Yoghurt Fruit Preparations
Due to this variety, the features required of yoghurt fruit preparations mainly have to do with sensory properties, such as taste, appearance and texture. In addition to this, depending on the application, very specific technological properties are required, properties which in particular have to do with the rheological behaviour of the fruit preparation during processing as well as with the miscibility with the yoghurt and a possible reaction with calcium ions from the milk product. Besides their good processing properties (e.g. pumping properties), fruit preparations used in stirred yoghurts must for example display an excellent mixing behaviour with the milk product.

Fruit yoghurts are mainly distinguished by the way the fruit preparation and the yoghurt are combined.

The majority of yoghurts are stirred yoghurts where the fruit preparation is directly mixed with the stirred yoghurt and then filled into the containers. Another large group are layered products. In these products, the fruit preparation and the yoghurt are filled into the containers in succession. In the case of the fruit-bottom type, the fruit preparation is filled first and topped by the milk product, whereas in the fruit-at-the-top type the milk product is filled into the container first, followed by the fruit preparation. Another possibility is to separate the fruit preparation and the milk product by filling them into two-part containers. In the case of these two-part containers (fruit-corner products), the two components are mixed by the consumer or are consumed separately.

For use in yoghurt fruit preparations, H&F offers Classic Apple Pectins and Low Methylester Amidated (“Amid”) Pectins, standardised specially for these applications. This way, optimum sensory and technological properties can be achieved in each product.
Yoghurt fruit preparations are industrially manufactured generally from fruit (whole or pieces, on rare occasions also fruit puree or fruit concentrate), sugar/sugar syrup, thickening agents, buffering salts (e.g. calcium salts) and sometimes culinary acids. Depending on the product, the soluble solids content of these fruit preparations may be between 20% SS and 60% SS, whereas the pH-value is usually set to approx. pH 4, thus adjusted to the natural pH of the milk product.

On account of these formulation parameters, Low Methylester H&F Classic Apple Pectins as well as H&F Amid Pectins are particularly suited for these applications as thickening agents.

After manufacturing, the yoghurt fruit preparations are usually filled into containers and transported to the yoghurt producers. For further processing the fruit preparation is pumped out of the respective container and is either stirred with the milk product (stirred yoghurt) or metered directly into the yoghurt cups (fruit-bottom type, fruit-at-the-top type or fruit-corner type).

To guarantee both a smooth manufacturing process and an optimum product from the manufacturing of the yoghurt fruit preparation via storage, transport, processing and subsequent storage of the finished fruit yoghurt, many requirements for yoghurt fruit preparations and thus for the gelling and thickening agents used have to be met.

The formulation parameters (soluble solids content, type of sugar, type of fruit, dosage and type of added buffering agent) as well as type and dosage of the thickening agents used have a significant effect on both the gelling properties and the texture of the fruit preparation.

Use of the appropriate H&F Classic Apple Pectins or H&F Amid Pectins and the respective pre-determined formulation results in products that display the desired properties.

If yoghurt fruit preparations contain, for example, whole fruits or pieces of fruit, these should neither be destroyed by the heating process nor by the shear stress sustained during processing (pumping, stirring). After filling, the fruit must not float; it must be distributed homogeneously in the container.

The floating of the fruit is only prevented if a yield point is formed. A high viscosity only delays this process.

When H&F pectins are added, fruit preparations obtain a distinctive shear-thinning flow behaviour. During processing, a relatively low shear stress then has to be applied, resulting in pumpable products with well-preserved fruits or fruit pieces.

In addition to this, fruit preparations made with H&F pectins build up a yield point already during the heating process. This yield point prevents the fruit from floating and guarantees a homogeneous fruit distribution in the container after filling and cooling.
Specific Requirements for Fruit Preparations for Stirred Yoghurts

Fruit preparations for stirred yoghurts should meet the following requirements:

- Good pumping properties
- Pumping stability
- No syneresis
- The desired texture is obtained in the final product

On account of their shear-thinning properties, fruit preparations made with H&F pectins can be pumped easily, requiring only minimum effort. The products are resistant to shear stress and unsusceptible during processing. Whole fruits or fruit pieces are not damaged. Even after repeated pumping, the original texture as well as the fruits and fruit pieces remain intact, the fruit preparations show little tendency to syneresis.

By using the appropriate H&F pectins, fruit preparations with the desired texture for each of the different final products (e.g. stirred yoghurts, layered products or fruit-corner products) can be obtained.

However, there are different requirements for the fruit preparations for stirred yoghurt and for layered products.

Specific Requirements for Fruit Preparations for Layered Products

Layered products are made by either putting the milk product on top of the fruit preparation or, vice versa, by putting the fruit preparation on top of the milk product.

Fruit preparations for layered products have to meet the following requirements:

- High regenerative capacity
- Forming a smooth surface and displaying form stability
- Clear separation of fruit preparation from milk product where they meet (no colour migration)
- Stable texture

On account of their shear-thinning flow behaviour, fruit preparations made with H&F pectins can be mixed exceedingly well with the milk product. When the fruit preparation is mixed with the yoghurt, the finished fruit yoghurt obtains the desired texture.

Unwanted changes in texture after the fruit preparation has been mixed with the milk product are prevented by adding a specific amount of a calcium salt to the appropriate H&F pectin or by using specially standardised H&F pectins. This ensures that the pectin is already saturated with calcium ions in the fruit preparation and can no longer react with the calcium ions from the milk product (please see page 34).

However, the reaction with calcium ions in the milk can also be utilised deliberately in order to help the milk product to thicken. For this, H&F offers Pectin Classic AM 901, which has been standardised to produce this very behaviour.
Rheological Characterisation of the Flow Behaviour of Yoghurt Fruit Preparations

The flow behaviour of yoghurt fruit preparations can be characterised by determining the following parameters, using, for example, a shear-stress controlled rheometer:

- Viscosity
- Yield point
- Regenerative capacity

Viscosity is the property of substances indicating their resistance to flow.

