Handbook on preserves

Diverse and useful information on semi- and fully preserved products

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Publisher: Matis ohf
Editor: Páll Gunnar Pálsson
Translation: Margeir Gissurarson

Preface

Currently, there are more canning factories operating in Iceland than has been for many years and therefore, it is important to have a good and accessible educational material for those who work or intend to work in the industry.

Preserves can be divided into two main categories. Fully-preserves are products that are packed into hermetically sealed containers and heated at high temperature, which gives the product a long shelf life, i.e. canning and semi-preserves that are chilled products and preserved with pasteurization, acid, salt and/or preservatives. Preserves are in most cases ready to eat products and therefore number of things needs to be considered during their processing to secure a safe and wholesome product.

Semi- and fully-preserved products are in many respects technically complex and good understanding of the importance of each processing step is necessary to secure the safety of the consumers.

Domestic small-scale food production of various kinds around the country has increased significantly and often, there are products that fall into this category of foods, called preserves. It is very important that materials will be made available in Icelandic and other languages regarding canning, thermal processing, preservation and packing food into hermetically sealed containers like cans, glass and plastics.

Preserves are very diverse as can be understood from the above and in this guide the main issues regarding semi- and fully preserved food will be covered. Cans closure is discussed in detail as it is a key item in the production of safe canned food.

Páll Gunnar Pálsson (left), a food scientist, compiled texts, drew diagrams and set up the handbook, but Einar Þór Lárusson (right), an expert at Ora was very helpful to convey his great experience and knowledge in the making of the book.

The handbook on preserves was financed by Matis, with support from the AVS research fund

The handbook on preserves was financed by Matis ohf., with support from:

AVS rannsóknasjóður í sjávarútvegi

The handbook was translated with support from:

Landsmennt

starfsafl

Samband stjórnendafélaga

The following companies also supported the translation of the hansbook:

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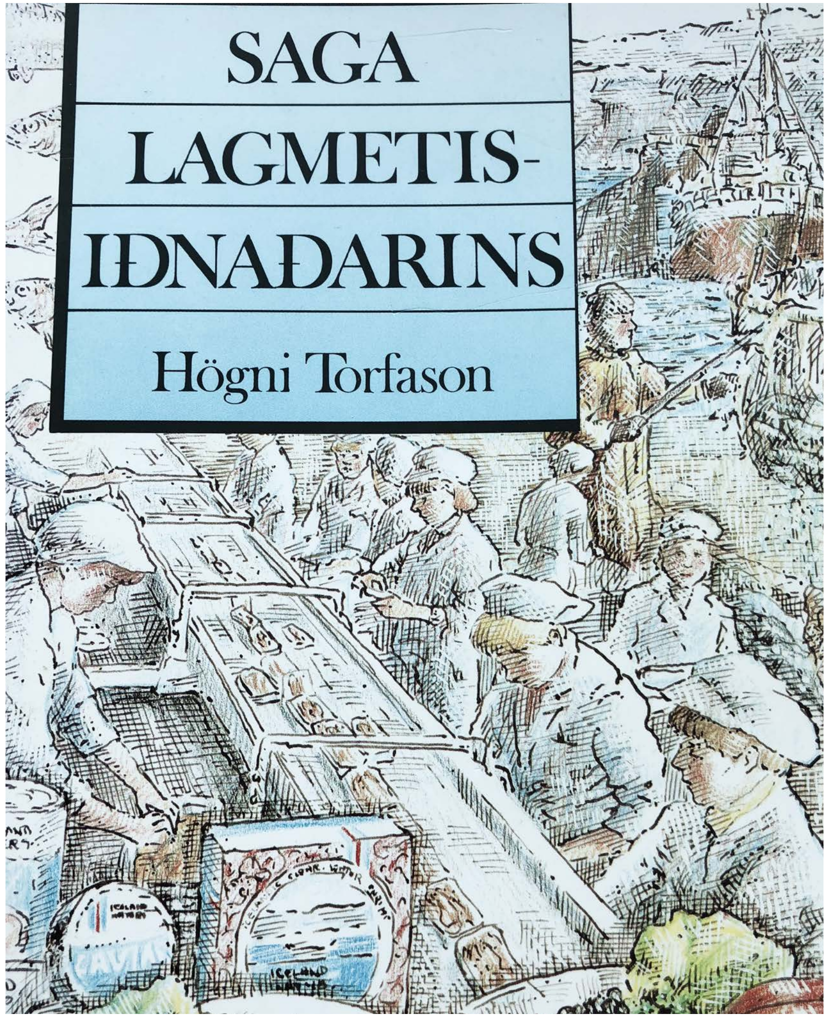
Few historical words

Food storage was and is a challenging task. In the past, it was primarily drying, salting and pickling that prevented food from spoiling. These were methods that were only learned from experience and that knowledge was inherited between generations. Households were like small food companies where life was all about obtaining and preparing enough food to survive.

After major changes in Europe and the French Revolution in 1789, many European countries were in a protracted war and the French were very prominent in these wars. Large armies arriving in unfamiliar areas could have difficulty with supplies that could have devastating consequences.

In 1795, the French government promised 12,000 francs to anyone who could come up with a cost-effective way to store food. And fourteen years later or in 1809, Nicholas Appert, a confectioner, managed to store some foods in glass bottles that had been placed into boiling water.

Generally, Appert is thought to be the inventor of canning, although there are sources saying that L. Spallanzani, an Italian, had before coincidentally in 1765 achieved similar results, but Appert received the award from the French state for his discovery



Appert had no idea what was going on and he could not clearly explain why the food did not spoil. For his support it is worth mentioning that at this time the knowledge in chemistry was limited and microbiology was not known.

Half a century later, or about 1860, a better understanding on food spoilage was gained when Pasteur revealed the results from his study in microbiology.

Soon after Appert's method became known the development of the canning industry started. As early as 1810, a patent was issued where metal cans were used instead of glass.

At first, the cans were closed by welding the cover onto the can, which was a slow process. Therefore, the production of canned products were very slow and consequently canned products became an expensive commodity. Main customers in the first years were the British army and various explorers of that time.

A major development and mechanization took place at the end of the 19th century and in 1888,

Here you can see a selection of preserved products at the Herring Museum in Siglufjörður, the author of this handbook worked on producing "kippers snacks "in the 1980s, but you can see seven" kippers snacks "- cans in this picture

Max Ams discovered a can closure, where welding of the lid was not needed. This closure is what is known today and is called the double seam.

With this new closing method, the performance increased, costs decreased, and the canning industry grew rapidly throughout the world. All kinds of foods were canned, and this storage method increased the supply of safe and healthy foods. But the hazards related to this production method was limited at that time so accidents due to lack of knowledge were quite frequent.

The beginning of canning in Iceland can be traced back to 1858 when a Scottish man, James Ritchie, arrived in the country and began canning salmon. He pursued this operation for about two decades at the junction of Hvítá and Grímsá in Borgarfjörður. Working with him was a young man from the area, Andrés Fjeldsted, who among other things, provided him with the raw material. Ritchie also set up a small factory in Akranes where he canned fish, mainly haddock.

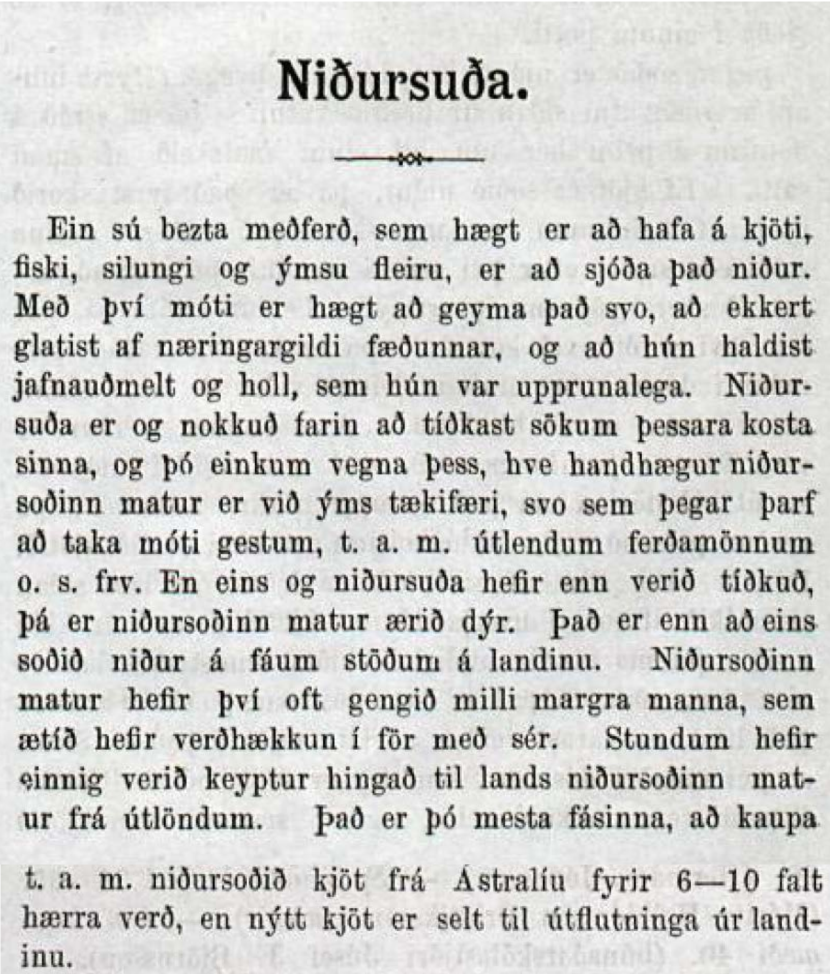
Ritchie´s business went under when English people started exporting iced salmon as they were able to pay higher prices for the raw material.

