount of sugar increases.

The optimal soluble solids content for jams is 60-65%. Replacing part of the sucrose with glucose syrup or the use of the optimal type of pectin may prevent the formation of brittle gels and the crystallization of sugar and dextrose.

The lower limit for proper gelation of high methylester pectins is a soluble solids content of about 55%. With 58-55% soluble solids, high methylester pectins with a very high degree of esterification (above 75%) show the best results. High methylester pectins do not gel at very low soluble solids contents, for this application low methylester and amidated pectins and calcium salts are used instead.

Substituting sucrose by other sugars or polyols has an influence on the gelling characteristics of pectins and the texture of gels. The reasons for these phenomena are not yet sufficiently studied. It is assumed that this is due to the different water activities of the sweeteners at similar solids contents or substance specific differences in the stabilizing effect (Oakenfull et al., 1984).

References:
Medium Rapid Set with a medium setting temperature
(Pectin Classic AF 401, Pectin Classic CF 301)

Slow Set with a medium setting temperature
(Pectin Classic AF 501, Pectin Classic CF 401)

The setting temperature depends, beside the raw material, the production technology and the pectin's degree of esterification, also on the sugar content and the product's pH-value as well as the amount of buffer salts added and the cooling rate. The faster the products are cooled, the lower the setting temperature required. Therefore, to be able to compare setting time and setting temperature for the evaluation of high methylester pectins.

The setting temperature is the temperature at which gelation starts subsequent to gel manufacture in the following cooling period. There is no setting above this temperature, even though all criteria for gel formation are met. Gelation of extremely high methylester pectins, as was shown in test gels, may, for example, start already at 90°C (194°F), that of less high methylester pectins at 60°C (140°F).

Based on these differences in setting temperature and setting time, the following types of pectins are supplied as:

- Very Rapid Set with a very high setting temperature
  (Pectin Classic AF 101, Pectin Classic CF 101)
- Rapid Set with a high setting temperature
  (Pectin Classic AF 201, Pectin Classic CF 201)
- Medium Rapid Set with a medium setting temperature
  (Pectin Classic AF 401, Pectin Classic CF 301)
- Slow Set with a medium setting temperature
  (Pectin Classic AF 501, Pectin Classic CF 401)

Rapid set pectins differ in their optimal pH-value from slow set ones. While slow set pectins achieve their greatest gel strength at a pH of 3.0 and less, the optimal pH-value for rapid set pectins is raised to higher pH-values. For extra rapid set pectins, a pH-value of under 3.0 may even be unfavourable, especially if the soluble solids content is clearly above 60%. Gelation may then set in during the cooling process, with the very real risk of pre-gelling.

Another look at chart 6 on page 15 makes clear why soluble solids of around 60% and a pH-value of about 3.0 are suitable for rapid set as well as slow set pectins. The differences are due to the setting temperature, setting time and gel texture.

With high soluble solids contents and at low pH-values, slow set pectins must be used since otherwise pre-gelling may occur; with high soluble solids and at high pH-values, on the other hand, rapid set pectin are indicated since otherwise gelation is not possible.

In selecting the suitable type of high methylester pectins – rapid, medium or slow set ones – the following criteria are of great importance:

Filling Temperature:
In this case, the criterion for selecting a suitable pectin is that the manufactured product's setting temperature is lower than the filling temperature. This prevents pre-gelling, which would weaken the gel and exert a negative influence on the texture. The height of the filling temperature is determined by the machines and systems applied in the process as well as the size of the packing containers used.

Containers which cool more quickly allow a filling at high temperatures of 85°C and 95°C (185°F and 203°F). Rapid set pectins in this temperature range provide good gelation as well as an even distribution of the fruits in the jelly. Containers which pass through a long cooling phase, on the other hand, require low filling temperatures of e.g. 70°C to 75°C (158°F to 167°F), since otherwise the consistency of the product might suffer by heat-related damage affecting the center. For this purpose, slow set pectins are used that do not tend to pre-gel in the temperature range in which they are applied. Furthermore, the setting rate may be controlled by adding suitable buffer salts (retarders). Such gelling retardation is usually practiced in the confectionery industry where processing with very high soluble solids is usual.
For the purpose of spreading jam on slices of bread or sweet rolls, it should be noted that jellies with a lower elastic phase are more difficult to spread. In the extreme case, this implies that jellies spread on with a knife will just break up from a large lump into many smaller pieces. Gels with a higher viscous share, on the other hand, will spread on easily and form a coherent jelly layer on the bread.

The proper selection of the suitable type of pectin will thus be a great help in controlling the desired rheological parameters of these products.

Fruits:
Fruits used in the manufacture also generate an influence on the gelling process, depending on variety, state of ripeness and storage conditions. The most important factors are the fruit-own pectin content, the sugar and acid content as well as the amount of minerals and other fruit-specific constituents.

With increasing ripeness, enzymes within the fruit degrade the fruit-inherent pectin and the pulp becomes softer. The fruit-own acid amount decreases and the sugar amount increases.

Acid content:
The adjusting of the optimal pH-value for the gelling process during jam production is achieved by adding edible acids and their salts. Together with the physical-chemical effect of the acids, the flavour enhancing factors are also of great importance in this respect. However, legal regulations need also to be considered. To control the pH-value, the German Fruit Jams Regulation permits the following additives:

- Lactic acid E 270
- Citric acid E 330
- Tartaric acid E 334
- Sodium lactate E 325
- Calcium lactate E 327
- Sodium citrate E 331
- Calcium citrate E 333
- Sodium tartrate E 335

The use of a pH-meter in production control to guarantee uniform gelation in jams, jellies and marmalades is an absolute necessity.

Texture:
Texture is a very important parameter for sensory acceptance and depends largely on the composition of raw materials such as the type of fruit, fruit quantity and sugars used, but also on the selected type of pectin.

Pectins with a very high degree of esterification result in firm gels which are characterized by the rheological parameter “highly elastic with a very low viscous phase”.

Pectins with a medium degree of esterification result in firm gels which are characterized by the rheological parameter “highly elastic with an important viscous phase”.

Apple pectins form gels with definitely higher viscous share than citrus pectins with the same degree of esterification do.

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Apple pectins form gels with definitely higher viscous share than citrus pectins with the same degree of esterification do.
On the other hand, if the pH-value in fruits is too low, it can be increased in order to prevent pre-gelation. If the aim is a stabilization of the pH-value within strict limits, as is the case for jams, one profits from the specific properties of fruit acids to form excellent buffer systems with their salts, e.g. in the combination citric acid and sodium citrate.

As a rule, fruit acids are added to the cooking batch towards the end of the cooking process. This prevents pre-gelling, which might occur if the temperature of the cooking batch drops below the setting temperature due to the blending in of the sugar or the pectin solution.

The gel texture will then lose its elasticity, becomes more pasty and shows a lower breaking strength. The precipitation of calcium pectinate is reversible if the gel is heated again above the setting temperature and cooled down in a destruction free process.

Even if all parameters are adjusted in an optimal way and the temperature is higher than the setting temperature, a processing time, which is too long, can lead to pre-gelation after the addition of acid.

### Low Methylester Pectins – Gelling Behaviour:

The gel formation of low methylester pectins must be seen as follows:

When small amounts of calcium ions are added, the pectin chains start to bond over calcium bridges. With increasing calcium ion concentration, gelation sets in. In case of an exceeded dosage of calcium ions, calcium pectinate will precipitate under the given gel forming conditions, which is referred to as “pre-gelling”.

The gel strength in these samples has been determined with the Herbstreith Pektinometer by testing the breaking strength.

The amount of calcium ions required for proper gelation largely depends on the concentration of soluble solids, the sugar, the pH-value of the product and the buffer substances.

### Concentration of Soluble Solids:

Chart 8 on page 24 shows how the breaking strength of a gel changes with increasing calcium dosage as a function of the different soluble solids contents. At a soluble solids content of 60%, hardly no calcium ions are required to form a firm gel, while at 20-30% of soluble solids major amounts of calcium become necessary. The lower the soluble solids content in a gel, the higher the calcium requirement in order to achieve proper gelation is. The gel strength in these samples has been determined with the Herbstreith Pektinometer by testing the breaking strength.

With increasing calcium dosage, gels become firmer until an optimal point is reached, from which on they become more and more elastic and brittle. Reaching a certain soluble solids dependent calcium dosage, the gel strength will drop rapidly and no gels but pre-gelled products are formed.

### Table 4: Important data on lactic acid, tartaric acid and citric acid

<table>
<thead>
<tr>
<th></th>
<th>lactic acid</th>
<th>tartaric acid</th>
<th>citric acid</th>
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<td>E 334</td>
<td>E 330</td>
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<tr>
<td>Structural form</td>
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<tr>
<td>pH-value (0.1 n solution)</td>
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<td>2.2</td>
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Citric acid: Citric acid is naturally present in a great number of fruits. It is crystalline and dissolves well in water. Citric acid as a weaker acid than tartaric acid, but stronger than lactic acid. The flavour of the citric acid is naturally sour and harmonious. This acid, too, is preferred to be added as 50% aqueous solution.

If the acid value is too high (pH-value under 2.8) the gel elasticity will be increased and the gels become firm and brittle. If the acid value is low (pH-value above 3.3) the gel structures become very soft. When exceeding a certain pH limit, gelation is no longer possible.

The presence of buffer salts in fruits, e.g. salts of citric and malic acid, suppresses the impact of pH modification by added fruit acids, part of the effective acid value is compensated. To get into the desired pH-value, the acid dosage must be raised.

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On the other hand, if the pH-value in fruits is too low, it can be increased in order to prevent pre-gelation.

If the aim is a stabilization of the pH-value within strict limits, as is the case for jams, one profits from the specific properties of fruit acids to form excellent buffer systems with their salts, e.g. in the combination citric acid and sodium citrate.

As a rule, fruit acids are added to the cooking batch towards the end of the cooking process. This prevents pre-gelling, which might occur if the temperature of the cooking batch drops below the setting temperature due to the blending in of the sugar or the pectin solution.

Even if all parameters are adjusted in an optimal way and the temperature is higher than the setting temperature, a processing time, which is too long, can lead to pre-gelation after the addition of acid.

### Low Methylester Pectins – Gelling Behaviour:

The gel formation of low methylester pectins must be seen as follows:

When small amounts of calcium ions are added, the pectin chains start to bond over calcium bridges. With increasing calcium ion concentration, gelation sets in. In case of an exceeded dosage of calcium ions, calcium pectinate will precipitate under the given gel forming conditions, which is referred to as “pre-gelling”.