Fruit preparations are shear-thinning, pseudoplastic substances where viscosity drops with increasing shear stress (shear rate). Therefore, shear-thinning products are subject to a drop in viscosity (shear-thinning) during processing due to stress (pumping, stirring). During the idle state or when exposed to little stress, these products have a high viscosity.

As yoghurt fruit preparations have to be frequently pumped or stirred during the manufacturing process, the level of the stress-dependent viscosity is an important factor.

The shear stress (shear rate) that can act on the fruit preparation differs depending on the production facility. In the case of pumping it depends on the pipe geometry and the pump’s delivery rate, with stirring it is mainly determined by the stirring speed and the container geometry.

If the viscosity is low during pumping and stirring, not only is less force and energy required to execute the process but the product is also prevented from damage due to the smaller force exerted, so that fruits or fruit components are better preserved.

Determining the Quality Criteria of Yoghurt Fruit Preparations

The quality criteria of yoghurt fruit preparations are mainly determined by their rheological flow behaviour. The formulation of the fruit preparation as well as the thickening agents used have a decisive effect on the flow behaviour.

The mixing behaviour with the milk product and the syneresis behaviour also affect the quality of yoghurt fruit preparations. Pectins for yoghurt fruit preparations, such as Low Methylester Classic Apple Pectins and Low Methylester Amidated Pectins from H&F, are systematically standardised to a specific flow behaviour. Thus if the appropriate pectin is selected for a pre-determined formulation, optimum products are obtained.
The lower the viscosity reached at the respective stirring speed, the better fruit preparations with shear-thinning behaviour can be mixed with the milk product.

To determine the viscosity, the shear rate is continuously increased and the resulting shear stress measured. Viscosity is the quotient of shear stress and shear rate \( \eta \) \([\text{Pas}] = \frac{\tau}{D \text{ [s}^{-1}]}.\)

In the manufacture of yoghurt fruit preparations with fruit pieces or whole fruits, it is advantageous when a certain level of viscosity builds up in the idle state during the heating process, as a high heat viscosity counteracts the floating of the fruits by delaying floating. Floating can only be completely avoided if a yield point is already built up during the heating process.

Substances with a yield point will not flow until external forces exceed their internal strength. When exposed to forces below the yield point the substances behave as though they were solids.

By using appropriate H&F pectins as gelling agents for yoghurt fruit preparations a yield point already builds up in the hot fruit preparation, counteracting the lifting power of the fruits and thus preventing the separation of fruit and gel.

To determine the yield point, the shear stress is continuously increased. The yield point \( \tau_0 \) \([\text{Pa}]\) is exceeded when a shear rate is measured for the first time.

To characterise both texture and regenerative behaviour of cold yoghurt fruit preparations, it is important to determine the yield point before and after distinct process steps. By means of a shear-stress controlled rotation rheometer, H&F is able to rheologically reconstruct various stress profiles, thus simulating the processing of yoghurt fruit preparations.

The so-called “yield point before shearing” is determined in the still intact fruit preparation and is a measurement of its firmness, as to be found for example in the container or other trading unit.

Fruit preparations with a higher yield point before shearing are perceived by the senses as being firmer than fruit preparations with a lower yield point before shearing. Without a yield point a fruit preparation would not be stable, it would be liquid and would run, even if the viscosity were very high.
To determine the structural disintegration of a fruit preparation during processing, the fruit preparation is sheared under defined conditions after determining the yield point before shearing. By shearing, the gelled portion is irreversibly destroyed. Immediately afterwards, the so-called “yield point after shearing” is determined within the sample. The yield point after shearing is a measure for the texture of fruit preparations immediately after a step in production. The difference between yield point before shearing and yield point after shearing describes the overall structural disintegration of a fruit preparation on account of the shear stress applied.

However, very high yield points are indicative of an elastic gelation. Elastic gelation is often unwanted in yoghurt fruit preparations as, on the one hand, this texture has a tendency to syneresis and, on the other hand, the regenerative capacity is adversely affected if the gel is irreversibly destroyed during further processing. On account of the high yield point, the processing of gelled products also requires huge forces in order to make products capable of flowing and thus being pumped.

If, after a given resting phase, another yield point measurement is conducted, the so-called “regenerated yield point” is obtained. The regenerated yield point is a measure for the texture of fruit preparations after these have been subjected to a defined mechanical stress and, subsequently, after a defined regenerative phase. The regenerated yield point specifies the texture of fruit preparations, e.g. after dispensing.

The irreversible, gel-like character of fruit preparations is determined by the difference between regenerated yield point and yield point before shearing, as the gelled portion cannot regenerate. The greater this difference, the more gel-like the product before shearing.

A conclusion on the regenerative capacity of fruit preparations can be made if the three parameters (yield point before shearing, yield point after shearing and regenerated yield point) are examined together.

Regenerative capacity means that fruit preparations that underwent structural disintegration after being destroyed by specific shear stresses (e.g. during pumping or dispensing) are capable of rebuilding part of their structure after a given resting phase.

The regeneration may, for example, be related to the yield point after shearing, i.e. the structural disintegration (destruction), whereby the percentage of the disintegrated structure that is regenerated after a defined resting phase can be determined.

It is also possible to relate the regeneration to the original state, specified by the yield point before shearing.

The more portions of the destroyed structure are regenerated during the resting phase – i.e. the closer the value of the regenerated yield point to the yield point before shearing – the higher the regenerative capacity.

A high regenerative capacity means that the texture of the fruit preparation is resistant to mechanical stress and thus remains stable. The regenerative capacity of yoghurt fruit preparations is for the most part controlled by the pectin and the formulation parameters used.

By using Low Methylester H&F Classic Apple Pectins – which have outstanding processing properties – an excellent regenerative capacity is achieved, especially in fruit preparations for layered products. After the fruit preparation has been dispensed into the yoghurt cups, it will, thanks to this characteristic, regain its original texture within a very short period of time, so that the fruit preparation and the milk product will remain clearly separated and will not mix once the milk product is put on top of the fruit preparation.
In Table 1 you find a short summary of the various requirements for yoghurt fruit preparations and their respective rheological properties.