It was then in 1906 that the entrepreneur Pétur M. Bjarnason founded the Icelandic Canning factory (Niðursuðuverksmiðja Íslands) in Isafjordur, this factory was well equipped and at one time about 50-60 people worked on canning seafood. The business did well in the first few years but then the warehouse burned in 1912 and the company experienced some problems and Peter moved south and started another type of business.

Almost 30 years past until another factory started operation, the Ísafjordur shrimp company (Rækjuverksmiðja Ísafjarðar), which started in 1936, and since then canning has been ongoing in Iceland.

Factories were set up all over the country. A canning factory was set up in Bíldudalur, Sales Association of Icelandic Fish Producers (SIF) set up a factory in Reykjavik and another small one in Vestmannaeyjar.

Then came the canning plant ORA, which still operates, the Hekla canning factory in Akranes was founded by the brothers Haraldur Bödvarsson and Sturlaugur in 1940. K.Jónsson & Co was founded in Akureyri 1947 by Kristján Jónsson and then came more factories that were often backed up by state and municipalities to promote employment levels and value across the country.


Niðursuða.

Ein sú bezta meðferð, sem hægt er að hafa á kjöti, fiski, silungi og ýmsu fleiru, er að sjóða það niður. Með því móti er hægt að geyma það svo, að ekkert glatist af næringargildi fæðunnar, og að hún haldist jafnauðmelt og holl, sem hún var upprunalega. Niðursuða er og nokkuð farin að tíðkast sökum þessara kosta sinna, og þó einkum vegna þess, hve handhægur niðursoðinn matur er við ýms tækifæri, svo sem þegar þarf að taka móti gestum, t. a. m. útlendum ferðamönnum o. s. frv. En eins og niðursuða hefir enn verið tíðkuð, þá er niðursoðinn matur ærið dýr. Það er enn að eins soðið niður á fáum stöðum á landinu. Niðursoðinn matur hefir því oft gengið milli margra manna, sem ætíð hefir verðhækkun í för með sér. Stundum hefir einnig verið keyptur hingað til lands niðursoðinn matur frá útlöndum. Það er þó mesta fásinna, að kaupa t. a. m. niðursoðið kjöt frá Ástralíu fyrir 6—10 falt hærra verð, en nýtt kjöt er selt til útflutninga úr landinu.

Above is part of an article in the "Búnaðarrit" from 1887, these are probably the oldest home canning instructions in this country, but the entire article can be accessed at www.timarit.is

Samhentir - Kassagerð ehf. sponsored the English translation of this handbook.

Microorganisms and preserves

It is necessary to have some knowledge on microbiology when discussing semi- and fully-preserved food.

The theory of canning started with the Frenchman Nicholas Appert when he conducted an experiment by placing some food into glass bottles, closing them with a cork and placing the bottles into a boiling water. Appert published his findings in 1810 showing that the food could be stored longer without spoiling. He however could not explain why, though he imagined that the heat had something to do with it. But he also thought that the vacuum inside the bottle could be the main cause.

It wasn't until 50 years later that Louis Pasteur demonstrated that microorganisms are responsible for fermentation and decay of food. Pasteurization is a mild heating method and named after Louis Pasteur.

Despite this discovery and knowledge that Pasteur introduced, the canners were unable to link this knowledge to what they were doing, because many of them believed "The vacuum" was the key to success.

It was then in 1895 that the Massachusetts Institute of Technology demonstrated that microorganisms were always the culprit if canned food was spoiled and it happened usually when the heat applied was inadequate.

Today it is clear to everyone that the food raw material is full of microorganisms, which ultimately spoils the food if not properly handled. Retaining the quality and safety of food is a fight against microorganisms, and it is necessary to know them and know what is required, in order to stop or slow down their progression.

The microorganisms that are most pronounced in this context are molds, yeasts and bacteria. What matters mostly is to know their nutritional requirements and what compound they generate when they break down the food. Finally, it is necessary to recognize the tolerances of the microorganisms towards oxygen, heat, moisture and various preservatives.

Photo: Páll Gunnar Pálsson

Canned soft roes.

Some of the products of the company Ora has become the "national treasure" in Iceland

Useful microorganisms

Many of the thousands of species of microorganisms, found in food, are extremely useful and lay the groundwork for or participate in producing many of our most important foods such as bread, cheese, yogurts, wine, beer and much more. Also, microorganisms are involved in production of enzymes and drugs, such as antibiotics.

The microorganisms also break down organic matter and alter them into nutrition and soil, which will be accessible for the greens that are consumed by animals and humans, so in short there will be no life without microorganisms.

Diseases

There are relatively few species of microorganisms that cause diseases and are carried between humans or from animals to humans, but these diseases can be very serious. Some microorganisms can be in the food and infect people when the food is consumed.

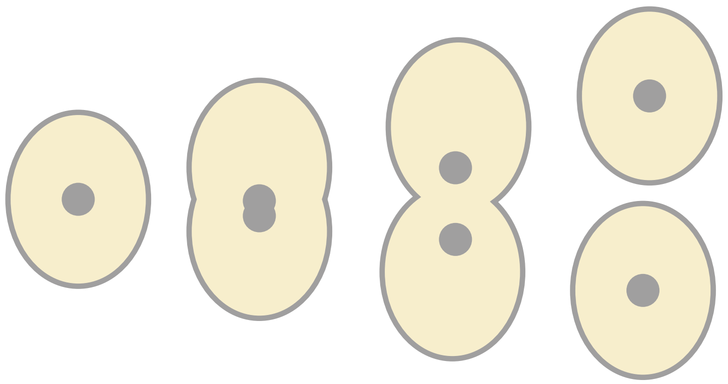
It is important, therefore, to understand how these microorganisms behave to prevent possible food infection and/or poisoning.

When it comes to microorganisms and preserves, it is the bacteria that are primarily important in terms of the safety of these products, but the mold and yeasts are not playing a major role in this context. Bacteria can in themselves be harmless, but when they break down the food, they can in some cases generate toxins.

Bacteria are small organisms and can only be seen in a potent microscope and when examined, their shape varies. The most frequently observed in preserves are sphere while others are rod shaped or spiral.

Bacteria reproduces by division, i.e. the bacterium expands until it is double in size and then forms a cell wall in the middle and one bacterium becomes two.

In the best growth conditions of bacteria, this partition only takes about 20 minutes so that one bacterium has become four by 40 minutes and after two hours, 64 bacteria are formed. But



Cell division, this process takes only 20 minutes in favorable conditions

after 15 hours the first bacteria have one billion i.e. thousands of millions of descendants that are exactly the same as the first one.

If a plant's conveyor belt has 75,000 bacteria per 10 cm^2 surface, then the same surface will have 300,000 bacteria after one hour and after three hours the number has become 4.8 million.

Fortunately, microorganisms cannot be reproduced indefinitely, as they may run out of nutrients and as they multiply, they will produce waste material that limits the growth potential, because they cannot survive on their own waste.

Over time, the bacteria die when the conditions become unfavorable, but the species that can form endospores can leave behind descendants in hibernation, which can later grow if conditions become favorable again.

It is important to bear in mind that bacteria can generally not travel between places of their own, they need assistance or infection routes. Here hygiene, cleaning and good housekeeping is of main importance and of course everything related to good manufacturing practices.

Bacteria can be divided into two groups based on their ability to form spores. In fact, no spherical and most rod-shaped bacteria cannot form spores. That just said some rod-shaped bacteria can form spores and are called spore forming bacteria.

Spores are a kind of bacterium in hibernation or "seeds", which can become an active bacterium when conditions permit, but spores can survive a much more hostile environment than bacteria

Spores are resistant to heating, cooling and various substances, such as some disinfectants, without being damaged, some spores tolerate boiling water for more than 16 hours while the parent bacterium does not tolerate such treatment.

Soil and water are the environment in which most bacteria and spores come from.

Conditions affecting bacteria

It is important to know what it is in the environment that prevents the reproduction and the

In Iceland, shrimp was canned in considerable quantities. Examples of packaging owned by Einar Lárusson.

Caviar is preserved with, salt, preservatives, and mild heating i.e. a pasteurizaton (72°C) and therefore needs to be kept in a refrigerator. Examples of packaging owned by Einar Lárusson.

presence of different bacteria. All microorganisms require a nutrition, which usually are plenty of in all types of food.

Moisture is important to bacteria, because the nutrients must be dissolved to enter through the cell walls of the bacteria, but they have no mouth to minimize the food nor a digestive tract to break it into even smaller units.

There are bacteria that produce enzymes to break down large nutritional molecules, such as proteins, carbohydrates and fats and thus form resolvable nutrients, which they can take through the cell wall.

Some bacteria need oxygen to thrive while others do not thrive unless there is no oxygen present. However, most microorganisms are not completely either or, with or against oxygen, but can completely accept a certain variation in oxygen levels.