The gel texture will then lose its elasticity, becomes more pasty and shows a lower breaking strength. The precipitation of calcium pectinate is reversible if the gel is heated again above the setting temperature and cooled down in a destruction free process.

The amount of calcium ions required for proper gelation largely depends on the concentration of soluble solids, the sugar, the pH-value of the product and the buffer substances.
The rise in pH will lead to an increased number of charged particles in the gel which dissociate the pectin molecules even more strongly. The reaction between the calcium ions and the other charged buffer substances will be enhanced, which in turn reduces the number of calcium ions available for reactions with pectin.

Effect of Buffer Ions:
Type and concentration of buffer ions present in the gels, which originate largely from the fruits used and may differ according to the variety of fruit, have a decisive impact on the calcium ion requirement in order to achieve sufficiently firm gels.

An increased concentration of buffer substances, especially with a strong binding effect on calcium as e.g. exists for the salts of citric acid, will, similar to a raise in the pH, require a simultaneous increase of the calcium dosage.

The amount of calcium required for gelation is not only, as already described, influenced by the formulation parameters, but also by the production technology, especially the height of the filling temperature. The higher the filling temperature, the more calcium ions can be incorporated in the gel network without causing pre-gelation. The amount of the calcium dosage does not only control the firmness of the gel, but also its rheological and sensory properties.

Effect of the Type of Sugar:
Not only the concentration, but also the type of sugar or sugar substitute used will affect gelation. Thus, the calcium requirement to achieve an optimal gelation is, for example, usually much greater with a sugar substitute than with sucrose. Fructose gels also require more calcium ions.

Effect of the Product's pH:
The increase of the pH-value in a gel must be followed by an increase of the amount of calcium ions required within the gel to achieve comparable gel strength.

An increased concentration of calcium ions provides more bonding points between the pectin molecules and will thus keep the gel strength intact.
Section I:
The calcium concentration in section I is very low: fruit preparations in this area are highly viscous or slightly gelled.

Section II:
Gels in this area have only just started gelation or are already gelled. The gels are very smooth and spreadable. Rheologically speaking, they may be characterized by their visco-elasticity as follows:

Pectin gels have visco-elastic properties which means elastic as well as viscous properties. The elastic component is responsible for high breaking strength, even reaching brittle textures and for low mechanical stability together with poor spreadability and a tendency to syneresis. The viscous component, on the other hand, prevents brittleness and causes good spreadability and a low tendency to syneresis.

Gels of section II show in their majority viscous influences, they are spreadable, stable gels with a high regeneration potential after mechanical stressing and show very little tendency to syneresis. In the sensory respect as well, viscous components influence the flavour. These are gels that will melt in the mouth and have a fruity, sweet taste which is very pronounced.

In resting condition, once the jams have been filled in containers and are no longer stirred or pumped but still hot and liquid, they have an unlimited high viscosity and behave like solids. Owing to this, fruit pieces will neither rise nor settle, but remain “cast” in position in the gel. This is understood by “good fruit distribution”.

Fruit pieces regularly distributed in the gel are considered a quality feature of jams.

The yield point cannot be substituted by a high viscosity. Indeed, a high viscosity delays the rising of fruits but will not prevent it.
In the case of low methylester, amidated pectins, the calcium ion concentration which is necessary for gelation, depends on different product parameters such as soluble solids content, pH-value of the product or the buffer concentration. Already at a low calcium ion concentration the pectin chains start to cluster via calcium bonds. Here the calcium ion concentration which is necessary for gelation, may yet come from the natural calcium content which is brought in by the fruits or the water contained in the recipe. The amid groups stabilise the network by hydrogen bonds resulting in elastic gel products already at a low calcium ion concentration. Besides the degree of esterification, the amount of amid groups determine the sensitivity and with that the calcium need for forming a gel network and the resulting setting temperature.

As the bondings are additionally stabilised due to the presence of amid groups and with that by the formation of hydrogen bonds, low methylester, amidated pectins are able to gel homogeneously and relatively independent from calcium ion concentration over a wide range.

If the calcium dosage is raised intensely, pre-gelation, that means an over-reaction between the pectin molecules and the calcium ions, occurs. Fine gel particles are formed, the gel arrangement loses its elastic character; the texture becomes pasty and with that the gel-ling strength is reduced. At mechanical treatment the gel loses water, syneresis occurs. This process of pre-gelation is reversible. If pre-gelled gels made of amidated pectins are heated again to a temperature which is higher than their setting temperature and then cooled down again, an elastic and firm gel will be obtained.

In section III the calcium concentration is very high with a lot of calcium bridges which cause the pectin molecules to approach each other closely. The pectin network is very tightly structured, originally bound water molecules are now easily squeezed out of the gel network.

The gel texture is dominantly elastic, the viscous phase is suppressed. This provides gels with a very high breaking strength, on the other hand, these gels are unstable against mechanical stressing. Once they have been processed, e.g. stirred or pumped, they are not able to regenerate or at least require a very long time to do so. The inclination to syneresis increases, the yield point or the fruit retention property also increases and the setting temperature is also raised.

In this section, the calcium concentration is too high and at the given filling temperature pre-gelling will occur. The gel strength decreases, the consistency is mushy or pasty, syneresis occurs and the yield point is lowered. The texture of such products is very unappealing. It is not recommended to apply this area to jams, jellies and marmalades.

Increasing the filling temperature may prevent pre-gelling up to a certain point. However, the gels remain very firm and are brittle with a high tendency to syneresis.

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Setting temperature and the formation of a particular gel texture, are decisively determined by the calcium sensitivity. Therefore the behaviour of low methylester, amidated pectins in dependence from calcium ion concentration is not only influenced by the fixed recipe parameters such as soluble solids content, pH-value of the product and the amount of present/added buffer salts, but additionally by the particular calcium sensitivity of the pectin. Due to this property low methylester, amidated pectins can be specifically selected that, also under most different product parameters, they gel homogeneously and relatively independent from calcium ion concentration for reaching the desired texture in the particular final product.

For special applications also H&F pectins with very high sensitivity are available. Furthermore, H&F offer tailor-made low methylester, amidated pectins which are already standardized with specific buffer salts to a defined gelling behaviour.

**Sensitivity levels of low methylester, amidated pectins:**

- **Low sensitivity:**
  - Pectin Amid AF 005, Pectin Amid CF 005
- **Medium sensitivity:**
  - Pectin Amid AF 010, Pectin Amid CF 010
- **High sensitivity:**
  - Pectin Amid AF 020, Pectin Amid CF 020

**Gelling properties of low methylester, amidated pectins with differing calcium sensitivity at different filling temperature**

The texture and the firmness of the final product can be decisively influenced by the selected filling temperature.

By means of two low methylester, amidated pectins with differing calcium sensitivity fig. 14 (page 32) shows, under comparable recipe parameters, the changing of firmness and texture of the final product, if the product was filled at different temperatures.

If a product, for example a fruit preparation (e.g. 45% ss, pH-value 3.3), is manufactured with a reactive pectin and then filled, elastic gels with a constantly high gelling strength will be obtained as long as the filling temperature is higher than the setting temperature of this fruit preparation. If the filling temperature is decreased and reaches a level beneath the setting temperature, pre-gelation will occur resulting in the partial loss of the maximal reachable gelling strength. At the same time the texture of the pre-gelled fruit preparation becomes more and more viscous, the lower the filling temperature is chosen.

**Influence of the raw material on the gelation of low methylester, amidated pectins**

Low methylester, amidated pectins can be made from apple pomace as well as from citrus peels.

The raw material used has also an influence on the texture of the manufactured gels. At comparable degree of esterification and degree of amidation, low methylester, amidated apple pectins form elastic-viscous textures which are easy to spread, show a high mouthfeel ("body") and low tendency to syneresis. Gels, which are manufactured with low methylester, amidated citrus pectins, have higher setting temperatures and result in elastic-brittle products.

**Gelling properties of low methylester, amidated pectins with differing calcium sensitivity**

The higher the calcium sensitivity of the low methylester, amidated pectin, the shorter the setting time resp. the higher the setting temperature in a gel preparation, produced with this pectin, is.

**Increase of calcium reactivity**

- Increase of setting speed/setting temperature

**Fig. 13**
Due to the relatively high setting temperature of the fruit preparation manufactured with reactive pectin, the final gelling strength decreases relatively quick with falling filling temperature. If finally this fruit preparation is filled at a low temperature (e.g. 60°C), a pasty texture with higher tendency to syneresis will result due to the pre-gelation accrued.

If the same fruit preparation is manufactured with a pectin with less calcium sensitivity, the gelling strength will be constant within a wider temperature range as this fruit preparation shows a lower setting temperature. Products which are manufactured with pectins with low calcium sensitivity, can therefore also be processed and filled at lower temperatures. The products show only very low tendency to syneresis.

c) Gelling properties of low methylester, amidated pectins with differing calcium sensitivity at different product pH-values

The product pH-value has an important influence on the gelling behaviour of low methylester, amidated pectins.

With the example of two pectins with differing sensitivity fig. 15 shows the breaking strength in dependence from calcium dosage at two different product pH-values of the gel preparation.

The breaking strength, which is reached by using the pectin with low calcium sensitivity in dependence from the calcium dosage, increases for the two product pH-values with increasing calcium ion concentration.

At comparable calcium ion concentration the gel strength decreases from pH 3.2 to pH 3.6 which means that the gels become weaker with rising pH-value, the viscous shares increase.

With rising pH-value of the final product the calcium need increases. That means to obtain comparably firm gels, gels with a higher pH-value need more calcium ions than gels with lower pH-value.

The breaking strength of the gels which are manufactured with a pectin with high sensitivity, at first also increases with rising calcium ion concentration.

In comparison, the absolute values in this range are higher than for the pectin with low sensitivity. At the same time the texture of the gels which are manufactured with a more reactive pectin, are more elastic at a comparable pH-value.

With a defined calcium ion concentration, however, the gel strength of the gels with a pH-value of 3.2 decreases, as the setting temperature of this gel preparation is high in a way that pre-gelation will occur under the given conditions. With that the texture losses its elasticity and becomes more and more viscous.