<table>
<thead>
<tr>
<th>Requirements for yoghurt fruit preparations</th>
<th>Rheological properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good pumping properties</td>
<td>Shear-thinning (= intrinsically viscous, pseudoplastic) flow behaviour</td>
</tr>
<tr>
<td>Protection of fruit pieces</td>
<td>Shear-thinning (= intrinsically viscous, pseudoplastic) flow behaviour</td>
</tr>
<tr>
<td>Mixes well with the milk product</td>
<td>Shear-thinning (= intrinsically viscous, pseudoplastic) flow behaviour</td>
</tr>
<tr>
<td>Delay of floating</td>
<td>High heat viscosity</td>
</tr>
<tr>
<td>Prevention of floating</td>
<td>Yield point during the heating process</td>
</tr>
<tr>
<td>Minimal gel-like character</td>
<td>Little destruction</td>
</tr>
<tr>
<td>➔ Low tendency to syneresis</td>
<td>Little difference between yield point before shearing and yield point after shearing/regenerated yield point</td>
</tr>
<tr>
<td>High regenerative capacity</td>
<td>Recovery of original texture</td>
</tr>
<tr>
<td>➔ Further processing can continue soon afterwards</td>
<td>Little difference between yield point before shearing and regenerated yield point</td>
</tr>
<tr>
<td>Texture</td>
<td>Yield point, viscosity</td>
</tr>
</tbody>
</table>

Table 1: Rheological properties that define the requirements for yoghurt fruit preparations

Mixing Behaviour when added to the Milk Product

When manufacturing stirred yoghurts, not only is the desired flow behaviour important, but it is also important that, on the one hand, the fruit preparation can be stirred easily into the milk product, and, on the other hand, that the final product has a pleasant, homogenous texture after stirring.

An undesirable change in texture could, for example, be caused by a possible reaction with calcium ions from the milk product. In this reaction, small gel particles are generated by partial gelation, which make the yoghurt product look rough and inhomogenous.

Thinning, i.e. lowering of the yoghurt's viscosity, caused by the fruit preparation is always undesirable and can be prevented by selecting the right pectin type. Manufacturers often attempt to make the yoghurt more viscous and full-bodied with the stabilisation system of the fruit preparation.

The mixing behaviour can be checked using a simple sensory test. A defined amount of the fruit preparation is hereby carefully spooned into a specified amount of yoghurt. In the sensory evaluation stirrability, sensory viscosity after stirring and visual appearance of the product are determined. Special attention is hereby given to the occurrence of gel particles.

Fig. 7: Sensory test Behaviour of a yoghurt fruit preparation when stirred into the yoghurt
Gelling Behaviour
of H&F Pectins

Tendency to Syneresis
Syneresis is the release of liquid from gels, especially after mechanical destruction of the gel network.

In yoghurt fruit preparations syneresis is undesirable. Especially in layered products, where the release of liquid is likely to discolour the white milk product, it is important to use fruit preparations showing little or no tendency to syneresis.

To determine syneresis behaviour, a defined amount of fruit preparation is mechanically destroyed under specified conditions and then filled into a funnel. The released liquid is collected in a test tube or measuring glass. The lower the amount of liquid released from the test fruit preparation over a specified time period, the lower its tendency to syneresis.

Pectin Structure
Pectin is an important structure-giving element of all plant foods. Chemically speaking, pectin is a macromolecular compound belonging to the heteropolysaccharides. Its main component is polygalacturonic acid, which is partly esterified with methanol.

Pectins with a degree of esterification of 50% or more are known as high methylester pectins, whereas pectins of a DE below 50% are known as low methylester pectins.

Low methylester amidated pectins are obtained if methylester groups are replaced by amidated groups under ammoniacalic conditions.

Degree of esterification and degree of amidation indicate the percentage of esterified or amidated galacturonic acid units.
Gelling Mechanisms

According to modern theories of gel formation, the regular zones of the pectin macromolecules form bonding zones during gelation. If neutral sugar side chains are present, these bonding zones are disturbed and new bonding zones form at another place. This way, a three-dimensional network forms, capable of immobilising large amounts of water.

Gel Formation of High Methylester Pectins

In high methylester pectins the bonding zones required for gelation are, on the one hand, created by hydrophobic interactions between the methylester groups and, on the other hand, by hydrogen bonds which can build up for example between free, non-dissociated carboxyl groups of the pectin chain. In this so-called “sugar acid gelling mechanism” a high sugar concentration lowers the system’s water activity. The pectin chains become dehydrated and can converge more easily. An acid addition reduces the dissociation of the free carboxyl groups, preventing the mutual repulsion of the negatively charged pectin molecules. High methylester pectins have an optimum gelation with a soluble solids content of more than 60% and in a pH range of approx. 3.0.

Gel Formation of Low Methylester Pectins

Low methylester pectins, like high methylester pectins, also gel according to the “sugar acid gelling mechanism”. In addition to this, low methylester pectins are also able to form bonding zones with divalent cations, such as calcium ions. The bonding is conducted by complexation of the divalent ions (“egg-box” gelling model). Gelation with calcium ions is relatively independent of the soluble solids content and the product pH.

Gel Formation of Low Methylester Amidated Pectins

Low methylester amidated pectins, like low methylester pectins, gel according to the “sugar acid gelling mechanism” as well as with divalent cations. Due to the presence of the amidated groups additional cross linkage is created by way of hydrogen bonds. The more amidated groups are present, the firmer the respective gels.