Most species of bacteria have their preferred temperature to thrive and grow, usually this is a definite temperature range that is suitable, and the bacteria are divided into four different groups in terms of this.

Cold loving bacteria (Psychrophilic) grow best at 14-20°C and may even grow in a refrigerator at 4°C, no bacteria in this group cause concern in canning except Clostridium botulinum Type E.

Cold tolerant bacteria (Psychrotrophic) are those called that grow best at 25-30°C

Moderate temperature bacteria (Mesophilic) enjoy their best at 30-37°C and this group contains most of the bacteria worth worrying about related to food safety. For example, the spore forming bacterium Clostridium botulinum belongs to this group.

Heat loving bacteria (Thermophilic) are found everywhere in the environment such as in soil and even in bubbling geysers. These are all spore forming bacteria that can be divided into groups depending upon the temperature of sporulation and the bacteria growth.

Some of this heat-resistant bacteria can grow to up to 77°C and experiments have shown that spores of these bacteria´s can survive heating for 60 minutes at 121°C. Heat resistant bacteria do not form toxins and therefore do not directly affect the safety of food.

Spoilage caused by bacteria

Most bacteria form gas when they grow in sealed cans or jars and the container swell due to increased pressure. There is however an exception in the spore forming bacteria that produce acid and make the contents acidic without generating gas. The cans therefore do not swell, but the contents spoils and is not good for consumption, although it is not directly hazardous to human health.

When a container is swollen, it is an obvious sign that bacteria can be present and are breaking down the contents as soon as they form gas. Consumers are advised not to use the contents of swollen cans even though the inflammation can have other explanations than bacterial growth.

Appearance and smell may indicate that the contents of the cans are not okay so not to mention if the content is more and less dissolved and the liquid that is to be clear has become cloudy, etc. Bacterial growth in sealed cans or jars may occur due to:

1. Spoilage started before heating
2. Contamination after heating (leaking containers)
3. Inadequate heating
4. Growth of heat-resistant microorganisms

When stripe like these are seen on the cans, it may indicate seam leakage and/or increased pressure in the cans due to growth of microorganisms.

1. Spoilage that have started before heating is primarily due to that closed and filled containers have been stored for too long before heating.

Bacteria that are present in the product can begin to form gas if the temperature is favorable and the under pressure in the cans can change to overpressure and cause an increased load on the can seam when heated and that load can later cause leakage of the seam. Therefore, a minimum waiting time should be secured between closing and heating.

2. Bacteria can penetrate leaking containers after heating and the containers can swell shortly after production. Cans swelling can also be visible considerably later, even after many weeks.

Leakage is usually caused by defects in closures and damaged containers. Clearly, there is a tremendous emphasis on preventing leaking containers and container closures. Preventive controls will be covered in the next chapters.

3. Insufficient heating can have serious consequences. The heating process is designed to eliminate all microorganism that can cause health hazards as well as all other microorganisms.

If the heating process is not to eliminating Clostridium botulinum, then the health of

Canned, ready-to-eat product in glass jars.

consumers might be compromised. The heating may be incomplete if the time and temperature profile for a given product is not according to what is needed or if the heating process is not implemented as requested.

4. The higher the growth temperature is for spore forming bacteria, the higher is the heat tolerance of their spores. The spores of heat tolerant bacteria can survive a heat treatment that is aimed for spores of mesophilic bacteria.

If the intention is to store a product at a temperature higher than 25°C, the heat treatment should aim at killing the spores of the most heat resistant bacteria.

In warm countries where temperatures can be considerably higher than 25°C, much higher heating is required to allow storage temperatures of up to 40°C. The highly thermotolerant microorganisms, such as *Bacillus stearothermophilus*, usually tolerate the canning treatment but do not grow if the temperature is below 25°C, but if the heat goes above that, such heat-resistant microorganisms can start to grow and cause problems.

Botulism

One of the mesophilic spoilage bacteria that can cause serious health problems to humans is *Clostridium botulinum*.

This bacterium is of great concern and especially in home-canning but also in all canning factories, because it produces a fatal poison and the bacteria is found in soil and water all around the world.

These harmful bacteria only grow at anaerobic conditions, where there is no oxygen precent and it can form very resistant spores that can tolerate unfavorable conditions such as heating and some chemical disinfection. The spores can sporulate and start growing when conditions become favourable.

The term "botulinum" comes from Latin and mean sausage, but this bacterium was first detected in sausage and the disease caused by the toxin it produces is called botulism.

Cl. botulinum grows preferentially at 30-37°C although growth can occur down to 4°C. There are a several types or strains of *Cl. botulinum* and they are divided by the letters A, B, C, D, E, F, and G, but these types form different toxins and that is the reason for this classification.

The types C, D, and G are usually not linked to Botulism in humans. Types E and F are usually found in sea and sea food products, but type E can grow at lower temperatures than the others or down to 4°C but heating to 80°C will kill the bacteria.

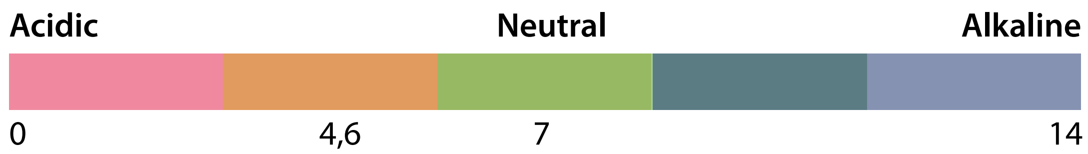
Since spores of *Cl. botulinum* are found everywhere, all foods can be contaminated with such spores, but only the living bacteria cell can form the toxin.

Spores of type A are very thermotolerant and the same applies to most spores of type B that can tolerate 5 to 10 hours in boiling water, but the toxin itself does not tolerate heating and can be inactivated by boiling for few minutes.

Acidic or alkaline, the effect of acidity on bacteria growth.

pH is a measure of how acidic or alkaline foods are. The pH scale ranges from 0 to 14 and foods with pH 7 are neutral; i.e. neither acidic nor alkaline.

pH scale



Acidity or pH is often to confuse those that do not recognize this unit of measurement, where low acidity means highly acidic and high acidity means little acidic or alkaline.

Most foods lie in the range of pH 3 and up to approximately pH 7.

Those foods that have a pH below 4.6 are called acidic while those with an acidity range of 4.6 to 7 are called slightly acidic . It is necessary to have knowledge about the acidity of food when taking decisions on preservative methods, storage conditions or shelf life.

The acid of food decides what kind of bacteria can grow in the food and the acid indicates precisely whether *Cl. botulinum* can grow and form toxins.

Heating above 70°C for a given time will kill all pathogenic bacteria and most bacteria in general, in both high- and low acid food. In high acid food the spores of *Cl. botulinum* cannot sporulate, but in low acid food the spores can germinate and the bacteria can start to grow if the heat treatment is not sufficient or at a temperature considerably higher than 100°C.

This means that high acid foods do not require as much heating, as the acid prevents the germination of the spores of Cl. botulinum. All spoilage bacteria and those that can be pathogenic are killed by relatively mild heating.

The fact that spores of Cl. botulinum cannot germinate at a pH below 4.6 is utilized in many foods and especially those that are sensitive to high temperatures, like brussels sprouts, artichokes, onions and broccoli.

When these foods are acidified to below pH 4.6, then only a mild heat treatment is needed to kill molds, yeasts and bacteria. The spores may remain present but they cannot germinate and change into the cell form of the bacteria that forms the toxin.

But it must be closely monitored and ensured that the acid level is below pH 4.6 and that no changes at later stages can cause the spores of *Cl. botulinum* to germinate. It must be kept in mind that acidity of food can change during storage.

Drying and water activity

For thousands of years, fruit, meat, fish and vegetables have been dried to prevent food spoilage. It was and still is known that adding sugar prevents spoilage as in jams and candy and salt was and is used to preserve meat and fish.

Up until 1940, microbiologists believed that the water content of the food was what controlled possible bacteria growth, but eventually it was realized that the availability of water was more important.