In contrast to that, elastic gels are formed over a wide range at a pH-value of pH 3.6 by using a reactive pectin. The curve progression is plain, that means the breaking strength of these gels changes only little with increasing calcium dosage.

A plain curve progression means to the user, that the working area under these conditions is wide, as the gels are very tolerant towards fluctuations of the calcium content. With that a high flexibility and production safety are guaranteed.

Low methylester, amidated pectins with high sensitivity such as Pectin Amid CF 020 or Pectin Amid AF 020 are therefore especially well suited for the use at higher pH-values, whereas for products with lower pH-value rather pectins with a lower sensitivity such as Pectin Amid CF 005 or Pectin Amid AF 005 are used.

Fig. 14: Texture of gels, manufactured with low methylester, amidated pectins with differing calcium sensitivity in dependence from filling temperature.
Gelling behaviour at 20% ss

With rising calcium ion concentration the breaking strength, determined with the Herbstreith Pektinometer Mark IV, increases, the texture of the gels becomes firmer and more elastic.

Over the whole range investigated the high reactive pectin results in firmer gels at comparable calcium ion concentration than pectins with medium resp. low reactivity do.

In order to reach a comparable breaking strength of the gels, pectins with medium and low reactivity require higher calcium dosages than pectins with high reactivity.

To form elastic gels, gel preparations which are manufactured with pectins with medium and low reactivity require a certain amount of calcium ions whereas gels, which are manufactured with a reactive pectin, already form an elastic gel at minor addition of calcium ions which might come from the fruits or the drinking water.

In contrast to pectins with low and medium reactivity, the curve progression of pectin with high reactivity is plain and the breaking strength of the gels changes over a wide range only little.

At low soluble solids contents (0-20% ss) the reactive pectin requires a certain amount of calcium ions for gelation, however then it shows a high tolerance towards fluctuations of the calcium content resulting in a homogeneous gelation over a wide working range.

As a result, low methylester, amidated pectins with high calcium reactivity such as Pectin Amid CF 020 or Pectin Amid AF 020 are excellently suited for the use in products with a low sugar content such as sugar reduced fruit preparations or delicatessen products.

Pectins with very high reactivity such as Pectin Amid CF 025 or Pectin Amid CB 025 are suited among others for glaze, spray nappage or jelly.

**d) Gelling properties of low methylester, amidated pectins with differing calcium reactivity at different soluble solids content**

Besides the pH-value of the product also the soluble solids content is an important parameter for choosing low methylester, amidated pectins. When altering the soluble solids content, low methylester, amidated pectins show different gelling properties in dependence from their calcium reactivity. Thus, depending on the product and its soluble solids content, the required gelling behaviour can be reached by choosing the suitable pectin.

The following figures show at the example of three pectins with differing reactivity the breaking strength of gel preparations in dependence from calcium dosage at different soluble solids ranges (20%, 40%, 60% ss).
As pectins with high calcium reactivity and especially pectins with medium calcium reactivity show, at a soluble solids content of 40%, a homogeneous gelation over a wide range and with that a high tolerance towards calcium ions, these medium reactive pectins are excellently suited for the use in products in this soluble solids range.

For example, in applications with gelling sugar (2:1) most different fruits are used at approx. 40% ss, which mainly differ regarding their calcium and acid content. Additionally the household production conditions vary depending from the user. Despite this fact, products with homogeneous gelation and sufficient firmness are expected. Low methylester, amidated pectins with medium calcium reactivity are a guarantee for the successful manufacture of these preparations. Furthermore, low methylester, amidated pectins with medium calcium reactivity such as Pectin Amid CF 010 or Pectin Amid AF 010 are used for example for calorie-reduced fruit preparations, fruit preparations for yoghurts or to stabilise fruit cream.

Gelling behaviour at 40% ss

If the soluble solids content is raised to 40% ss, low methylester, amidated pectins with medium and higher calcium reactivity will form elastic gels already at a low concentration of calcium ions. Especially for gels which are manufactured with a pectin with medium reactivity, the breaking strength is homogeneously high over a very wide range and relatively independent from calcium ion concentration. At a defined, relatively high calcium ion concentration the gel strength of gels, which are manufactured with the high reactive pectin, slightly decreases, as here the setting temperature is high in a way, that pre-gelation occurs under the given conditions. Then the texture becomes more and more viscous resulting in falling breaking strength values.

On the contrary, the pectin with low calcium reactivity requires a certain amount of calcium ions to form elastic gels. Then the breaking strength values rise with increasing calcium ion concentration and the gels become firmer.

At comparable gel strength the pectin with high calcium reactivity forms an elastic-brittle texture, whereas gels manufactured with a pectin with low reactivity are elastic-viscous and pasty.

As pectins with high calcium reactivity and especially pectins with medium calcium reactivity show, at a soluble solids content of 40%, a homogeneous gelation over a wide range and with that a high tolerance towards calcium ions, these medium reactive pectins are excellently suited for the use in products in this soluble solids range.

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Gelling behaviour at 60% ss

At a soluble solids content of 60% pectins with high and medium calcium reactivity already gel without the separate addition of calcium ions. When adding calcium ions, the breaking strength values increase at first, the texture of the gel becomes firmer and more elastic-brittle.

With a further raise of the calcium ion concentration pre-gelation will occur relatively quick and, as a consequence, the gel strength decreases. At a soluble solids content of 60% ss the setting temperature of these pectins increases with increasing calcium ion concentration very intensely, the preparation gels already during the boiling process and the gel can no longer be filled without being destroyed. Due to the pre-gelation, the obtained gels are pasty with decreasing firmness and increased tendency to syneresis.

As the setting temperature of gels increases with increasing reactivity of the pectins, the calcium ion concentration at which pre-gelation starts, is the lower, the higher the reactivity of the low methylester, amidated pectin is. The pectin with the low reactivity gels at a soluble solids content of 60% already without separate calcium addition. In contrast to pectins with high and medium reactivity, the curve progression of the pectin with low reactivity is plain and the breaking strength of the gels changes only little over a wide range. Even at high calcium dosages pre-gelation will not occur.

Therefore low methylester, amidated pectins with low calcium reactivity such as Pectin Amid CF 005 or Pectin Amid AF 005 are very well suited for the use in products with high sugar content, as for example jams, fruit spreads and fruit preparations for yoghurt.

The high setting temperature of the low methylester, amidated pectins with high reactivity such as Pectin Amid CF 020 or Pectin Amid AF 020 can be used for technological reasons to prevent floating. The gelation process starts already during the boiling process and is additionally enhanced by the addition of acid. This gelation results in an increase of viscosity because of which the fruits in the preparation do not separate during the filling process.
**Syneresis Behaviour**

In general, syneresis is an undesired phenomenon for jams and other fruit preparations and depends on many factors. It is described more closely in the following:

Pectin is supposed to immobilize the free water in the product. If the desired water binding effect is not completely achieved in gel production or during further processing of the gel, gels show a tendency to shrink and to release fluid, which is called syneresis (the pectin chains approach each other too closely and squeeze the originally bound water out of the gel network).

Based on the different gelling mechanisms, syneresis must be differently assessed in high and low methylester pectins.

**High Methylester Pectins (HM Pectins):**

Gelled products with HM pectins have, as a rule, a soluble solids content of at least 60%. At these high soluble solids, the manufactured products should not show any syneresis under optimal conditions, that is if the gel is not destroyed.

Syneresis to a minor extent may occur in the normal consumption of gelled products, e.g. in household consumption and especially if a gel is stirred or pumped.

HM pectin gels are not able to regenerate their gel texture after mechanical destruction. Once the texture of these gels has been damaged, syneresis sets in and becomes more pronounced during a longer storage period.

Pectins form visco-elastic gels, i.e. gels with elastic as well as viscous phases. The greater the elastic and the smaller the viscous phase in a gel, the greater the sensitivity of gel textures to mechanical stressing and their inclination to syneresis are.

The ratio of elastic and viscous phases in pectins is determined by the degree of esterification and their sensitivity to multivalent ions.

Very high methylester pectins form very elastic gels with high setting temperatures. Medium methylester pectins form elastic gels with greater viscous phases and lower setting temperatures. Due to the greater viscous phase, medium methylester pectins are less sensitive to mechanical stressing, show less inclination to syneresis and result in more spreadable gels.

Another reason for high gel elasticity is ion sensitivity, which occurs also in high methylester pectins as a function of raw materials and production methods. Ion sensitivity is probably also influenced by the way the free carboxyl groups are distributed in the pectin molecule. A clustered appearance of free carboxyl groups due to the corresponding enzyme activity in the raw material results in high ion sensitivity. This makes gels highly elastic, up to being even brittle with a stronger inclination to syneresis.

High methylester Classic Apple Pectins are comparatively insensitive to ions since the carboxyl groups are statistically distributed throughout the molecule due to the production method. Enzymes, which cause a clustered demethoxylation, are not active in the raw material pomace, contrary to other raw materials, e.g. citrus peels.

The most frequent cause for syneresis is the series of unsuitable production conditions which may be summarized by the term “pre-gelling”.

Pre-gelling will always occur if the filling temperature for the gel has been set too low. The reason for this may be (at correct pectin dosage):

- that the sugar concentration is too high
- that the acid dosage (which causes the pH in the product to be too low) is too high or
- an unsuitable type of pectin, e.g. a pectin that sets too fast.

This may be remedied by correcting the sugar and acid concentrations, and by matching the filling temperature and the type of pectin.

Another reason for syneresis may be an insufficient sugar exchange between fruits and the liquid medium, which might be due to a too short cooking time for fruits with very hard skins or firm fruit pulp.

A fluid separation will also occur if the pectin dosage is too small or the pectin has not been completely dissolved. This means, the available water cannot be sufficiently immobilized.
**Low Methylester Pectins (LM Pectins):**

Whether or not syneresis in gels with low methylester pectins occurs, depends on the ratio between selected pectin and calcium for a certain formulation.

The proper dosage of low methylester pectin and relatively few calcium ions result in thixotropic gels with a high regeneration rate. This means that after mechanical stressing of a gel, e.g. spooning jam from a pot, the destroyed gel can regenerate quickly and liquid does not seep from the pectin network; the tendency to syneresis is relatively low in these gels.

An increased amount of calcium, in comparison to the selected pectin dosage, renders gels more elastic, the viscous phase is smaller, the texture becomes even brittle and is no longer spreadable and thixotropic gels with a very low regeneration rate are the result. After destruction, these gels take much longer to restructure their texture and fluids may be released.