The ratio between degree of esterification and degree of amidation determines the so-called calcium reactivity of low methylester amidated pectins. Calcium reactivity measures the capacity to form a gel with a specified setting time under defined conditions at a constant calcium ion concentration.
Influence of the Calcium Ion Concentration on the Gelation of Low Methylester and Low Methylester Amidated Pectins

It follows from the gelling mechanisms of low methylester and low methylester amidated pectins that the concentration of fruit-inherent and/or added calcium ions has a significant influence on the gelation, and hence formation of a specific texture under given formulation parameters. When small doses of calcium are added to the gel preparation, the pectin chains start to stick together by means of calcium bridges, resulting in an increase in the viscosity of the gel preparation. With a further increase of the calcium dosage a gel forms. However, in the event of a calcium overdose, which leads to pre-gelation, the gel structure loses elasticity and the texture will become more viscous and pasty, resulting in a decreasing breaking strength and increasing tendency to syneresis.

Therefore, gel strength – a measure for the breaking strength, which is, for example, determined with the Herbstreith Pectinometer – increases in low methylester pectins as the calcium ion concentration increases up to a defined maximum. The gels become firmer and the gel texture more elastic and brittle. In the event of a calcium overdose, which leads to pre-gelation, the gel structure loses elasticity and the texture will become more viscous and pasty, resulting in a decreasing breaking strength and increasing tendency to syneresis.

Factors Influencing the Gelation of Low Methylester and Low Methylester Amidated Pectins

On account of the specific formulation parameters of yoghurt fruit preparations (soluble solids content usually < 60%, product pH > 3.5) high methylester pectins are rarely used in this area of application, whereas low methylester pectins and low methylester amidated pectins are the optimum choice.

Both gelation and formation of a specific gel texture depend on a variety of factors, such as calcium ion concentration, soluble solids content, sugar type, product pH as well as type and quantity of the added buffering agents. The selected filling temperature is also significant for the texture of the final product.

Depending on the calcium dosage, low methylester amidated pectins usually display a similar behaviour. However, due to the presence of the amidated groups, the gels are more tolerant towards calcium ions. Low methylester amidated pectins already gel with very small amounts of calcium ions, so that sometimes the calcium from the fruits may be sufficient to form a firm gel. Low methylester amidated pectins are able to gel homogeneously and relatively independently of the calcium ion concentration over a wide range, i.e. if the calcium dosage is increased, pre-gelation – and hence a loss in gel strength – occurs at a relatively late point of time.

Fig. 13: Gelation of low methylester pectins in dependence of the calcium ion concentration
The texture of gels made with low methylester amidated pectins differs from the gel textures obtained from low methylester non-amidated pectins. Whereas H&F Amid Pectins are able to form very smooth and supple gels that are able to regenerate and show little tendency to syneresis, gels with low methylester amidated pectins tend to form more elastic textures with a slightly lower capacity to regenerate.

The calcium reactivity of a pectin determines the amount of calcium it needs to form a gel network and has therefore an additional influence on the breaking strength and the texture of the gels formed. The higher a pectin’s calcium reactivity, the lower the amount of calcium ions needed to form a gel with a defined breaking strength.

**Influence of the Soluble Solids Content on the Gelation of Low Methylester and Low Methylester Amidated Pectins**

The soluble solids content that is specified by the formulation is an important parameter when selecting pectins suitable for application in specific products, as a change in the soluble solids content may have a significant influence on the gelling properties of low methylester and low methylester amidated pectins.

Gels made with low methylester pectins achieve their overall reachable breaking strength when the soluble solids content is at its highest. To reach this overall reachable breaking strength, i.e. to obtain a relatively firm gel, a lower calcium ion dosage is required with a high soluble solids content (e.g. at 60% SS) than with a lower soluble solids content (e.g. 20% SS).

At the same time, the “working range”, i.e. the range at which gels are firm but not pre-gelled, increases as the soluble solids content declines. The basic principle that the overall reachable breaking strength increases as the soluble solids content increases, and that the calcium amount required in order to obtain a defined breaking strength decreases as the selected soluble solids content in the gel preparation increases is also true for low methylester amidated pectins. The working range increases as the soluble solids content decreases.

The calcium reactivity of a pectin determines the amount of calcium it needs to form a gel network and has therefore an additional influence on the breaking strength and the texture of the gels formed.
Firmer gels are obtained with pectins of high calcium reactivity. Their breaking strength also increases more rapidly with increasing calcium dosage compared to pectins of medium or low reactivity. Maximum breaking strength and possible start of pre-gelation are already reached at a lower calcium dosage.

With a soluble solids content around 40%, pectins of medium calcium reactivity exhibit the homogeneous gelation typical of low methylester amidated pectins, which is relatively independent of the calcium ion concentration.

If there is a change in the soluble solids content, the calcium reactivity of pectins affects the gelling behaviour in different ways. Comparing, for example, low methylester amidated pectins of differing reactivity, it becomes apparent that, at high soluble solids contents (e.g. 60% SS) pectins of high or medium calcium reactivity already gel without further addition of calcium ions.

With very low soluble solids contents, the reactive pectin requires a certain amount of calcium ions for gelation, but is characterised over a wide working range by a high tolerance towards fluctuations in the calcium content. Depending on the product and its respective soluble solids content, the desired gelling behaviour can be obtained by selecting the appropriate pectin type.

**Influence of Sugar Types on the Gelation of Low Methylester and Low Methylester Amidated Pectins**

The gelling behaviour of low methylester and low methylester amidated pectins is influenced not only by the sugar concentration but also by the type of sweetener used. The calcium requirement for an optimum gelation of gels is, for example, much higher when sorbitol is used than when sucrose is used. Fructose and glucose lie between the two with regard to their calcium requirement.

<table>
<thead>
<tr>
<th>Sweetening Strength</th>
<th>Calcium Requirement of the Fruit Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>low</td>
</tr>
<tr>
<td>50</td>
<td>low</td>
</tr>
<tr>
<td>110</td>
<td>high</td>
</tr>
<tr>
<td>70</td>
<td>high</td>
</tr>
</tbody>
</table>

Table 2: Influence of sugar types on calcium requirement
An increase in the pH-value results in a higher quantity of charged particles within the gel. In this state the calcium ions also react more with other negatively charged buffering agents whereby the ratio of calcium ions reacting with the pectin decreases. On account of the pH-dependent stronger dissociation of the free carboxyl groups, the pectin chains repel each other more strongly whereby the gel strength also decreases. An increase in the calcium ion concentration again creates more cross linkage between the pectin molecules, thus increasing the gel strength.