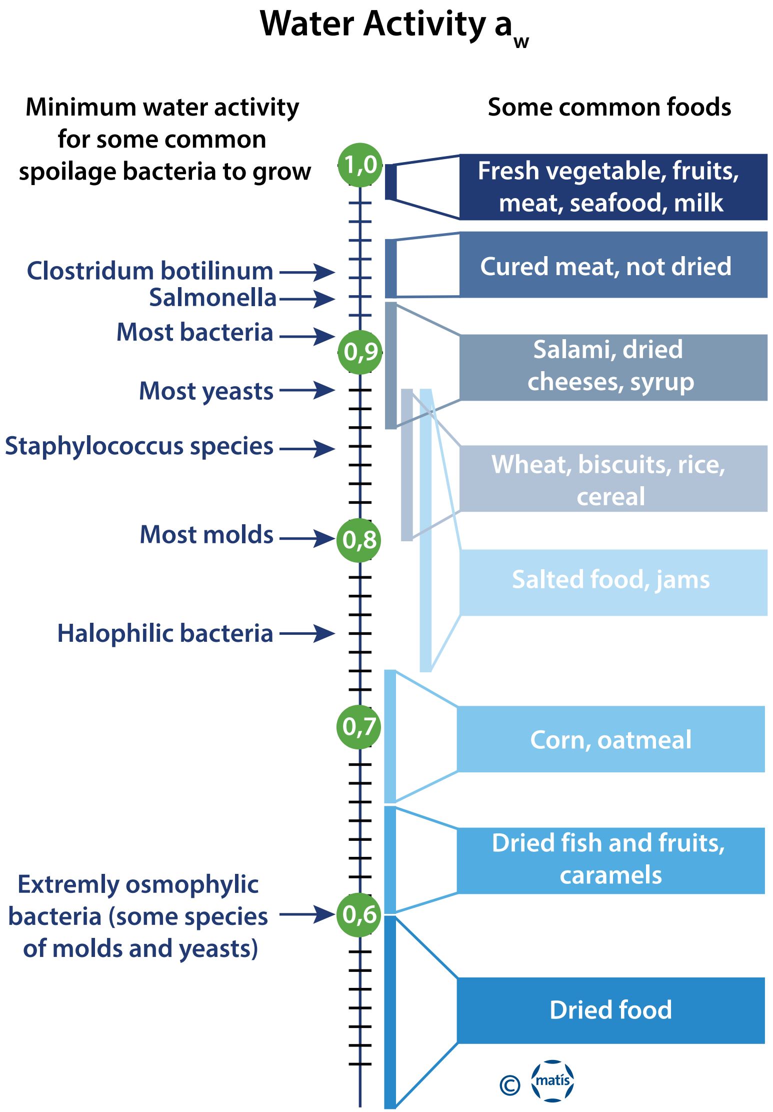
This is what is called the water activity (a_w) and is defined as the ratio between partial vapor pressure of water of a solution, which is in equilibrium with water in food, and the partial vapor pressure over pure water at the same temperature. The water activity has a value from 0 to 1.

It has a major effect on the water activity if there are many chemicals present that bind the water and make it inaccessible for the microorganisms, such substances are, for example, sugar and salt. Most foods have water activity of 0.96 to 0.99 and most bacteria, yeasts and mold grow in such an environment.

Spores of *Cl. botulinum* cannot usually germinate if the water activity is below 0.93. If the water content of the food is increased and the water activity goes above this limit, then spores can germinate. The bacteria cells that will come to live can be killed by mild heat treatment and in that way protect foods that cannot tolerate high heat treatment. Examples of such foods are peanut butter, syrup, jam, jelly and various types of candies.

If the water activity is greater than 0.85 and the pH higher than 4.6, then heat treatment must be high enough to secure the destruction of *Cl. botulinum* spores. If the water activity is lower than 0.85, such heat treatment is not necessary no matter what the pH is.

When water activity and mild heating such as



The water activity of food affects the potential growth of microorganisms pasteurization is used to preserve food in sealed containers, then the water activity must be below 0.85, which is considerably lower than 0.93, which are the actual limits for the germination of spores of *Cl. botulinum*.

The reason for setting the water activity so much lower is to increase the safety of the food, as a considerable uncertainty may exist when the water activity is measured.

Salting and water activity

Salting is known process in Iceland and salted products was earlier one of the country main foreign income where salted cod and salted herring played the main role.

Salting of meat and fish lowers the water activity and makes it difficult for bacteria to grow, but sometimes extra preservatives are added as in some meat products and salted herring.

This is to prevent spore forming bacteria, such as *Cl. botulinum* from being able to grow and that the spores can germinate. It is known that some strains of *Cl. botulinum* can grow at 7% salt concentration but if the concentration goes to 10%, responding to water activity of 0.93, then the growth stops. Although growth can occur at 7% salt, it has not been demonstrated that toxin will form at that concentration.

Spoilage without the aid of microorganisms

Bacteria is most often responsible for spoilage of preserves. Nevertheless, there are incidents where bacteria are not involved.

A chemical reaction between food in cans and substances in the inner surface may generate hydrogen (gas compound). This hydrogen generation can cause the cans to swell without the contents being in any manner dangerous, but as the consumer cannot differentiate between swollen cans due to bacteria or hydrogen formation, the only logical thing is not to consume the content of swollen cans.

A chemical reaction of acid in the food and the surface of metal containers, can cause formation of tiny holes, which bacteria can penetrate and cause spoilage of the content.

Cans can also swell if the ingredient in the can is more than its capacity.

When cans are closed without vacuum it may look as they are partly swollen when taken for a mountain climb where the air pressure is lower.

Photo: Páll Gunnar Pálsson

All cans are coated on the inside with a chemical that prevents the content for corroding the metal. The materials used should meet strict criteria for substances that may be in contact with foods. In the combined three-piece cans where the body is welded together the joint is coated to prevent the metal from coming into contact with the content.

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Saltkaup ehf sponsored the English translation of this handbook.

Variety of packaging materials available

The role of packaging is multifaceted, but primarily the food is being protected from the external environment, damage and dirt, but packaging also retains the food and make it possible to transfer the food between places. Labelling such as the ingredients, nutrient information and instructions for storage and use is also an important role of package.

Convenience, usability, traceability information, sustainability, re-use and potential recycling is more important now than ever.

Packaging must protect and keep the food safely and economically for the producer and the consumer and now no one can avoid considering environmental issues.

Food packaging can influence the shelf life, quality and safety of food as packaging prevents chemical contamination from the environment, microbial contamination and can also protect the contents from rough handling.

Many packaging materials protect the food from chemical contamination from the environment, but this contamination can, for example, just be the atmosphere, mainly oxygen. Packaging can also prevent water loss or water absorption of the food.

Packaging may also be useful in protecting

There is a large variety of packaging available for preserved products, here you can see, for example, a vacuum packed plastic bag with a cardboard card for cured salmon, plastic containers for a sauce and glass jars for herring in sauce.

Glass jars may be well suited for small batches, here is "gourmet mustard" in jars.

sensitive foods from different waves of light, which can negatively affect the food, such as its colour and nutritional value.

Glass and metal almost eliminate all chemical contamination, however, there may be some weaknesses linked to the closure, if for example, stoppers or covers are made of plastic.

Many forms of plastic packaging possess the properties of mostly preventing external chemical contamination but not like glass and metal.

Organic pollution caused by microorganisms, insects, pests and other animals can result in food spoilage and can cause food-born illnesses.

Prevention of rough handling in transport or distribution is very important as many foods cannot tolerate harsh treatment.

Packaging plays an important role in bringing food products undamaged through the entire value chain. Smartly designed packaging can decrease food waste considerably at all levels of the food chain, but studies have shown that food waste can run at very large numbers in quantity and value.

Packaging can be a valuable and important marketing tool, as well-designed packaging allure buyers and clear information about the product increases credibility.

Acts and regulations set out the labelling requirements and the packaging come into good use to illustrate the correct information about the contents and other things that may be associated

Packaging plays an important role when messages and information must be brought to the consumer attention. These glasses, in addition have prominent seals.

with traceability and sustainability markings.

Comfort and usability of packaging should not be forgotten, sometimes it is suitable to have a packaging that allows the content to be seen or not seen at all, It is convenient if the packaging can, for example, go into a microwave, regular oven or into boiling water.

It is important to secure that it will be noticed if the packaging has been opened before it reaches the consumer, and there are many variations of so-called seals, which must be broken before the packaging is opened.

Glass packaging

Glass has been used for centuries and there is historical knowledge on use of glass as a packaging for foods.

Glass is odourless and does not infect the food contained in glass containers and, in the same way, the glass will not be affected by the food, and it is not

Glass jars on their way to filling.

important if it is very acidic or fatty. As a packaging material, glass is very good. Odour and moisture do not penetrate through glass and it can thereby maintain the freshness and the characteristics of the food for a long time.

Glass is heat tolerable and can therefore easily be used for canned and pasteurized products. Glass is also relatively strong, insulates well and can be produced in different sizes, colours and shapes.

Finally, the glass can be reusable or recycled, which is very positive.

Glass still has a few negative aspects, because despite of experiments in using thinner glass, the glass is proportionally a heavy packaging and therefore increase transport costs.

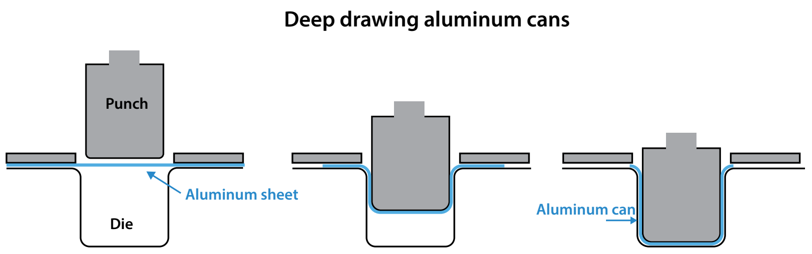
Then it should be mentioned that glass can break if handled improperly and heat strains or sudden heat changes cause breakage.

Metal packaging

Metals are in many ways a good packaging material and protect the food for damaging and external contamination. It is relatively easy to form metals into various shaped containers and it is also possible print images and text directly on the metal. The most common metals used in packaging are aluminium and steel which makes these packaging useful for recycling.

It is common to use aluminium to produce cans, films, and aluminium can also be found as a film on cardboard or plastic packaging. Aluminium is very good when it comes to keeping moisture, air, odour, light and microorganisms from food as well

It is possible to print images and text directly on metal



Aluminium cans are formed from aluminium plates, where the punch presses the material into forms.

as being very flexible and easy to shape into all kinds of packaging.

The aluminium is easy to recycle, but it is rather expensive to produce aluminium and therefore recycling should be encouraged.