The suitable pectin and calcium dosage depends, as already described, on the pH-value, ion strength, sugars and sugar quantities, which follows that all these parameters have to be exactly matched. An important factor, very difficult to assess in its impact, is the ion composition of fruits, because this can even vary within one and the same type and variety of fruit.

It is recommended to use a calcium insensitive pectin in such cases.

Strong syneresis in jams, marmalades and jellies does not only make an unappealing impression but is also considered as a quality defect by jam manufacturers and consumers and should thus be avoided.
Different methods of standardization are used depending on the intended application of the pectins. The standardization of high methylester pectins to constant grade value is internationally done by way of a Ridgelimeter according to the "USA-Sag-Method".

A sugar-pectin-water gel with 65% soluble solids and a pH-range of about 2.0 is manufactured for this purpose. The gel is cooled under defined conditions (25°C [77°F] 24 hours). After cooling, the gel is released from its mould and the percentage of sagging under its specific gravity is measured with the so-called Exchange Ridgelimeter after exactly 2 minutes. A Gel with a 23.5% sagging is considered a standard gel.

The grading of pectin is calculated according to the following formula:

\[ ^\circ\text{USA-Sag} = \frac{F \times a}{b} \]

\[ a = \text{amount of sugar in the gel (650g)} \]
\[ b = \text{amount of pectin in the gel (4.33g)} \]

A sagging of 23.5% is equal to factor F = 1 and \(^\circ\text{USA-Sag} = 150\). Gels which sag more strongly (weaker gels) are corrected by a factor < 1; gels which sag less strongly are calculated with the correcting factor > 1. A table has been compiled with these factors.

The method described has served as commercial basis for high methylester pectins for many years. However, this method is not undisputed, it is frequently criticized that the extremely low pH-value in the gel is not practice oriented. This means, that pectin is assessed by the gellation of a product which would not be produced in this way in practice. The so-called "internal strength", also termed "breaking strength", correlates more directly with the sensory stability perception than the USA-Sag-values do. Therefore, lately efforts have been increased to assess high methylester pectins not only according to the USA-Sag-Method, but additionally to their breaking strength.

For determining the breaking strength and the texture with the Herbstreith Pektinometer a nearly optional gel is put on strain up to the destruction of the gel network. The force necessary for this effect is measured in dependence from time.

The simple handling, good reproducibility and above all the great flexibility regarding the recipe are the advantages of this method. With that gels can be assessed which are exactly adjusted to the particular application.

But, fruit spreads containing fruit components can only be assessed reproducibly if the fruits are finely ground or at least relatively small and distributed homogeneously.

For determination of the breaking strength and the texture with the Herbstreith Pektinometer the gel preparation is filled into a standardized measuring beaker with shear insert. After a defined time this shear insert is pulled out of the gel and the force necessary herefore is measured. From the resulting force-time-diagram the following information is obtained:

The maximum value is the force which is necessary for disrupting the gel and which is called breaking strength. This breaking strength resp. inner firmness correlates very well with the firmness which is perceived during the first swallowing or first spooning up for sensory assessment.
Elastic-viscous gels for example require a smaller force to be disrupted resp. broken and therefore their breaking strength is relatively low. As elastic-viscous gels have an inner cohesion, a low but steady power input is necessary to pull the shear insert out of the gel. Therefrom a relatively large integral area in the force-time-curve results.

From the ratio of breaking strength, i.e. the maximum force, and integral of the force-time-curve a relatively low value for the texture constant $K$ is obtained. Sensorily the gels are assessed very easy to spread and homogeneously firm with high mouthfeel.

Elastic gels show high breaking strength values, thus they require a high power input for breaking. Elastic gels break into single fragments when ruptured. Therefore after breaking only a small power input is necessary to pull the shear insert out of the gel which results in a comparatively small area in the force-time-curve. The calculated texture constant $K$ is then higher than for viscous, easy to spread gels.

Sensorily elastic-brittle gels are often assessed less easy to spread and slightly rough with less mouthfeel.

From the ratio of the maximum force and the integral of the resulting force-time-curve the so-called texture constant $K$ is determined. This value gives information on the ability to spread gels and on the behaviour of a gel preparation during chewing and swallowing in the mouth.

With the Herbstreith Pektinometer Mark IV the terms breaking strength and texture constant $K$ can be determined. Different types of pectin gels can be distinguished:

**Determination of Texture Properties using the Oscillating Rheometer**

The above mentioned texture constant $K$ which is used together with the Herbstreith Pektinometer Mark IV for determining the texture properties of pectin gels correlates very well with the so-called dynamic Weissenberg number $W'$ (Windhab, 1990) which can be determined by using the oscillating rheometer.

The determination of the dynamic Weissenberg number $W'$ is a comparatively extensive rheometric method in which the ratio between elastic ($G'$) and viscous shares ($G''$) of a pectin gel is determined by a special oscillating measurement mode ($W' = \frac{G'}{G''}$).

Pectin gels are visco-elastic substances, which means they are predominantly elastic. However, they additionally possess more or less high viscous shares which have a very significant influence on texture.
The determination of setting time according to Joseph and Bayer (Joseph, G.H., Bayer, W.F., 1949) has proved to be simple and easy to carry out without any technical input.


In this method a gel preparation is produced according to the Ridgelimeter method. The setting process is observed under defined cooling conditions. The time at which gelation starts, is measured and defined as setting time.

Due to the less practice-oriented recipe parameters (no buffer salts, pH-value approx. 2.2) the measured values correlate only to some extend with practical experiences.

This becomes very clear when observable reactions with ions, mostly bivalent cations such as calcium ions, are already expected due to the low degree of esterification or due to the raw material (as for citrus pectins by a blockwise distribution of carboxyl groups).

For the determination of the setting temperature H&F have established a rheometric method using an oscillating rheometer. In this method, the sample is, during cooling, exposed to a force in form of a sinusoidal, oscillating motion. The corresponding sinusoidal response curve is then measured in the sample. The sample is not destroyed in the process.

If the sample is in a liquid state, the viscous phase is dominant and the phase displacement between the curve of the applied force and the response movement amounts to approx. 90°C (194°F) if the sample has become a firm gel, the elastic forces are paramount and the resulting phase displacement between curves approaches 0. If viscous and elastic phases are balanced, one gets a so-called sol-gel-transition or gel point. The angle of shift between phases will then amount to 45° and the corresponding temperature is defined as the setting temperature.

On the basis of setting time/setting temperature the high methylester pectins are usually divided into the following groups:

- rapid set (rs)
- medium rapid set (mrs)
- slow set (ss)
- extra slow set (xss)

As up to now there is no official method for the determination of setting time resp. setting temperature of pectin gels, this classification is arbitrary and may highly fluctuate from producer to producer.

The texture, that means appearance and structure of the gel surface, the sensorily felt firmness when spooning and spreading, and the haptic impression (mouthfeel) of fruit spreads are determined by the ratio of elastic and viscous properties. The higher the elastic shares in a gel, the higher is the dynamic Weißenberg number $W'$.

The texture of gels with a high dynamic Weißenberg number ($W' = 15-20$) is elastic-brittle, the gels show a structured, rough surface and often a slightly higher tendency to syneresis.

Gels with a small dynamic Weißenberg number ($W' = 5-10$) are elastic-viscous, easy to spread and smooth, and show a glossy surface with low tendency to syneresis.

**Determination of Setting Time/Setting Temperature**

Besides the desired texture also the setting time is a very important parameter for the manufacturers of fruit preparations. The higher the setting temperature, the faster the product starts to gel and the higher the filling temperature in the production process has to be fixed.

If the setting temperature of the product is higher than the fixed filling temperature, pre-gelation will occur, that means the products already starts gelling before the filling process. The mechanical treatment during the filling process irreversibly destroys the gel network already formed resulting in a partial loss of the final gel strength in the product.

On the other hand, products, which contain whole fruits or fruit pieces, require a comparatively high setting temperature as these products are intended to gel quickly after the filling process in order to prevent the contained fruits or fruit pieces from floating and with that from separating from the gel.

Setting time resp. setting temperature are influenced on the one side by recipe parameters such as soluble solids content, pH-value of the product, buffer salts and pectin dosage, on the other side by the degree of esterification, the raw material for pectin production and production technology of pectin.
Generally, citrus pectins form highly elastic, even brittle gels with a relatively high tendency to syneresis. Apple pectins, on the other hand, form elastic gels with a certain amount of viscosity, to which they owe their good spreadability with low tendency to syneresis, which, in turn, also influences the taste of the gels. Apple pectin gels melt in the mouth, and the fruity-sweet flavour is intensively perceived. Based on these properties, H&F supply Classic Apple and Citrus Pectins for a great variety of product designs.

Furthermore, H&F have also developed Combi Pectins (apple/citrus), which differ from traditional pectins due to their production method and properties. To produce Combi Pectins, pomace and citrus peels are extracted jointly in a fixed mixing ratio, which depends on the intended finished product.

Classic Pectins:
The Classic Pectins of interest in this area receive a letter coding in their nomenclature, which is “AF”, “A” stands for “apple” as raw material and “F” for the application area “fruits”, also “C” for “citrus” as raw material.

All high methylester Classic Pectins listed here are suitable for jams and marmalades with more than 60% soluble solids, but also the low methylester Pectin Classic AF 802 may be applied. Which type is suitable in a specific case depends on:

- the formulation
- the production technology
- the texture requirements

With a declining degree of esterification the setting temperature of these gels also drops, if their manufacture happens under the same conditions and according to the same formulation. Pectin Classic AF 101 is an extra rapid set pectin, Pectin Classic AF 201 a very rapid set pectin and Pectin Classic AF 401 a medium rapid set pectin. The texture will also change with a declining degree of esterification, smoothness and spreadability of the pectin gels increase simultaneously.