The gelling behaviour of low methylester amidated pectins also changes in dependence of the product pH-value. At comparable calcium ion concentrations, the gel strength decreases as the pH-value increases, i.e. as the pH increases, the gels become smoother and the texture more visco-elastic. As the pH-value in the final product rises, the calcium requirement increases. Gels with higher pH-values require more calcium ions to obtain comparatively firm gels than gels of lower pH-values.

Depending on their calcium reactivity, pectins react differently to a change in the product pH-value. Gels with a comparable pH-value, for example, reach higher breaking strengths when reactive low methylester amidated pectins are added than with pectins of a low reactivity. At the same time, the texture of the gels with the more reactive pectin is more elastic when the pH-value is comparable.

In comparable gel preparations, higher setting temperatures are obtained when pectins of high calcium reactivity are added than with pectins of low calcium reactivity. Therefore, especially at lower product pH-values, gel preparations made with reactive pectins have a tendency to pre-gel even with low calcium dosages, whereas pectins of low reactivity show a relatively stable gelation. At higher pH-values (e.g. pH > 3.6) reactive pectins are tolerant towards fluctuations in the calcium content, i.e. products of a stable texture are obtained over a wide range. For the user, stable gelation means high flexibility and product safety.
Influence of Buffering Agents on the Gelation of Low Methylester and Low Methylester Amidated Pectins

Buffering agents and buffering systems, such as sodium citrate or potassium citrate together with citric acid, are used in the production of gels in order to adjust the pH-value in the final product and to obtain a specific taste profile. Fruit inherent buffering ions naturally enter the fruit preparations whenever fruits or fruit pulp are used. The type and concentration of the buffering agents present significantly influence the calcium dosage required for a specific gel strength. An increase in the buffering agents with constant pH-value also requires an increase of the formulation’s calcium dosage in order to obtain a comparable gel strength. The reason for this is, on the one hand, that some buffering agents are able to form stable complexes with calcium, thus withdrawing the calcium from the pectin. On the other hand, negatively charged buffering ions disturb the homogeneous formation of the gel structure. An increased dosage of calcium ions creates more cross linkage between pectin chains, thus encouraging gel formation.

Influence of the Filling Temperature on the Gelation of Low Methylester and Low Methylester Amidated Pectins

The setting temperature of a gel preparation, i.e. the temperature at which the gelation of pectin gels starts during the cooling phase after the heating process has been completed, is an important parameter. At this point, a “sol-gel” transition takes place, i.e. the pectin chains arrange themselves in a three-dimensional network.

The setting temperature determines the filling temperature, depending on whether pre-gelation is to be prevented or is specifically intended.

Pre-gelation always occurs if the filling temperature is below the setting temperature. In this case, a gel network forms even before depositing and is then again destroyed by mechanical stress during the filling process. This results in a partial loss of the overall reachable gel strength and in an increased tendency to syneresis. The filling temperature has an important influence on both the texture and the firmness of the final product.

If a product, e.g. a fruit preparation, is produced and deposited, elastic gels of constantly high gel strengths are obtained as long as the filling temperature exceeds the setting temperature of the respective fruit preparation. If the filling temperature decreases and, finally, drops below the setting temperature, pre-gelation starts and part of the overall reachable gel strength is lost. At the same time, the lower the selected filling temperature, the more the viscosity of the gel texture of the pre-gelled fruit preparation increases.

Fig. 23: Influence of the filling temperature on the gel strength
H&F Pectins for Yoghurt Fruit Preparations

- Selectively Influencing the Texture,
  Flow Behaviour and Mixing Behaviour

Texture, regenerative behaviour and mixing behaviour of yoghurt fruit preparations made with low methylester or low methylester amidated pectins can be influenced very precisely by selecting the appropriate formulation parameters, and especially by adding buffering agents (e.g. calcium salts). This results in fruit preparations which, depending on the customer's requirements, can range from viscous and capable of regenerating to visco-elastic, and which meet the requirements of the respective products (stirred yoghurts, layered products, fruit-corner products).

For use in yoghurt fruit preparations H&F offers low methylester and low methylester amidated pectins, leaving it up to the user to influence the specified properties by adding calcium ions. In addition to this, H&F offers pectins that have already been standardised to a specific flow behaviour with the respective buffering agents, and which are thus able to meet the high demands on yoghurt fruit preparations.
The texture of the fruit preparation is evaluated both with the senses and rheologically by determining the yield point. The regenerative behaviour is described by the percentage regeneration (in relation to the yield point before shearing). The mixing behaviour with the milk product is determined by means of a sensory test.

**Range 1:**
When calcium ions are added to the formulation a weak pectin network develops, rendering the fruit preparation more viscous at first and finally building up a yield point. The value of the yield point increases as the calcium ion concentration increases. In this range, the products are not yet elastically gelled, but are highly viscous and very smooth with a high regenerative capacity.

When the fruit preparation is stirred into the yoghurt, there is a distinct reaction with the calcium ions of the milk product as the added pectin is not yet saturated with the calcium ions.

**Range 2:**
As the calcium ion concentration increases, the fruit preparations become firmer, the yield point further increases and gel formation gradually starts. Products in this range are characterised by their spreadability, glossy texture and high regenerative capacity.

When the fruit preparation is stirred into the yoghurt, no reaction with calcium ions from the milk product can be detected sensorily once a specific minimum calcium dosage ([Ca\(^{2+}\) min.]) is reached. At this point the pectin is saturated under the selected conditions. This range is the preferred working range for yoghurt fruit preparations used in layered products or in fruit-corner products.

**Range 3:**
If the calcium dosage is further increased, elastically gelled gels with a high yield point are obtained. In this range, fruit preparations lose part of their regenerative capacity, as the yield point in the resting phase is partly due to an elastic gelation. This part of the yield point is not able to regenerate as it has been irreversibly destroyed by the shear stress.