Aluminium cans are usually one piece, the body is formed from a thin aluminium sheet by pushing the plate with a plunger into a form. It is quite common that the cans are made conical, so that empty cans can be stacked into each other, thus saving considerable space in transport of empty containers.

Aluminium cans are always so-called two-piece cans, that is a one piece can and a cover.

Steel is also used and then usually coated on both sides with a thin layer of tin to prevent corrosion. If this material is to be used in packaging for foods, then it is necessary to varnish the side that touches the food with approved chemicals. The steel protects the food in the same way as the aluminium, but it is generally cheaper and also suitable for recycling.

Steel cans are mostly common as three-piece cans, where a cylinder is formed and welded

Side by side the three-piece steel can (to left) and a two-piece aluminium can (to right). On the steel can it can be seen how the cylinder is welded together, dark line on the can body.

together, the can manufacturer then closes the bottom with a cover in a similar way as the canning factory close the top with a cover after the can has been filled.

Plastic packaging

There are numerous types of plastics and over 30 types of plastics are used for food but mostly used are plastics that are named polyolefin and polyester. The main materials in the Polyolefin group are

Smoked salmon laid on a cardboard card before the plastic bag is vacuumed.

polyethylene (PE) and polypropylene (PP) and then there are several variations of these materials that have different properties and usability. In the group of polyester is the so-called PET packaging.

Many more plastic types can be mentioned that are used as packaging material for food and in addition different plastic types are mixed to receive some special properties.

Generally, plastics have many positive properties

So-called "squeezes" have largely taken over the market for canned baby food in jars. These plastic sacks can tolerate canning and now you can find nutritious food for all age groups in this suitable package.

when it comes to packaging and what encourage the use of plastic material is that it is considerable inexpensive and easy to use.

Although many types of plastics can be recycled in an easy manner, it can be said that the amount of plastics in use is very inflictive for the environment since it is not all returned for recycling or reuse.

Paper packaging

It is possible to produce paper in a variety of ways that gives different properties, but in general paper alone is not a particularly good protection for foods and is also not used to protect food for a long time.

If a paper is used to protect food, it is often specially treated, coated, for example, with wax, varnish or plasticizers and quite often to embed plastic or metal film to the inner board of the paper.

But the importance of paper should not be forgotten when it comes to outer packaging like cartons and boxes

When it comes to the choice of packaging for foods, there is a lot to consider as has been mentioned, and lately environmental issues have received far more weight regarding this aspect of the food production.

Packaging material is a huge problem when it comes to waste from industry and homes. Many recent years, packaging manufacturers have been finding ways to produce environmentally friendly packaging, as well as reducing them by producing thinner and lighter material.

It is important to choose packaging that may be reused in some ways and likewise the possibilities for recycling should be considered. The future demands that the impact of food packaging will not be negative for the environment and that packaging will no longer be rubbish but a valuable that can be exploited in a sustainable way.

Additives

Additives are substances of various types that are enhanced or added to foods in order to affect, for example, shelf life, colour, smell and taste. It is not uncommon for preserved products to contain various additives. The chemical flora is diverse and in all instances the intention is to affect the different properties of the food and including the environment of the microorganisms that may be present.

It is emphasized that additives cannot be used in foods unless authorized for a specific food. All additives must be approved and verified in various ways before allowed for use in foods. Once additives have been approved it receives a definite E-number, whereas E stands for Europe, and these numbers can be used in the ingredient list for the product.

Depending on the food, the ingredients and the quantities used can vary and in some foods the use of additives are very limited, as in e.g. fresh raw meat or fish, while other more processed foods may contain a variety of additives. It may be noted that some additives can be used in many different foods, while other additives can only be used in few foods or individual products.

It is obvious that the diversity is great when it comes to additives for foods and therefore it is not possible to dive into a long list of chemicals in this forum or their use in different food products. It is also appropriate to mention that this review cannot be advisory because all use of additives must be in accordance with the laws and regulations of each time. In this context, official domestic and foreign websites do list all the criteria for all additives under the current regulations.

It is ideal to check the website of the Environmental and food agency (MAST) in this context.

Caviar and masago are examples of products that contain additives, which affect storage, appearance and taste

Photo: Páll Gunnar Pálsson

This product is preserved by heating and high acidity (low pH). The product is heated somewhat above the temperature that is required for minimum pasteurization and after the heating acetic acid compared as a minimum temperature during germination and after the heating it is the acid that prevents the growth of pathogens.

The additives added to foods to maintain or improve safety and their freshness are in the category of preservatives and antioxidants, but they prevent spoilage caused by fungi, oxygen (rancidity), bacteria and yeasts.

Preservatives, for example, prevent pathogenic microorganisms such as Clostridium botulinum from being able to grow and contaminate the food with dangerous toxins.

The antioxidants are preventing fats and oils from oxidation and forming undesirable taste and colour caused by oxygen.

Additives are also important regarding taste, texture and appearance. Spices, flavourings and sweeteners are added to achieve a better taste. Food colours are used to maintain or improve appearance. The emulsifier, stabilizer, and the thickeners form the texture that the consumer wants. In breadmaking various chemicals are used to lift the dough and others are used for adjusting the acidity of food.

As can be seen, the additives play different roles and most of them have been used for years to preserve, flavour and colour of food. Preservatives have therefore taken part in improving public health by allowing access to safe, good and wholesome food at a reasonable price all year around.

Additives go through stringent research processes and their use is in constant review in the context of the safety and health of consumers.

To secure the use of additives and to prevent that consumers are not abused in any way then limits and rules are set on the use of all additives.

Manufacturers are required to label their products and specify which substances are present, especially since some additives can cause allergic reactions in some consumers.

Preservatives and antioxidants are used in many preserved products, other than those that are canned, but in such products, preservative or antioxidants are needed.

Sometimes preservatives are used in combination with other chemicals to prevent growth of microorganism. Some processing methods are also used like mild heating to stop or reduce the growth of microorganism. Thus, there is often one or more synergistic and microbiological preventive factors involved in the composition and processing of preserved products.

Photo: Páll Gunnar Pálsson

The most common additives in marinated herring products are acids to adjust the pH, and then it is common to use the preservatives sodium benzoate and potassium sorbate in combination.

The challenges that modern food producers face is bringing their products without any problems through the entire value chain, where the safety, quality and wholesomeness of the product is never at risk.

One of the most important for food producers is to have a good understanding on activities of microorganisms and what it is that affects their growth and development to prevented spoilage of the product.

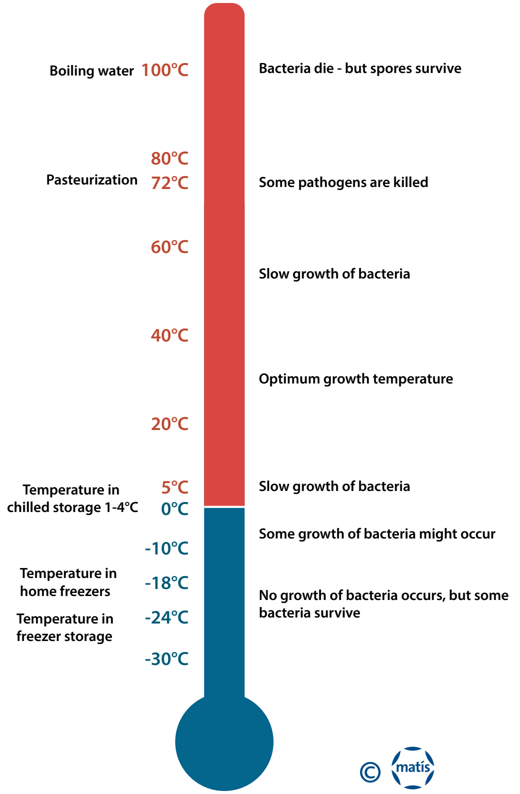
Primarily the food must be produced in the best possible conditions and hygiene, so the number og microorganisms will be minimal from the beginning.

There are various factors influencing the development of microorganisms and the common practice to combine these factors to achieve best results.

First, the temperature, as microbial species are different in terms of optimal growth temperature and many microorganisms are killed if the temperature goes over 60°C, but there are still some that are not affected and can survive this temperature.

The fact should not be forgotten that some bacteria can form very heat resistant spores when condition for growth become unfavourable, which then can sporulate when conditions become better and turn into a living bacterium again.

Cold slows down the growth of microorganisms and in the refrigerator at 0-4°C, the growth of most microorganisms is slow or none and, in the freezer,



The temperature of product storage has a major impact on the growth and growth potential of microorganisms

the microorganisms will be inactive even though most of them will survive.

It is possible to influence the development of microorganisms by packing, for example, a vacuum prevents microorganisms that need oxygen to grow, but then it needs to be borne in mind that a number of pathogens never grow better than in the absence of oxygen. The species composition of microorganisms and their development can then be affected by replacing the usual atmosphere and inserting other gases in specific proportions.

The growth potential of microorganisms can be affected by adjusting acidity (pH) and water activity. All microorganisms require moisture to survive but the amount needed varies between species. The development of the microorganisms can be reduced by drying or lowering the water activity of the food by adding salt or sugar.

Food can be preserved by marinating, for example by adding acetic acid and also by adding special chemicals that prevent growth and development of microorganisms, these chemicals are called preservatives.