An Example for Formulation Parameters and Technology:
Jam with 62% soluble solids, pH at 3.0:
If Pectin Classic AF 101 is used for this purpose, the product will, under the given parameters, show a very high setting temperature. To avoid pre-gelling, it must be possible with the technology applied to fill at a very hot state. The texture of the gels is highly elastic, the spreadability is poorly developed. To lower the setting temperature and to improve spreadability, pectins with a lower degree of esterification are used instead. On the other hand, if the same product should be produced with a higher pH-value of e.g. 3.3, then Pectin Classic AF 101 has certain advantages compared with other pectins. This pectin, due to its high degree of esterification, shows still a good setting at a higher pH-value and, owing to the higher product pH, the setting temperature will be lowered and the texture becomes smoother.
For jellies with a soluble solids content of more than 60%, all the above listed high methylester pectins may be used, especially Pectin Classic CF 501 can be recommended in this respect. The setting temperature of this slow set pectin is comparatively low; air bubbles which have been drawn in during cooking may escape from the product before setting, which provides a clear and transparent gel. Higher methylester pectins form gels with a sometimes firm, even brittle gel texture, because fruit pieces or fruit fibres that might contribute to the gel’s smoothness, are missing.

Gels which are manufactured with Pectin Classic AF 504 show a very spreadable texture and an extremely low tendency to syneresis.

### Jams, Jellies and Marmalades

#### Extra Jam

**Herbstreith & Fox KG**

**Recipe**

**Product** Pectin Classic AF 401

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectin solution 5% (= 0.25%)</td>
<td>50g</td>
</tr>
<tr>
<td>Fruit</td>
<td>450g</td>
</tr>
<tr>
<td>Sucrose, crystalline</td>
<td>420g</td>
</tr>
<tr>
<td>Glucose syrup (15% dextrose, 15% maltose, 13% maltotriose)</td>
<td>200g</td>
</tr>
<tr>
<td>Citric acid solution 50% to adjust the pH-value</td>
<td>x ml</td>
</tr>
</tbody>
</table>

**Procedure:**

A Production of pectin solution (mix pectin dry with a part of sucrose, stir into water and heat to approx. 90°C).

B Mix fruit, glucose syrup and sucrose and heat to approx. 90°C.

C Add the hot pectin solution and cook to final soluble solids.

D Add the citric acid solution to adjust the pH-value.

E Adjust filling temperature to trading unit size.

**Input:** approx. 1120g  
**Output:** approx. 1000g  
**ss:** approx. 63%  
**pH-value:** 3.0-3.1

---

**Herbstreith & Fox KG**

**Recipe**

**Product** Pectin Classic AF 504

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectin solution 5% (= 0.4%)</td>
<td>80g</td>
</tr>
<tr>
<td>Fruit</td>
<td>450g</td>
</tr>
<tr>
<td>Sucrose, crystalline</td>
<td>420g</td>
</tr>
<tr>
<td>Glucose syrup (15% dextrose, 15% maltose, 13% maltotriose)</td>
<td>200g</td>
</tr>
<tr>
<td>Citric acid solution 50% to adjust the pH-value</td>
<td>x ml</td>
</tr>
</tbody>
</table>

**Procedure:**

A Production of pectin solution (mix pectin dry with a part of sucrose, stir into water and heat to approx. 90°C).

B Mix fruit, glucose syrup and sucrose and heat to approx. 90°C.

C Add the hot pectin solution and cook to final soluble solids.

D Add the citric acid solution to adjust the pH-value.

E Adjust filling temperature to trading unit size.

**Input:** approx. 1150g  
**Output:** approx. 1000g  
**ss:** approx. 63%  
**pH-value:** 3.0-3.1

---

**Herbstreith & Fox KG**

**Recipe**

**Product** Pectin Classic CF 501

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectin (= 0.4%)</td>
<td>4g</td>
</tr>
<tr>
<td>Fruit juice, approx. 12% ss</td>
<td>450g</td>
</tr>
<tr>
<td>Sucrose, crystalline</td>
<td>410g</td>
</tr>
<tr>
<td>Glucose syrup (15% dextrose, 15% maltose, 13% maltotriose)</td>
<td>200g</td>
</tr>
<tr>
<td>Citric acid solution 50% to adjust the pH-value</td>
<td>x ml</td>
</tr>
</tbody>
</table>

**Procedure:**

A Mix the pectin with approx. 100g sucrose from total sucrose amount.

B Stir mixture “A” into fruit juice and boil until the pectin has dissolved completely.

C Add the remaining sucrose and the glucose syrup and cook to final soluble solids.

D Add the citric acid solution to adjust the pH-value.

E Adjust filling temperature to trading unit size.

**Input:** approx. 1065g  
**Output:** approx. 1000g  
**ss:** approx. 63%  
**pH-value:** 3.0-3.1

---

Pectin Classic AF 401 has a medium rapid setting time and is characterized by a distinctive smoothness, spreadability and full-bodyness of the gels.

The special property of Pectin Classic AF 504 is its ability to form a sufficient yield point already at high temperatures during the production process. Whole fruits or large fruit pieces are kept swimming and an optimal fruit distribution is reached. Therefore this pectin is very well suited for products for which a good fruit distribution is important, e.g. cherry jam with large fruit pieces.

For jellies with a soluble solids content of more than 60%, all the above listed high methylester pectins may be used, especially Pectin Classic CF 501 can be recommended in this respect. The setting temperature of this slow set pectin is comparatively low; air bubbles which have been drawn in during cooking may escape from the product before setting, which provides a clear and transparent gel. Higher methylester pectins form gels with a sometimes firm, even brittle gel texture, because fruit pieces or fruit fibres that might contribute to the gel’s smoothness, are missing.
Fruits spreads sweetened with fruit juice concentrate are usually rich in minerals. It is therefore recommended to use, depending on the desired texture and soluble solids content, buffered low methylester or medium methylester pectins such as Pectin Classic AF 601 or the high methylester Pectin Classic AF 401.

Pectin Classic AF 101 is recommended for products with a soluble solids content between 55-60%, since owing to its high degree of esterification, this pectin is more tolerant to fluctuating solids than less methylester pectin types are. If the soluble solids content drops below 55%, low methylester pectins with a suitable amount of calcium salts, are used.

Herbstreith & Fox KG

Recipe

Dietetic Fruit Spread

Product Pectin Classic AF 703

<table>
<thead>
<tr>
<th></th>
<th>180g Pectin solution 5% (= 0.9%)</th>
<th>450g Fruit</th>
<th>630g Fructose syrup, 70% ss</th>
<th>0.9g tri-calcium dicitrate x 4H2O</th>
<th>x ml Citric acid solution 50% to adjust the pH-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>approx. 1260g</td>
<td>approx. 1650g</td>
<td>approx. 2000g</td>
<td>approx. 9.9g</td>
<td>approx. 1860g</td>
</tr>
<tr>
<td>Output</td>
<td>approx. 1000g</td>
<td>approx. 1000g</td>
<td>approx. 1000g</td>
<td>approx. 9.9g</td>
<td>approx. 1000g</td>
</tr>
<tr>
<td>pH-value</td>
<td>approx. 3.2-3.4</td>
<td>approx. 3.2-3.4</td>
<td>approx. 3.2-3.4</td>
<td>approx. 3.2-3.4</td>
<td>approx. 3.2-3.4</td>
</tr>
</tbody>
</table>

Procedure:

A Production of pectin solution (mix pectin dry with a part of sucrose, stir into water and heat to approx. 90°C).

B Mix fruit, glucose syrup and sucrose and heat to approx. 90°C.

C Add the hot pectin solution and cook to final soluble solids.

D Add the citric acid solution to adjust the pH-value.

E Adjust filling temperature to trading unit size.

Herbstreith & Fox KG

Recipe

Low-Calorie Extra Jam

Product Pectin Classic AF 802

<table>
<thead>
<tr>
<th></th>
<th>180g Pectin solution 5% (= 0.9%)</th>
<th>450g Fruit</th>
<th>380g Sucrose, crystalline</th>
<th>100g Water</th>
<th>x ml Citric acid solution 50% to adjust the pH-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>approx. 1050g</td>
<td>approx. 1050g</td>
<td>approx. 1050g</td>
<td>approx. 1050g</td>
<td>approx. 1050g</td>
</tr>
<tr>
<td>Output</td>
<td>approx. 1000g</td>
<td>approx. 1000g</td>
<td>approx. 1000g</td>
<td>approx. 1000g</td>
<td>approx. 1000g</td>
</tr>
<tr>
<td>pH-value</td>
<td>approx. 3.2-3.3</td>
<td>approx. 3.2-3.3</td>
<td>approx. 3.2-3.3</td>
<td>approx. 3.2-3.3</td>
<td>approx. 3.2-3.3</td>
</tr>
</tbody>
</table>

Procedure:

A Production of pectin solution (mix pectin dry with a part of sucrose, stir into water and heat to approx. 90°C).

B Mix fruit, sucrose and water and heat to approx. 90°C.

C Add the hot pectin solution and cook to final soluble solids.

D Add the citric acid solution to adjust the pH-value.

E Adjust filling temperature to trading unit size.

Herbstreith & Fox KG

Recipe

Low-Calorie Extra Jam

Product Pectin Classic AF 703

<table>
<thead>
<tr>
<th></th>
<th>240g Pectin solution 5% (= 1.2%)</th>
<th>500g Fruit</th>
<th>240g Sucrose, crystalline</th>
<th>70g Water</th>
<th>0.7g tri-calcium dicitrate x 4H2O</th>
<th>x ml Citric acid solution 50% to adjust the pH-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>approx. 1050g</td>
<td>approx. 1050g</td>
<td>approx. 1050g</td>
<td>approx. 1050g</td>
<td>approx. 1050g</td>
<td>approx. 1050g</td>
</tr>
<tr>
<td>Output</td>
<td>approx. 1000g</td>
<td>approx. 1000g</td>
<td>approx. 1000g</td>
<td>approx. 1000g</td>
<td>approx. 1000g</td>
<td>approx. 1000g</td>
</tr>
<tr>
<td>pH-value</td>
<td>approx. 3.2-3.4</td>
<td>approx. 3.2-3.4</td>
<td>approx. 3.2-3.4</td>
<td>approx. 3.2-3.4</td>
<td>approx. 3.2-3.4</td>
<td></td>
</tr>
</tbody>
</table>

Procedure:

A Production of pectin solution (mix pectin dry with a part of sucrose, stir into water and heat to approx. 90°C).

B Mix fruit, sucrose, water, tri-calcium dicitrate and the preserving agent and heat to approx. 90°C.

C Add the hot pectin solution and cook to final soluble solids.

D Add the citric acid solution to adjust the pH-value.

E Adjust filling temperature to trading unit size.

The principles described before are also valid for dietetic jams, jellies and marmalades with a soluble solids range above 60%. However, the sugar substitutes used in these products, e.g. fructose and sorbitol, have an impact on the consistency of the gels. With these sugar substitutes, the gels are softer and very smooth. In contrast to the traditional products, in this field, depending on what type of texture is intended, also pectins with a higher degree of esterification can be used.