**Range 4:**
From a certain calcium dosage onwards, pre-gelation will occur under the selected conditions, rendering the fruit preparations smoother and gradually lowering the yield point. In this range, the texture of the fruit preparations is soft and creamy with low regenerative capacity. A reaction with the calcium ions from the milk product is not to be expected as the amount required for saturation was already exceeded at lower calcium dosages (range 2). Range 4 is the preferred working range for fruit preparations used in stirred yoghurts.

**Range 5:**
With further calcium overdosing, the pre-gelation results in products with a rough, course gel texture, of little regenerative capacity and a strong tendency to syneresis.

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**Fig. 24: Yield point and regeneration (in relation to structure during resting phase) of a yoghurt fruit preparation in dependence of the calcium ion concentration**
With Pectin Classic AY 601, H&F has developed a high methylester apple pectin for application in yoghurt fruit preparations which already contains buffering salts and which is standardised to a specific flow behaviour. Fruit preparations made with Pectin Classic AY 601 have excellent fruit retention properties, as, already during the heating process, a yield point is formed preventing floating. The fruit preparations have a viscous and very regenerative texture and show little tendency to syneresis.

As the pH-value is relatively high (pH approx. 4) and the soluble solids contents are generally below 60% SS, the formulation parameters of most yoghurt fruit preparations are outside the range where high methylester pectins gel best. However, high methylester pectins still have certain advantages in this application. High methylester pectins for example have an extremely low calcium reactivity on account of their degree of esterification, resulting in a low reaction with calcium ions from the milk product.

Pectins have long been recognised as natural gelling and thickening agents in the jam industry and they enjoy a good reputation. When we speak of an economic cost-benefit ratio, the desired quality and the pectin dosage required to achieve it must not be overlooked.

High-quality fruit preparations can be produced with H&F pectins, which are specially standardised to the application “yoghurt fruit preparations”. These pectins guarantee products that fully meet the technological and sensory properties required with regard to texture, flow and regenerative behaviour.

In products requiring less stringent quality standards, other hydrocolloids, such as locust bean gum, xanthan or starch, can be combined with the pectin.

In these combinations, the addition of pectin has specific benefits. Products with a low soluble solids contents have, for example due to their low sugar concentration, a low viscosity and therefore only limited fruit retention properties. Adding a small dosage of pectin renders the fruit preparations, on the one hand, shear-thinning which makes them easy to pump. However, after the fruit preparations have been filled into the containers an adequate viscosity or even a yield point is built up, which significantly delays or prevents the fruit floating. On the other hand, due to the high water binding capacity, the pectin gives the fruit preparations not only a high mouth-feel but also prevents the fruit preparations’ diluting effect after they are mixed with the milk product.

In this application, combining pectin with other hydrocolloids can furthermore be used to obtain very specific rheological properties that cannot be obtained by the use of one of the afore mentioned hydrocolloids alone.
When using H&F pectins for the production of yoghurt fruit preparations the following principles of pectin application must be observed:

- The pectin must be added to the solution under ideal conditions, i.e. at a soluble solids content below 30% SS.
- During the heating process the pH-value must be relatively high (4.0-4.5) so that the pectin dissolves well and any heat-related pectin destabilisation is kept to a minimum.
- The filling temperature must be adjusted to the size of the container in order to avoid heat denaturation in the centre. The selected filling temperature has an influence on the texture of the final product.

H&F Classic Apple Pectins

H&F Classic Apple Pectins for yoghurt fruit preparations have been produced especially for use in high-quality yoghurt fruit preparations and are standardised to meet the high requirements regarding gelling behaviour, texture and flow behaviour.

H&F offers Classic Apple Pectins for yoghurt fruit preparations that enable the user to determine the texture and flow behaviour himself by the addition of calcium salts and, if necessary, other buffering agents, or as “custom-made” Special Pectins which already contain all necessary buffering agents and leave nothing to be desired.

H&F Classic Pectins for Layered Products

H&F offers the Special Pectins Classic AY 601 for a soluble solids range of 30-50% SS and Classic AY 901 for a higher soluble solids range of 50-65% SS. These pectins were designed specially for application in fruit preparations used in layered products or fruit-bottom products combined with yoghurt.

Besides good fruit retention properties, yoghurt fruit preparations made with these pectins have high shear stability, a smooth texture of high regenerative capacity and a yield point and excellent mixing behaviour. The products have little tendency to syneresis and exhibit no post-gelation after the milk product is put on top of the fruit preparation. Use of these Special Pectins facilitates the production of the fruit preparation and guarantees a reliable production process.
Pectins in Yoghurt Fruit Preparations

**Pectin Classic AY 905** is standardised to constant flow behaviour and produces textures of regenerative capacity with high yield points and sufficiently high viscosity. The fruit preparations have good fruit retention properties and can be easily mixed with the milk product without diluting the final product.

**H&F Classic Pectins in Fruit Preparations for Stirred Yoghurt**

H&F offers Special Pectin Classic AY 905 for use in fruit preparations for stirred yoghurt. When this pectin is used, a calcium salt must be added separately in order to control the texture and to adjust the rheological properties. During production of the fruit preparation, the calcium salt dosage is specifically adjusted to the properties intended for the final product.

### Pectin Classic AY 901

<table>
<thead>
<tr>
<th>Product</th>
<th>Pectin Classic AY 901</th>
</tr>
</thead>
<tbody>
<tr>
<td>160g pectin solution 5% (= 0.8%)</td>
<td></td>
</tr>
<tr>
<td>400g fruit</td>
<td></td>
</tr>
<tr>
<td>500g sucrose, crystalline</td>
<td></td>
</tr>
<tr>
<td>x ml sodium citrate solution 10%, to adjust the pH-value</td>
<td></td>
</tr>
<tr>
<td><strong>Net weight:</strong> 1060g</td>
<td><strong>Output weight:</strong> 1000g</td>
</tr>
<tr>
<td><strong>SS content:</strong> 55%</td>
<td><strong>pH-value:</strong> 3.6-3.8</td>
</tr>
</tbody>
</table>

**Manufacturing:**

A Make pectin solution (see “Technical Application Information”).