Most microorganisms grow in a slightly acidic or neutral environment or with pH 6.6 to 7.5 in this context, there are microorganisms that can tolerate acidic environment or develop below pH 4.

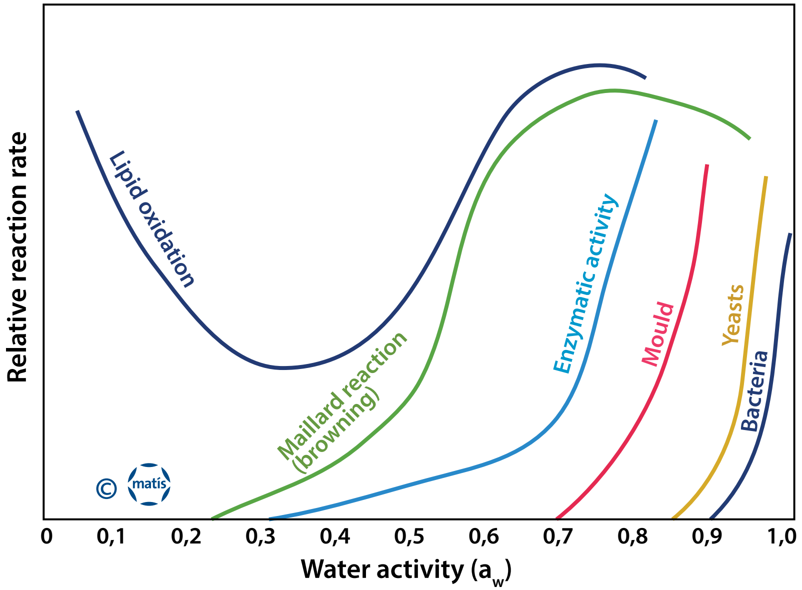
As a guideline, it can be said that moulds can grow in the range of pH 0-11, yeasts grow at pH 2-8 and bacteria between pH 4 and 9.

In terms of water activity, it is good to review the picture on page 13 along with the picture on this page, but generally bacteria do not grow at a water activity lower than 0.9, the yeasts stop at 0.88 and the moulds at 0.7, but there are always exceptions and there are examples where yeast and moulds grow to a water activity of about 0.6.

Preservatives are added in order to stop the growth of undesirable microorganisms, that spoil foods or can cause food-born illnesses. Acids are then used to influence the environment of the microorganism and furthermore affect the activity of the preservative.

The preservatives most often used in processed seafood like semi-preserved products are sodium benzoate and potassium sorbate, often these chemicals are used together but their activity is pH dependent.

Sodium benzoate works best at pH 2.5-4.0 and the potassium sorbate is working best at pH 3.0-6,5.



Growth of microorganisms is greatly affected by the water activity, but a_w also has various other effects, like f.ex. on oxidation

For the product to be at suitable acidity for the above preservatives, acids, like citric acid, lactic acid or acetic acid are often added to adjust the pH.

No matter what additives are added to a product, the rules and limits that apply in the marketing area in which the product is sold must be followed. The consumers must also be informed by correct labelling of the product.

Fastus sponsored the English translation of this handbook.

Heating

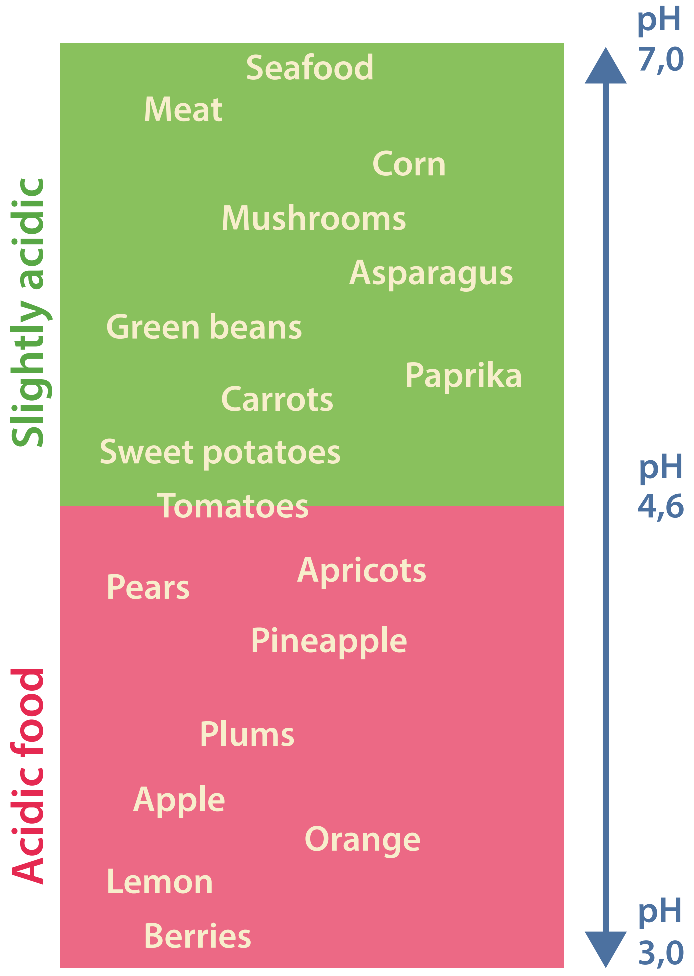
Heating foods can influence their shelf life. The heating can be the dominant method for longer storage or be a part of the process and then sometimes in combination with other kind of preservation such as salt, sugar, acidity, preservatives, etc. But then the heating is milder than if it was the dominant preserving method.

When the heating of food is covered, food is divided into two groups depending on the acidity. The foods are considered high acidic if the pH is lower than 4.6 but low acidic if the pH is higher. These criteria arise from the fact that Clostridium botulinum cannot grow and form toxins if the pH is lower than 4.6.

The heating after the food has been placed into the packaging can be different depending on the product and how long it needs be stored and under what conditions.

If the intention is to store the product in a refrigerator for a limited time, then the heating at 72°C is enough to kill the pathogenic microorganisms.

Products such as caviar receive such heating treatment, but the caviar is also preserved by, for example, salt and preservatives and can be stored for up to 12 months in a good refrigerator. There



are very many products that fall into this category of mild heating and here the closures and the safety of packaging is important just as products that are classified as canned.

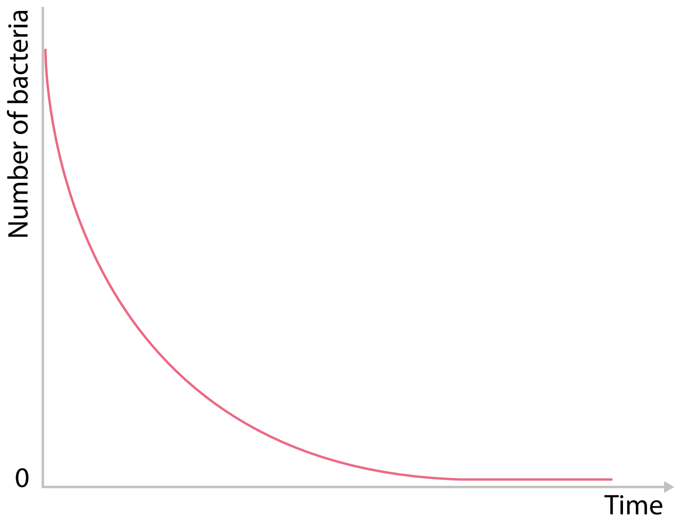
In the context og canned foods, the heating is considerably higher and different, as there the target is to kill all microorganisms in the product, both pathogens as well as those that can grow in the food and spoil them. Despite this heating, some types of the heat resistant microorganisms may survive the treatment and if the product is intended to be stored at a temperature higher than 25°C, it is advised to heat the product sufficiently to kill all the heat-resistant microorganisms also.

This product, lightly smoked herring fillets in oil, (Kipper snacks) was heated considerably longer that needed due to food safety rules F-value was 12. The reason for this long heat treatment was that by heating the herring fillets for such a long time, the consumer could not sense the bones present in the fillets. This way the heat treatment served to purposes.

Heat treatment of canned products aim at eliminating the spores of *Clostridium botulinum*, but spores are a kind of "seeds" or a dormant form of a microorganism, which at a favourable conditions can germinate i.e. become a living microorganism, which is then ready to reproduce and generate toxins.

Spores of *Clostridium botulinum* can tolerate high heating and this microbe is the most dangerous if it can grow and form toxin, it can only grow in total absence of oxygen and such condition can be present in canned food products.

It is possible to monitor the death rate of bacteria by measurements, but it is important how many microorganisms are present at the beginning, because the death rate is just proportional and theoretically the number of microorganisms at the end of heating will never reach 0. Heating for a specific time at a given temperature does not eliminate certain number but a certain proportion of the microorganisms.



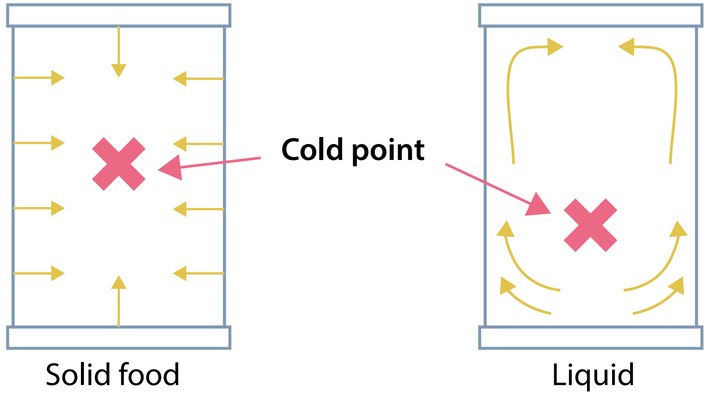
It is important how many microorganisms are present at the beginning, because the death rate is just proportionate and theoretically the number of microorganisms at the end of heating can never be 0.