The lowering of the calorific input for jams requires a noticeable reduction of sugar. This does not only cut the sweetness of the jams but affects texture and mouthfeel at the same time. Texture and mouthfeel are reconstituted with a suitable dosage of low methylester pectin plus the proper calcium dosage.
H&F offer two qualities of low methylester Classic Apple Pectins for the use in low-calorie jams and fruit preparations:

- **H&F Classic Apple Pectins**, which are already standardized to a constant calcium sensitivity, e.g., Pectin Classic AF 703. This pectin needs a separate addition of calcium to reach a viscous, spreadable texture. On the one hand, the calcium dosage depends on the soluble solids content of the final product, on the other hand on the desired texture properties, which can be adjusted by the calcium dosage.

- **H&F Classic Apple Pectins with constant calcium sensitivity**, which are already standardized with calcium salts and/or other buffer substances to constant gelling properties, e.g., Pectin Classic AF 802/Pectin Classic AF 803. These pectins do not require a separate calcium addition and are, due to the added buffer substances, flexibly applicable at different soluble solids contents. The firmness of the product as well as the desired texture properties are adjusted by the pectin dosage.

Pectin Classic AF 901 has been especially developed for the preparation of cranberries. It gives these products a very smooth texture and also provides a good fruit distribution.

### Combi Pectins:
Special extraction conditions have been designed to produce Combi Pectins with specific properties. These pectins show gelling properties which are situated between the classical apple and the classical citrus pectins. The pronounced viscous properties, characteristic for apple pectins, are complemented by the higher elasticity of citrus pectins. The result are pectins which form gels with great elasticity with simultaneous spreadability and little tendency to syneresis.

### Standard HB Pectins:
Standard HB Pectins are produced in a special production process. They form elastic and brittle gels which tend to a comparable texture as produced with citrus pectins. Despite this, the tendency to syneresis of the gels is extremely low – comparable to apple pectins. Further advantages are provided by Standard HB Pectins in the production of jams and other fruit preparations due to their very high flexibility in their application and thus in a raised production safety.

### Amidated Pectins:
With amidated, low methylester pectins fruit spreads with a smooth, elastic gel texture can be produced. Compared with low methylester Classic Pectins, there is no necessity of a separate calcium addition in a soluble solids range of approx. 40-55%. In order to reach optimal gelling properties, the addition of calcium may become necessary for fruit spreads below 40% ss depending on fruit type, pectin and processing parameters.

### Herbstreith & Fox KG Recipe

#### Fruit Preparation

**Product** Pectin Amid AF 010

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectin</td>
<td>7g (0.7%)</td>
</tr>
<tr>
<td>Fruit</td>
<td>400g</td>
</tr>
<tr>
<td>Sucrose, crystalline</td>
<td>350g</td>
</tr>
<tr>
<td>Water</td>
<td>280g</td>
</tr>
<tr>
<td>Citric acid solution</td>
<td>50% to adjust pH-value</td>
</tr>
</tbody>
</table>

**Procedure:**

A. Mix the pectin with approx. 100g sucrose from total sucrose amount.
B. Stir mixture “A” into fruit and water and boil until the pectin has dissolved completely.
C. Cook to final soluble solids.
D. Add the citric acid solution to adjust the pH-value.
E. Adjust filling temperature to trading unit size.

#### Fruit Spread

**Product** Pectin Amid CF 005

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectin</td>
<td>5g (0.5%)</td>
</tr>
<tr>
<td>Fruit</td>
<td>450g</td>
</tr>
<tr>
<td>Sucrose, crystalline</td>
<td>350g</td>
</tr>
<tr>
<td>Glucose syrup (15% dextrose, 15% maltose, 13% maltotriose)</td>
<td>180g</td>
</tr>
<tr>
<td>Water</td>
<td>50g</td>
</tr>
<tr>
<td>Citric acid solution</td>
<td>50% to adjust pH-value</td>
</tr>
</tbody>
</table>

**Procedure:**

A. Mix the pectin with approx. 100g sucrose from total sucrose amount.
B. Stir mixture “A” into fruit and water and boil until the pectin has dissolved completely.
C. Add the remaining sucrose and the glucose syrup and cook to final soluble solids.
D. Add the citric acid solution to adjust the pH-value.
E. Adjust filling temperature to trading unit size.
How to Incorporate Pectins into the Product Batch:
The production of pectin solutions by way of a suitable system is the best possibility to add standardized pectin to the cooking process.

If only slow-speed mixers are available, the pectin is mixed with about 5 times the amount of sugar and this mixture is dissolved in water with a temperature of at least 80°C (176°F). In this way, a 3-5% pectin solution can be produced.

If a dissolver with high-speed mixer is available (more than 1,500rpm), pectin is added while the mixer is running and the water temperature is at least 80°C (176°F), directly poured into the mixer flux and dissolved. Depending on the type of pectin, pectin solutions of 5-7% may be produced.

Nowadays, 7-10% pectin solutions can be produced, on modern injection mixers. Flowchart 24 on the previous page shows such a modern injection blending unit.

The evaporating water volume is clearly smaller when such high percentage pectin solutions are added in the cooking process than it is the case with 3-5% pectin solutions.

If sugar solutions or sugar syrups are used, pectin may also be suspended in 10 times the amount of liquid sugar/sugar syrup while stirring slowly. This suspension may then be incorporated into hot water with at least 80°C (176°F), which results in a 3-5% pectin solution.

If pectin is directly added to the product batch, i.e. not as pectin solution, this is best achieved with the above mentioned pre-mix of pectin and 5-10 times the amount of sugar or a suspension with liquid sugar or sugar syrups. In this case it is important to observe that the soluble solids content in the batch during the dissolving of pectin is not above 30%, since it otherwise interferes with the solubility.
The material for modern cookers is a V2A special steel. The construction of cookers is determined by various factors:

- A flat construction provides large surfaces of the cooking material and thus reduces cooking time due to the large evaporation area.
- A flat, spacious kettle floor with adjacent steam jacket provides a large heating surface.
- The flat construction requires a low filling level, which in turn shortens the way of the steam bubbles from the heated floor to the surface of the liquid, thus reducing the risk of overheating.
- A slow-speed anchor mixer with scrapers guarantees the careful fruit treatment and prevents burning on the vessel walls.
- In-built baffles which purposefully override the agitator from above interrupt the agitated flux and improve distribution and diffusion during cooking, while preserving the integrity of fruit pieces.
- A high shaped dome on closed cooking systems prevents foam overflow from the cooking material.

Modern cooking systems are equipped with automatic metering devices for glucose syrup, acid solution and pectin solution. The integration of a process refractometer and pH measuring sequence provide automatic control of soluble solids content and pH-value. Jams, jellies and marmalades are also produced on continuous vacuum cooker systems.

Cooking in Vacuum Systems:
Cooking in vacuum systems is done in closed kettles under reduced pressure. The great benefit of this cooking method consists in low cooking temperatures and short cooking times. Both criteria are decisive for an optimal finished product as regards appearance, colour, flavour and vitamins, since the raw materials are exposed to only minimal stressing.

Reduction by Boiling:
This concentration of jams, jellies and marmalades is done with the objective to create a finished product with a long shelf-life and with the required soluble solids content as well as the other product features aimed for.

During cooking, a sufficient exchange between sugars, liquid medium and fruits is achieved, which prevents water loss in the finished product during storage. When fruits preserved with SO$_2$ are used, it is important to consider the maximum admissible level of sulphur dioxide which must not be exceeded.

The Cooker:
In the large-scale production of jams, jellies and marmalades with cooking kettles two basic types exist for the concentration process:

- Cooking in an open kettle under atmospheric pressure.
- Cooking in a closed vacuum system with reduced pressure.

Jams, Jellies and Marmalades

Berry fruits often require pre-cooking with water in order to get the hard skins of the fruits to burst and to provide a sufficient exchange with the sugar.
Filling of Jams, Jellies and Marmalades:
Jams, jellies and marmalades are discharged from the vacuum kettle by way of pumps or, even more sensitively, by gravity into heated filling troughs with agitators, from which they are fed into filling machines. The temperature of the cooking batch at the time of filling is about 70-85°C (158-185°F).

The relatively high filling temperature and capping under vacuum with headspace sterilization guarantees germ-free filling and perfect stability during storage. Before closing the jars, suitable measures for the sterility of the product surface during the filling process are recommended. UV-radiation of the empty jars or the caps before filling is also indicated to protect against secondary infections.

After filling and capping, the jars pass through a tunnel cooler and are sprinkled with cold water which lowers their temperature to 40-50°C (104-122°F). The rapid lowering of the temperature prevents caramelization and colour changes in the filled article (centreburning) and brings the product into a temperature range, in which gelation is initiated and an optimal gel texture may be slowly formed.

After cooling and labelling, the products go into packaging. Before distribution, however, the jars should be stored until the product has thoroughly gelled.

Short cooking times and relatively large cooking batches also guarantee the economic efficiency of the process. Vacuum cooking is divided into the following processing steps:

Vacuum Kettle:
The pre-heated fruit/sugar mix is fed from the pre-heater by negative pressure into the kettle and reduced by boiling under vacuum with constant stirring. To prevent foaming, edible oils and fats such as mono- and diglycerides of edible fatty acids may be added during cooking.

The pectin solution is then metered and further reduced by boiling under vacuum until the desired final soluble solids content is reached. Due to the low cooking temperatures, which may be as low as 65°C (149°F), slow to medium rapid set pectins are applied in this process.

Once the final soluble solids content is reached, the batch will be vented and acid is added. The temperature of the cooked material increases in this process, before discharging it should reach 80-85°C (176-185°F) in order to guarantee germ-free filling.

Sophisticated cooking systems with flavour recovery condense the volatile aroma components from the escaping steam and return them to the cooking batch before its discharge. This cooking process is not only suitable for the production of jams, jellies and marmalades, but also for dietetic fruit products and fruit preparations for the dairy and baking industries.

Fig. 25: Boiling equipment
Soluble Solids Content and Refractometry:

The soluble solids contents of raw materials and finished products are important parameters for the calculation and design of jam, jelly and marmalade formulations. They indicate what amounts of dissolved solids (sugar, acids, pectins, salts, etc.) are contained in anhydrous form in 100g of mass. Thus an anhydrous substance, for example, consists of 100% ss, a fruit with 10% soluble solids and 90% water has a soluble solids content of 10%. To measure the ss content, a refractometer is used.