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

C Add hot pectin solution and decoct to final soluble solids.

D Add sodium citrate solution to adjust the pH.

E Adapt filling temperature to container size.

### Pectin Classic AY 905

<table>
<thead>
<tr>
<th>Product</th>
<th>Pectin Classic AY 905</th>
</tr>
</thead>
<tbody>
<tr>
<td>170g pectin solution 5% (= 0.85%)</td>
<td></td>
</tr>
<tr>
<td>400g fruit</td>
<td></td>
</tr>
<tr>
<td>250g sucrose, crystalline</td>
<td></td>
</tr>
<tr>
<td>230g water</td>
<td></td>
</tr>
<tr>
<td>0.5g tri calcium citrate x 4H2O</td>
<td></td>
</tr>
<tr>
<td>x ml sodium citrate solution 10%, to adjust the pH-value</td>
<td></td>
</tr>
<tr>
<td><strong>Net weight:</strong> 1050g</td>
<td><strong>Output weight:</strong> 1000g</td>
</tr>
<tr>
<td><strong>SS content:</strong> 30%</td>
<td><strong>pH-value:</strong> 3.6-3.8</td>
</tr>
</tbody>
</table>

**Manufacturing:**

A Make pectin solution (see “Technical Application Information”).

B Add fruit, sucrose, calcium citrate and water and heat to approx. 90°C.

C Add hot pectin solution and decoct to final soluble solids.

D Add sodium citrate solution to adjust the pH.

E Adapt filling temperature to container size.
H&F Amid Pectins
Not only H&F Classic Apple Pectins, but also amidated pectins of differing calcium reactivity are used in yoghurt fruit preparations. Here, the user is able to control the texture and flow behaviour by adding calcium and, if applicable, other buffering salts. In addition to these regular amidated citrus pectins, H&F also offers amidated pectins which already contain all necessary buffering agents and which have been specially manufactured and standardised to application in yoghurt fruit preparations.

H&F Amid Pectins for Layered Products and Stirred Yoghurt
H&F offers the special amidated Pectin Amid AY 005-C especially for application in fruit preparations used both in layered products/fruit-bottom products and stirred yoghurt.

This pectin is a low methylester amidated apple pectin already standardised with buffering salts for application in high-quality yoghurt fruit preparations. This special pectin is characterised by a particularly high calcium tolerance and flexibility. Products of a wide soluble solids range can be manufactured by using Pectin Amid AY 005-C. By separate addition of a calcium salt, the texture can be controlled and the rheological properties adjusted. Fruit preparations made with Pectin Amid AY 005-C have a sufficiently high viscosity and a texture with regenerative capacity and yield point. The products have good fruit retention properties and can be stirred easily into the milk product.

On account of the high flexibility of Pectin Amid AY 005-C towards variations in the calcium content, the same formulation can be used for different types of fruit. In order to obtain products with stable properties, the calcium dosage neither needs to be adjusted due to seasonal fluctuations nor due to the differing calcium content of the different fruits.

H&F Amid Pectins in Fruit Preparations for Stirred Yoghurt
The H&F amidated pectins Amid CF 005, Amid CF 010 and Amid CF 020 are unbuffered low methylester amidated citrus pectins of differing calcium reactivities. These pectin types are suitable for use in fruit preparations for stirred yoghurt with soluble solids contents of 10-65%. When these pectins are used, the formulation parameters, such as pH-value and soluble solids content, determine which pectin needs to be selected due to its suitable reactivity level.

It is necessary to add a calcium salt, the dosage of which will be adjusted to the properties required in the final product during the manufacturing of the fruit preparation. Already at relatively low dosages, H&F Amid Pectins form a yield point and develop a sufficiently high viscosity. The fruit preparations have good fruit retention properties and can be easily stirred into the milk product.

When properly selected, low methylester amidated pectins can gel homogeneously and relatively independently of the calcium ion concentration with greatly differing product parameters and will produce the intended texture in the respective final product.

### Dosage Examples

<table>
<thead>
<tr>
<th>Pectin Type</th>
<th>Calcium Reactivity</th>
<th>SS Range</th>
<th>Soluble Solids</th>
<th>Pectin Dosage</th>
<th>Calcium Citrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amid CF 005</td>
<td>low</td>
<td>50-65</td>
<td>55% SS</td>
<td>0.5%</td>
<td>0.02%</td>
</tr>
<tr>
<td>Amid CF 010</td>
<td>medium</td>
<td>30-50</td>
<td>45% SS</td>
<td>0.7%</td>
<td>0.03%</td>
</tr>
<tr>
<td>Amid CF 020</td>
<td>high</td>
<td>10-30</td>
<td>20% SS</td>
<td>0.9%</td>
<td>0.10%</td>
</tr>
</tbody>
</table>

Table 3: Use of H&F Amid Pectins

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**Recipe**

<table>
<thead>
<tr>
<th>Product</th>
<th>Pectin Amid AY 005-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 g pectin solution 5% (= 0.6%)</td>
<td></td>
</tr>
<tr>
<td>400 g fruit</td>
<td></td>
</tr>
<tr>
<td>350 g sucrose, crystalline</td>
<td></td>
</tr>
<tr>
<td>180 g water</td>
<td></td>
</tr>
<tr>
<td>0.3 g tri calcium dicitrate x 4H2O</td>
<td></td>
</tr>
<tr>
<td>x ml sodium citrate solution 10%, to adjust the pH-value</td>
<td></td>
</tr>
<tr>
<td>Net weight: 1050g</td>
<td></td>
</tr>
<tr>
<td>Output weight: 1000g</td>
<td></td>
</tr>
<tr>
<td>SS content: 40%</td>
<td></td>
</tr>
<tr>
<td>pH-value: 3.6-3.8</td>
<td></td>
</tr>
</tbody>
</table>

**Manufacturing:**

A. Make pectin solution (see “Technical Application Information”).
B. Mix fruit, sucrose, calcium citrate and water and heat to approx. 90°C.
C. Add hot pectin solution and decoct to final soluble solids.
D. Add sodium citrate solution to adjust the pH.
E. Adapt filling temperature to container size.