There are thus always some probabilities of microorganisms being able to survive the canning process, just everything needs to be done to secure that the probability is as low as possible. In order to reduce the probability, it is important to have the number of bacteria at the beginning as low as possible. The heating process can be very long at a very high temperature to increase the death rate of the microbes, but such a process is costly and affects the quality of the product. Compromise is therefore necessary between the safety of the product on one hand and cost and quality on the other.

In the canning industry the criteria for a successful sterilization is that the probability for a one *Clostridium botulinum* spore to survive the heat treatment is one against billion (million millions). This means, that if billion cans were heated, which each would contain one spore of *Cl. botulinum*, then it is accepted that one spore in one can, from the billion cans, may survive the heating process. A product receiving such a heat treatment is called a commercially sterile product or canned.

To evaluate a heating process a so-called cooking value is used, represented by the letter F, and the minimum cooking value is equivalent to a heating at 121.1°C (250°F) for 2.52 minutes and it is represented by the symbol F_0.

The effect of heating is dependent on temperature and time at a given temperature. Heating, for example, at 110°C for 20 minutes returns a lower cooking value F than heating at 117°C for as many minutes and the same applies if the time at 117°C is extended, for example to 30 minutes then the F-value increases further.



Temperature measurements are always aimed at the coldest spot in the product and the location of the heat sensor can be place at different location, depending on the product, a good example is for fish pudding compared to liquid products such as soups.

The same heating effect can be achieved by using either a lower temperature and a longer time or higher temperature and a shorter period.

It hardly needs to be noted that temperature measurements and F-values are based on the coldest spot in the product.

Therefore, the size and shape of the packaging must be valuated and not the least the composition of the product, for example is the product a fish cake or soup or a mixture of the both.

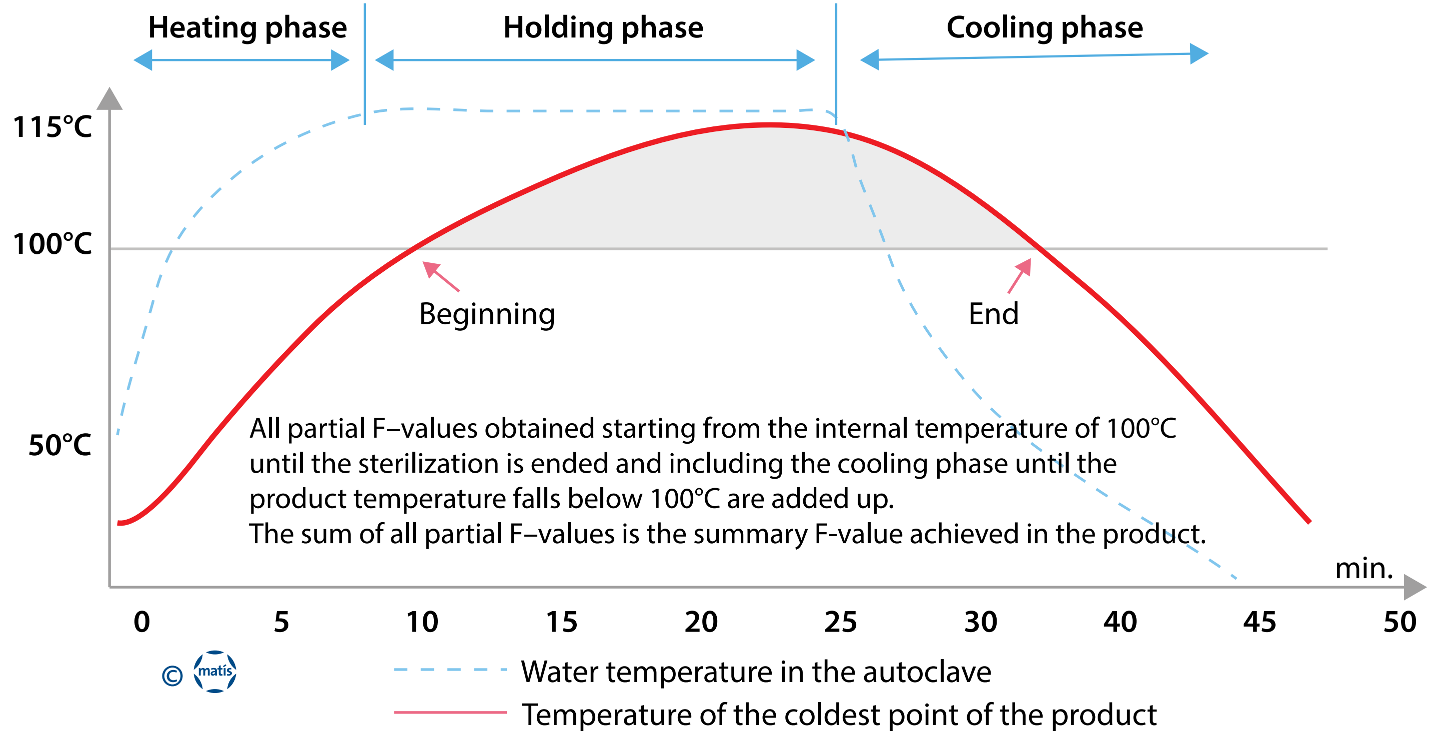
To simplify this and make it more understandable, then F = 1 when heated for one minute at 121°C, F = 2 when heated for 2 minutes at 121°C, etc.

°C	F - value	°C	F - value
100	0,0077	115	0,2449
101	0,0097	116	0,3083
102	0,0123	117	0,3880
103	0,0154	118	0,4885
104	0,0194	119	0,6150
105	0,0245	120	0,7746
106	0,0308	121	1,000
107	0,0388	122	1,2270
108	0,0489	123	1,5446
109	0,0615	124	1,9444
110	0,0775	125	2,4480
111	0,0975	126	3,0817
112	0,1227	127	3,8805
113	0,1545	128	4,8852
114	0,1945	129	6,1501

The values in the table are form "Meat Processing Tech. FAO 2010

The temperature inside the cans that are being heated is not the same all the time, it takes time to reach the target temperature, and it also takes time to reduce the heat again. Both the heating and cooling time counts when the effect of heating is evaluated.

Thermometers and measuring instruments handle the F – value measurements of each batch in canning and therefore complex manual calculations are not needed. The table below shows the heating performance at different temperatures and shows also that the whole heating process needs to be



The figure shows a typica heat process for a product that is to be cooked at 115°C. When the temperature of the product is above 100°C, the F-values start counting like can be seen in the table.

analysed to find the final F value for the batch by summarizing the F value for each temperature of the process.

As an example, the figures in the table indicate that a product needs to be heated at 115°C for approximately four minutes to achieve a cooking value of F = 1, but it equals to a heating for one minute at 121° C.

As mentioned many times, then canning aims at killing the very heat stable spores of Clostridium botulinum and to do that the F-value must reach at least 2.25 min.

Canned Saith fillets in Mexican sauce is a product that contains ingredients of different origin, therefore it is an increasing likelihood that various bacteria from soil are accompanied by the raw material.

Given the microbiological load in general food processing and an acceptable safety limits, it is normal to aim the cooking process to a F-value of 4.0-5,5. The temperature of the process is usually in the range of 110-120°C depending on how sensitive the product is to heat. Product receiving this heat process can be stored without spoiling for up to four years if the storage temperature is lower than 25°C.

In warm countries where temperatures can be considerably higher than 25°C, a higher F-value must be targeted or up to 12-15, which should be able to allow storage temperatures up to 40 °C.

There are very heat-resistant microorganisms, such as *Bacillus stearothermophilus*, which can tolerate standard canning procedures but do not grow if the temperature is below 25 °C, but if the temperature goes higher, such heat-resistant microorganisms can start growing and thrive and cause problems.

With heating under pressure, higher temperatures can be reached than in an open pot and it is a scientific fact that higher temperature shortens the time it takes to kill certain microorganisms or deactivate their spores.

Canned Cod liver from Iceland in a retail shop in Madrid

If the intention is to gain the same results as higher temperatures have by just boiling longer at 100°C, then the time is so long that the product that is being heated will fall apart and be destroyed, and the energy cost of such a process is very high. According to the table above, boiling for 125 hours at 100°C is required reach F = 1 and a secure heating will need approximately F = 5. That means it would take whole month at 100°C to reach that value. That is, of course, not a realistic alternative. Heating with overpressure is therefore necessary.

The microorganisms that mainly are a risk in canning live in soil or elsewhere in nature and these microorganisms can be transmitted into the factories by raw materials, additives, machines, packaging material or personnel.

Microorganisms can be in the processing areas and contaminate the product being produced if cleaning, hygiene and good housekeeping is not in good order. The probability of contamination varies depending on the raw material being processed, spores of pathogenic microorganisms are more in raw materials that have been in contact with soil at some stage.