Modern jam cookers have digital display refractometers with temperature compensation installed in the vessel walls, which allows monitoring the solids content throughout the complete cooking process.
The content in solid ingredients in a solution is determined by the refraction index "n"; refractometry is the designation of the determination method. The refraction index "n" is the ratio of the velocity of light in the examined medium and the air. The physical principle at the basis of this method is Snellius' Law, which says that during the refraction of monochromatic light (light of a uniform wavelength) at the boundary line of two media, the angle of incidence alpha is to the angle of refraction beta as is the light speed in these media.

The refractometric determination of the soluble solids content is executed at 20°C (68°F). Since the refraction index is dependent from temperature, a thermostatic refractometer should be used for accurate measuring. With increasing temperature and decreasing density, the refraction index becomes smaller.

The Abbe refractometer directly displays the refraction index; instruments calibrated on sugar solution show the soluble solids content in percentage of sugar. The measuring accuracy of refractometric solids readings amounts to ± 1%.

The most important parts in a refractometer are:

- A binocular prism to take in the liquid to be measured.
- A telescope to observe the boundary line of total internal reflection.
- An adjustable compensator for colour contrasting of the boundary line.
- A scale window fixed in the telescope, on which the units of refraction index or soluble solids are displayed.

Hand Refractometer

Using a manual or pocket refractometer is very handy and without complications.

These instruments are slightly less accurate in their measurements than an Abbe refractometer, however, they are quite sufficient for most applications.

The optical construction of such a small manual refractometer is shown in the fig. 28 on page 64.

The weighted-in volume of purée, pulp, juice or aqueous fruit extract, as set down in the German Fruit Jams Regulation, and the refractometrically determined minimum content of soluble solids of 60% are the basis for the design of formulations. A general example shows how formulations and yield can be calculated.

The total volume of all raw materials determines the batch size. The batch consists of 60kg soluble solids and 41.5kg water. To reach a soluble solids content of e.g. 63%, a certain amount of water must be evaporated.

The amount of water to be evaporated is determined by calculating the difference of the batch size and the theoretical yield (101.5kg - 95.2kg = 6.3kg water). When designing formulations, it is frequently assumed that the average soluble solids of fruits amount to 10%. However, in reality these values fluctuate greatly. The table above shows the most important types of fruit and their medium soluble solids content as well as the range in which this may fluctuate.
With the exception of food additives, the Fruit Jams Regulation describes finally and bindingly the composition of food products which are marketed by the designation extra jam, jam, extra jelly, jelly, marmalade and chestnut purée.

Except these food additives, the regulation describes the production and condition of these products and lists the admissible raw materials and the optional ingredients.

All products covered by the regulation must have a minimum soluble solids content of 60%. Products, for which the sugar is completely or partially replaced by sweeteners, are excluded from here.

The following legal provisions and regulations are valid in Germany for fruit jams, jellies and marmalades on the basis of the “Lebensmittel- und Bedarfsgegenständegesetz” (German Food Law):


As regards low-calorie and/or dietetic fruit jams, jellies and marmalades, these are governed additionally by the “Nährwertkennzeichnungs-Verordnung” (Nutritional Labelling Regulation) (Verordnung über nährwertbezogene Angaben bei Lebensmitteln vom 25.11.1994 [BGBl. I. S. 3526] in its current version) and the “Zusatzstoff-Zulassungs-Verordnung” (Food Additives Regulation) (Verordnung über die Zulassung von Zusatzstoffen zu Lebensmitteln vom 29.01.1998 [BGBl. I. S. 231] in its current version) as well as the “Diät-Verordnung” (Dietetic Regulation) (Verordnung über diätetische Lebensmittel vom 25.08.1988 [BGBl. I. S. 1713] in its current version).

The minimum quantity of fruits to be used is different for the various products depending on the type of fruit and the additional designation “extra”:

- **Extra jam** requires a minimum of 450g fruits per 1000g finished product. Lower quantities are admissible for red and black currant, rose hip, quince, ginger, cashew apple, rowan berry, sallow thorn and passion fruit.
- **Jam** must be manufactured with 350g fruits per 1000g finished product. The fruits mentioned above are also exempted.
- **Marmalades** are made with a minimum quantity of 200g citrus fruit per 1000g finished product.

The Codex Alimentarius Commission has formulated a standard draft for jams, jellies and marmalades featuring many parallels to German resp. European law.
The addition of preservatives is not scheduled and not considered necessary in view of the high quantity of soluble solids. Exceptions here-from are low-calorie products, for which sorbic acid and benzoic acid and their salts are allowed. With the exception of extra products, the sulphur dioxide content in jams, jellies and marmalades may be 50mg/kg at the highest, due to the use of sulphurized fruits.

Extra jam, extra jelly and chestnut purée must not be coloured.

A Community Regulation for jams, jellies and marmalades with less than 60% soluble solids has not yet been established. Up to now, the Jams Directive allows different national regulations for this group of products. The designation for such products with sometimes 50% soluble solids thus differs greatly within the EC. In Germany, for example, the labelling “Frucht-aufstrich” (fruit spread) is used. In Austria the term jam is allowed for a product with 55% soluble solids content.

The designation protection of the German Fruit Jams Regulation allows two exceptions:

- low-calorie products
- dietetic products

Pectins, amidated pectins and “liquid pectin” are the only gelling agents allowed for extra jams and jellies, all of them without any restrictions concerning the amount used – quantum satis, that means as much may be used as technologically necessary.

For jams, jellies and marmalades also the gelling agents alginites, agar-agar, carragheen, locust bean gum, guar, xanthan and gellane with the limit of 10g/kg are allowed.

To adjust the pH-value, lactic acid, malic acid, citric acid und tartaric acid as well as their salts are permitted.

**Low-Calorie Products:**

In these products the sugar is completely or partially replaced by sweeteners (sugar substitute or sweetener). A bare reduction of the sugar content is not sufficient. The flavourful component has also to be considered. According to the German Fruit Jams Regulation, products which undergo the demanded minimum soluble solids content, may still be allowed to use the protected designation if

a) all other provisions in the German Fruit Jams Regulation are met. This includes the provisions on quantity of fruit, type of fruit, ingredients and additives. There are exceptions:

- A number of colourings such as cochineal red A (E 124), curcumin (E 100) or chinolin yellow (E 104) are permitted for the colouring of low-calorie jams, jellies and marmalades.

b) the provisions of the Nutrition Labelling Regulation have to be met. Lowering the soluble solids content means a reduction in calorific value. The Regulation on Nutrition Labelling stipulates that food products claiming a lower calorific input may be marketed if:

- The calorific value compared to the traditional product is reduced by at least 30%; an extra jam, low-calorie, must not have a soluble solids content of more than 44%.

- For "jams, jellies and marmalades with low sugar content as well as similar low-calorie products", it is permitted to use benzoic acid and its salts up to a maximum amount of 500mg/kg, sorbic acid and its salts up to a maximum amount of 1000mg/kg, the combination of both preserving agents up to a maximum amount of 1000mg/kg for preservation.
Example:
The minimum soluble solids content for extra jam is 60%; the vast majority of extra jams, however, boast a soluble solids quantity of 63% for reasons of shelf-life. Thus for the traditional product, it is safe to say that the soluble solids content is 63%. The soluble solids content for a low-calorie jam may be calculated as follows:

\[
63 \% = \frac{63 \times 30}{100} = 44 \%
\]

The average calorific value and content in available carbohydrates is listed as based on 100g.

The sugar substitutes and sweeteners mentioned in table 7 are allowed as sweetening agents:

“No sugar added” means: no addition of monosaccharides or disaccharides and no foodstuff added which are used because of their sweetening properties; in food products for diabetics “no sugar added” means: without the addition of mono- or disaccharides with the exception of fructose.

Food Colours:
Except the extra products, all other products covered by the Fruit Jams Directive, such as jams and corresponding low-calorie products, may be coloured. The list of allowed colourings contains e.g. carotene, betanin and anthocyanins without any limits for use as well as e.g. cochineal red A or chinoline yellow which may be used in a maximum quantity of 100mg/kg.

Dietetic Products:
Dietetic food products are intended for special diets. They must decisively differ in composition or characteristics from ordinary food products of similar type.

The basic principle in this context is that dietetic jams and similar products may be marketed under designations protected by the German Fruit Jams Regulation if their difference to the binding product provisions is due to their dietetic destination. Dietetic products of importance in the group of jams are currently only those destined for diabetics:

- in their sugar reduction, i.e. jams for diabetics may also be produced with a soluble solids content of less than 60%;
- in their substitution of D-glucose containing sugars by sweeteners (sugar substitutes and sweeteners).

All requirements concerning type of fruit, fruit quantity, ingredients comply with the German Fruit Jams Regulation, the requirements concerning additives comply with the German Food Additives Regulation.

For low-calorie, dietetic jams the same sweetening agents are allowed as for the low-calorie jams.