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**Herbstreith & Fox KG Product 43**
H&F apple pectins in particular have the capacity to form elastic gels of relatively high viscous shares. The ratio between elastic and viscous share in a gel of otherwise identical formulation parameters is mostly determined by the degree of esterification of the pectin, its reactivity toward polyvalent ions, the raw material used and the pectin manufacturing process.

The higher the degree of esterification and the higher the ion sensitivity of the pectin, the more predominant the elastic parts in the gel will be. With increasing elastic shares, the product becomes more brittle and therefore more sensitive towards mechanical stress, and the tendency to syneresis increases.

Depending on certain enzyme activities in the raw material and the manufacturing method, the distribution of the free carboxyl groups over the molecule can be block-wise or random. If the free carboxyl groups, on account of the raw material and the gentle manufacturing method, are randomly distributed over the molecule – as is the case with H&F apple pectins – this results in pectins which are able to form visco-elastic gels with comparably high viscous shares.

Yoghurt fruit preparations made with H&F Classic und H&F Amid Pectins distinguish themselves by

- Excellent flow behaviour
- High resistance towards mechanical stress
- Excellent regenerative capacity also after mechanical stress
- Smooth textures with high yield points
- Can be stirred very well into the white mass
- Extremely low tendency to syneresis
- Sufficient viscosity in layered products
- High tolerance towards pH-value and calcium fluctuations in the final product

When yoghurt fruit preparations are manufactured with H&F pectins, the aim is to achieve specific gelling properties that result in products which are easy to process and which have a regenerative, smooth and supple texture with a yield point.

The role of pectin as a gelling agent is to form a network and to bind water. If, during the manufacturing of the gels and their further processing, the water-binding effect is not achieved or is destroyed by mechanical stress, the gel tends to contract and to release liquid – the gel displays syneresis. Syneresis is an undesirable effect that is observed in particular in pre-gelled products where the gel network has already been destroyed by mechanical stress.

Pectins, such as Low Methylester Classic Apple Pectins and Low Methylester Amid Apple Pectins from H&F, to a high degree meet the requirement to prevent the occurrence of syneresis as far as possible. This is possible as these pectins are able to produce special rheological gel properties.

Pectins form visco-elastic gels, whereby the main part is elastic, the smaller part viscous. The higher the viscous portion of the gel, the more resistant the gel is to mechanical stress and the lower its tendency to syneresis.

H&F apple pectins in particular have the capacity to form elastic gels of relatively high viscous shares.
## Overview

<table>
<thead>
<tr>
<th>Pectin</th>
<th>DE° [%]</th>
<th>A° [%]</th>
<th>Standardisation with neutral sugars and composition</th>
<th>Characteristics and properties of the fruit preparations</th>
<th>Main area of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amid CF 005</td>
<td>33-39</td>
<td>11-15</td>
<td>E 440 stable breaking strength, stable gel strength</td>
<td>amidated citrus pectin low calcium reactivity high yield point</td>
<td>fruit preparations for yoghurt (SS 50-65%, pH 3.5-4.0)</td>
</tr>
<tr>
<td>Amid CF 010</td>
<td>31-35</td>
<td>15-19</td>
<td>E 440 stable breaking strength, stable gel strength</td>
<td>amidated citrus pectin medium calcium reactivity high yield point</td>
<td>fruit preparations for yoghurt (SS 30-50%, pH 3.5-4.0)</td>
</tr>
<tr>
<td>Amid CF 020</td>
<td>28-31</td>
<td>19-22</td>
<td>E 440 stable breaking strength, stable gel strength</td>
<td>amidated citrus pectin high calcium reactivity high yield point</td>
<td>fruit preparations for yoghurt (SS 10-30%, pH 3.5-4.0)</td>
</tr>
<tr>
<td>Amid AY 005-C</td>
<td>34-39</td>
<td>6-10</td>
<td>E 440, E 331, E 340 stable gel strength</td>
<td>amidated apple pectin high calcium tolerance</td>
<td>fruit preparations for yoghurt, yoghurt drinks (SS 10-60%, pH 3.5-4.0)</td>
</tr>
<tr>
<td>Classic AY 901</td>
<td>41-48</td>
<td>-</td>
<td>E 440, E 341 stable flow behaviour stable calcium reactivity</td>
<td>apple pectin low calcium reactivity, able to regenerate calcium needs to be added with low SS</td>
<td>fruit preparations for layered products (SS 45-65%, pH 3.5-4.0)</td>
</tr>
<tr>
<td>Classic AY 905</td>
<td>34-37</td>
<td>-</td>
<td>E 440 stable calcium reactivity, stable flow behaviour</td>
<td>apple pectin able to regenerate, high yield point calcium needs to be added with low SS</td>
<td>fruit preparations for stirred yoghurts (SS 20-50%, pH 3.6-4.0)</td>
</tr>
<tr>
<td>Classic AY 601</td>
<td>52-57</td>
<td>-</td>
<td>E 440, E 333 stable flow behaviour</td>
<td>apple pectin able to regenerate high viscosity, very smooth texture calcium needs to be added with low SS</td>
<td>fruit preparations for layered products (SS 30-50%, pH 3.2-4.0)</td>
</tr>
<tr>
<td>Classic AM 901</td>
<td>38-44</td>
<td>-</td>
<td>E 440 stable calcium reactivity, stable flow behaviour</td>
<td>apple pectin low calcium reactivity</td>
<td>fruit preparations with multi-purpose functions (yoghurt fruit preparation increases the viscosity of the fruit yoghurt)</td>
</tr>
</tbody>
</table>