### Table 7:

<table>
<thead>
<tr>
<th>Sugar substitutes:</th>
<th>Maximum quantity in mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low-calorie jams, jellies and marmalades or produced without addition of sugar</strong></td>
<td></td>
</tr>
<tr>
<td>sorbitol</td>
<td>E 420</td>
</tr>
<tr>
<td>mannite</td>
<td>E 421</td>
</tr>
<tr>
<td>isomalt</td>
<td>E 953</td>
</tr>
<tr>
<td>maltitol</td>
<td>E 965</td>
</tr>
<tr>
<td>lactitol</td>
<td>E 966</td>
</tr>
<tr>
<td>xylitol</td>
<td>E 967</td>
</tr>
<tr>
<td><strong>Sweeteners:</strong></td>
<td></td>
</tr>
<tr>
<td>acesulfame-k</td>
<td>E 950</td>
</tr>
<tr>
<td>aspartame</td>
<td>E 951</td>
</tr>
<tr>
<td>aspartame-acesulfame-salt</td>
<td>E 962</td>
</tr>
<tr>
<td>cyclamate</td>
<td>E 952</td>
</tr>
<tr>
<td>sucralose</td>
<td>E 955</td>
</tr>
</tbody>
</table>
### 1. Jams, jellies, marmalades and fruit preparations, ss > 55°Bx

<table>
<thead>
<tr>
<th>Pectin</th>
<th>DE°</th>
<th>A°</th>
<th>Standardization with neutral sugars + composition</th>
<th>Characteristics + properties</th>
<th>Main application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classic AF 101</td>
<td>&gt; 77%</td>
<td>-</td>
<td>const. breaking strength E 440</td>
<td>apple pectin, extra rapid set</td>
<td>jams, marmalades and fruit preparations (ss ≥ 58%, pH 3.0-3.3) with sorbitol (≤ 55%, pH 2.8-3.2)</td>
</tr>
<tr>
<td>Classic AF 201</td>
<td>72-76%</td>
<td>-</td>
<td>const. breaking strength E 440</td>
<td>apple pectin, very rapid set</td>
<td>jams, marmalades and fruit preparations (ss ≥ 58%, pH 2.8-3.3)</td>
</tr>
<tr>
<td>Classic AF 202</td>
<td>70-72%</td>
<td>-</td>
<td>150 +/- 5° USA-Sag const. breaking strength E 440</td>
<td>apple pectin set, firm texture</td>
<td>jams, marmalades and fruit preparations (ss ≥ 58%, pH 2.8-3.2)</td>
</tr>
<tr>
<td>Classic AF 401</td>
<td>59-64%</td>
<td>-</td>
<td>150 +/- 5° USA-Sag const. breaking strength E 440</td>
<td>apple pectin, medium rapid set, smooth gel</td>
<td>jams, marmalades for glass products and large trading units, fruit preparations (ss 15-25%, pH 3.0-3.4) and fruit spreads, e.g. sweetened with concentrate (ss &gt; 35%, pH 2.8-3.6)</td>
</tr>
<tr>
<td>Classic AF 501</td>
<td>56-63%</td>
<td>-</td>
<td>150 +/- 5° USA-Sag const. breaking strength E 440</td>
<td>apple pectin, slow set, spreadable gel texture</td>
<td>jams, marmalades and fruit preparations for large trading units, fruit preparations and spreadable texture at high filling temperature (ss ≥ 58%, pH 2.8-3.2)</td>
</tr>
<tr>
<td>Classic AF 504</td>
<td>51-58%</td>
<td>-</td>
<td>const. breaking strength E 440</td>
<td>apple pectin, optimal fruit distribution, smooth gel also at high filling temperature</td>
<td>jams, marmalades and fruit preparations (ss ≥ 58%, pH 2.8-3.2)</td>
</tr>
<tr>
<td>Classic AF 601</td>
<td>48-54%</td>
<td>-</td>
<td>150 +/- 5° USA-Sag const. breaking strength E 440</td>
<td>apple pectin, smooth gel, spreadable texture</td>
<td>jams, marmalades and fruit preparations (ss ≥ 58%, pH 2.8-3.2)</td>
</tr>
<tr>
<td>Classic AF 605</td>
<td>48-54%</td>
<td>-</td>
<td>const. breaking strength E 440</td>
<td>apple pectin, very well soluble also at higher soluble solids</td>
<td>household gelling agents 1+1 (1 part sugar/1 part fruit)</td>
</tr>
<tr>
<td>Amid AF 005</td>
<td>32-40%</td>
<td>10-16%</td>
<td>const. gelling strength E 440</td>
<td>amidated apple pectin</td>
<td>fruit preparations (ss 50-65%, pH 3.0-3.5)</td>
</tr>
<tr>
<td>Classic CF 201</td>
<td>&gt; 70%</td>
<td>-</td>
<td>150 +/- 5° USA-Sag const. setting time E 440</td>
<td>citrus pectin, rapid set</td>
<td>jams, marmalades and fruit preparations (ss ≥ 58%, pH 2.9-3.3)</td>
</tr>
<tr>
<td>Classic CF 301</td>
<td>65-70%</td>
<td>-</td>
<td>150 +/- 5° USA-Sag const. setting time E 440</td>
<td>citrus pectin, medium rapid set</td>
<td>jams, marmalades and fruit preparations (ss ≥ 58%, pH 2.9-3.3)</td>
</tr>
<tr>
<td>Classic CF 401</td>
<td>60-66%</td>
<td>-</td>
<td>150 +/- 5° USA-Sag const. setting time E 440</td>
<td>citrus pectin, slow set</td>
<td>jams, marmalades and fruit preparations (ss ≥ 58%, pH 2.9-3.3)</td>
</tr>
<tr>
<td>Classic CF 501</td>
<td>55-61%</td>
<td>-</td>
<td>150 +/- 5° USA-Sag const. setting time E 440</td>
<td>citrus pectin, extra slow set</td>
<td>jams, marmalades and fruit preparations (ss ≥ 58%, pH 2.9-3.3)</td>
</tr>
<tr>
<td>Amid CF 005</td>
<td>32-40%</td>
<td>10-16%</td>
<td>const. gelling strength E 440</td>
<td>amidated citrus pectin, low calcium reactivity</td>
<td>jams, marmalades and low-calorie fruit preparations, fruit spreads (ss &gt; 55%, pH 3.0-3.5)</td>
</tr>
</tbody>
</table>

### 2. Jams, jellies, marmalades and fruit preparations, ss < 55°Bx

<table>
<thead>
<tr>
<th>Pectin</th>
<th>DE°</th>
<th>A°</th>
<th>Standardization with neutral sugars + composition</th>
<th>Characteristics + properties</th>
<th>Main application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classic AF 703</td>
<td>38-44%</td>
<td>-</td>
<td>const. breaking strength E 440</td>
<td>apple pectin, medium calcium reactivity</td>
<td>jams and fruit preparations (ss &lt; 55%, pH 3.0-3.4) with sorbitol (≤ 55%, pH 2.8-3.2)</td>
</tr>
<tr>
<td>Classic AF 802</td>
<td>38-44%</td>
<td>-</td>
<td>const. breaking strength E 440</td>
<td>apple pectin, smooth gel, spreadable texture</td>
<td>jams, marmalades and fruit preparations (ss 25-50%, pH 3.0-3.4) and fruit spreads (ss 10-25%, pH 3.0-3.8)</td>
</tr>
<tr>
<td>Classic AF 803</td>
<td>38-44%</td>
<td>-</td>
<td>const. breaking strength E 440</td>
<td>apple pectin, smooth gel, spreadable texture</td>
<td>jams, marmalades and fruit preparations (ss 35-60%, pH 3.0-3.4) and fruit spreads (ss 25-45%, pH 2.8-3.6)</td>
</tr>
<tr>
<td>Classic AF 813</td>
<td>36-43%</td>
<td>-</td>
<td>const. breaking strength E 440</td>
<td>apple pectin, smooth gel</td>
<td>jams, marmalades and fruit preparations (ss &gt; 55%, pH 3.0-3.4)</td>
</tr>
<tr>
<td>Amid AF 005-A</td>
<td>30-38%</td>
<td>7-14%</td>
<td>const. gelling strength E 440, E 333, E 452</td>
<td>amidated apple pectin, low calcium reactivity</td>
<td>jams, marmalades, low-calorie fruit preparations, fruit spreads, jams, jellies (ss &gt; 55%, pH 3.0-3.5)</td>
</tr>
<tr>
<td>Amid AF O10</td>
<td>30-36%</td>
<td>14-20%</td>
<td>const. gelling strength E 440</td>
<td>amidated apple pectin, medium calcium reactivity</td>
<td>jams, marmalades, low-calorie fruit preparations, fruit spreads (ss 30-55%, pH 3.0-3.5)</td>
</tr>
<tr>
<td>Amid AF O20</td>
<td>27-32%</td>
<td>18-23%</td>
<td>const. gelling strength E 440</td>
<td>amidated apple pectin, high calcium reactivity</td>
<td>jams, marmalades, low-calorie fruit preparations, fruit spreads, jams, jellies (ss &gt; 55%, pH 3.0-3.5)</td>
</tr>
<tr>
<td>Amid CF 010</td>
<td>30-36%</td>
<td>14-20%</td>
<td>const. gelling strength E 440</td>
<td>amidated citrus pectin, medium calcium reactivity</td>
<td>jams, marmalades, low-calorie fruit preparations, fruit spreads (ss 30-55%, pH 3.0-3.5)</td>
</tr>
<tr>
<td>Amid CF 020</td>
<td>27-32%</td>
<td>18-23%</td>
<td>const. gelling strength E 440</td>
<td>amidated citrus pectin, high calcium reactivity</td>
<td>jams, marmalades, low-calorie fruit preparations, fruit spreads, jams, jellies (ss &gt; 55%, pH 3.0-3.5)</td>
</tr>
<tr>
<td>Amid CF 025</td>
<td>24-29%</td>
<td>21-25%</td>
<td>const. gelling strength E 440</td>
<td>amidated citrus pectin, very high calcium reactivity</td>
<td>jams, marmalades, low-calorie fruit preparations, fruit spreads, jams, jellies (ss &gt; 55%, pH 3.0-4.5)</td>
</tr>
</tbody>
</table>

| Table 8: DE° = Degree of esterification | A° = Degree of amidation | Table 9: DE° = Degree of esterification | A° = Degree of amidation |
Pectins by Herbstreith & Fox have enjoyed a worldwide reputation over many decades. Constantly improving production methods and high quality standards have decisively contributed to our present success in the world market. This development has always been characterized by innovative thinking and farsighted research.

Today, we are in a position to offer pectins which can be used in all foreseeable areas of application. Consistent production and quality controls with state-of-the-art analytical instruments guarantee a regular high quality of our pectins.

This positive and continuous progressive approach has not only been upheld in the face of challenges, which our staff in research and development have faced successfully many times, but also by the great variety of requirements brought to us by our customers, the users.

This successful cooperation with our users is, of course, complemented by the transfer of our know-how. We are able to give valuable assistance already at the stage of analysis and control of raw materials.

Furthermore, we also supply our customers with formulations and technical service, as e.g. for the manufacture of high quality jams, jellies or marmalades.

For this purpose, specific pectins are integrated by our technological experts in the most advantageous way in the composition and optimization of formulations.

The analysis of your finished products also contributes successfully to assure a high and consistent quality of your product, or even permits conclusions as regards potential improvements of your finished articles.

New and promising product ideas should not fail because of formulation or production specific problems. This is what we stand for. Keeping in mind the producer, the product and the consumer.

Individuality
is our Strength

JAMS, Jellies and Marmalades