Most cases of food poisoning where canned foods are involved, are due to contamination after the cans are opened. In canning companies the heating processes are carefully monitored to secure that all safety requirements are followed. Usually the minimum heading requirements are exceeded to further increase the safety of the product and prevent the presence of *Clostridium botulinum* spores.

It may happen that the cans and their contents are contaminated after heating and then it is primarily due closure failures but it can also happen that the sealant in the double seam, which is soft and semi-liquid in the hot cans, open the routes for microorganisms from unclean water or the environment into the cans. It is therefore very important that the good hygiene is practiced when handling hot cans coming from the retort.

Insufficient heating can certainly cause the cans to swell, but it is then due to failures or mistakes that should be observed immediately as equipment and devices should be carefully monitored and continuous recording of temperature, pressure and time is done for each batch.

In order to further ensure that everything is done correctly regarding the heating, some cans are taken from each cooking batch and stored in an incubator at 37°C for three weeks. After that time, the cans are inspected and checked whether any changes can be marked, such as leakage by the seam, or whether the cans have swollen.


Photo: Einar Þór Lárusson

Cans stored in an incubator at 37°C for three weeks after retorting.

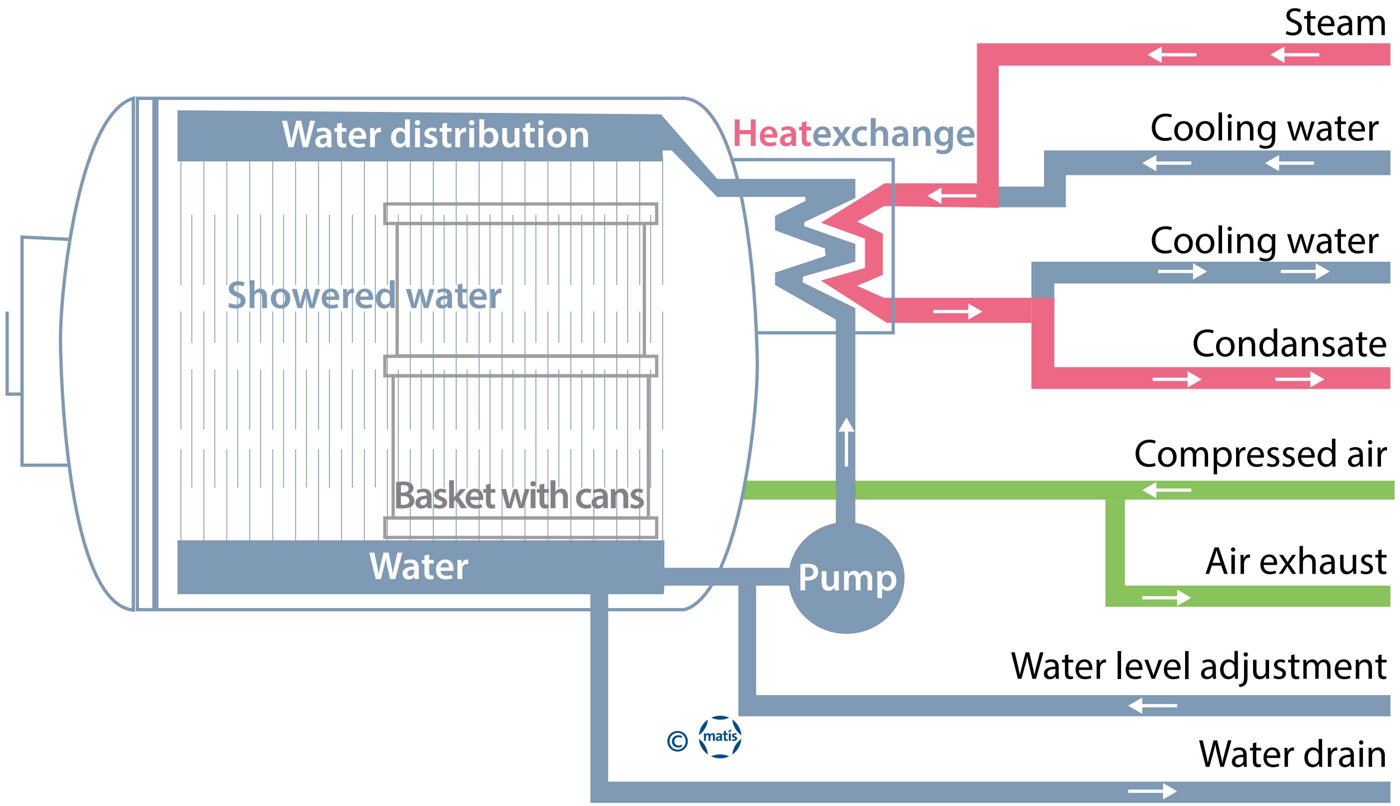
Autoclaves/retorts

In short, an autoclave is a device for cooking a product under pressure and by applying an overpressure it is possible to increase the temperature to over 100°C and thereby achieve better results in killing the microorganisms and spores that can be present in the product.

There are several types of autoclaves available but they all must have the following:

A mercury thermometer, which is calibrated to least 1°C, the meter shall be easily readable.

The thermometer should be calibrated during installation and at least once a year after that or each time there is any doubt about its accuracy. The mercury thermometer is the meter to be targeted, continuous recorders can easily change.



The drawing shows an autoclave that has a closed system in a way that heating, and cooling is done by a heat exchanger. The water used to heat the product is also used to cool down the product and is therefore not contaminated by microorganism, which is said to be sterile

A continuous temperature recorder is needed for every autoclave and the chart from the recorder confirms the temperature and time of cooking. The continuous recorder must be calibrated to an accuracy of 1°C or less.

The continuous recorder must be adjusted to the mercury thermometer.

Pressure meters are necessary and should be calibrated and should be tested regularly and at least once a year.

A big clock should be located close to the autoclave to regulate the time of cooking as small deviation in time can cause serious problems.

Heat control, water or steam, must be automatic to secure even heat distribution and to maintain even heat during cooking.

The crates used, must be designed to prevent cold spots forming during cooking and secure even distribution of heat.

The pressure control device must maintain correct pressure during the cooking.

The process flow of cooed and raw product must be carefully controlled to avoid confusion.

Charts from the continuous recorders must identify the product, date and time of heating to be able to trace back the product and the heat treatment the product received.

At regular intervals the mercury thermometer and the pressure meter should be checked and compared to the continues recorder.

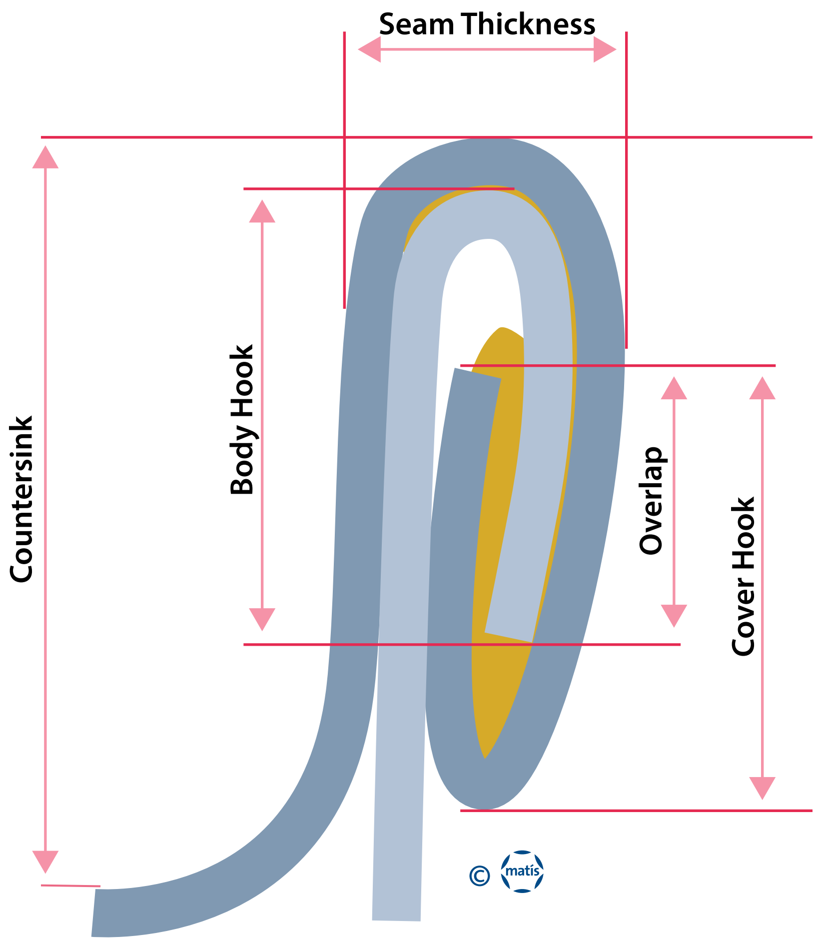
Canned products can be kept for 3-4 years after production at room temperature.

This is how cans are closed

Cans must be tightly closed and fulfil set limits to avoid leakage and cause harm to the consumer.

Modern closing machines operate at high speed and the machine performance must be monitored carefully and the closure compared to set standards. Small deviations from set standards can be costly in such high-speed operation.

The can is closed in two operations and the lock that is formed when the can and the cover are bent together is usually called the double seam.



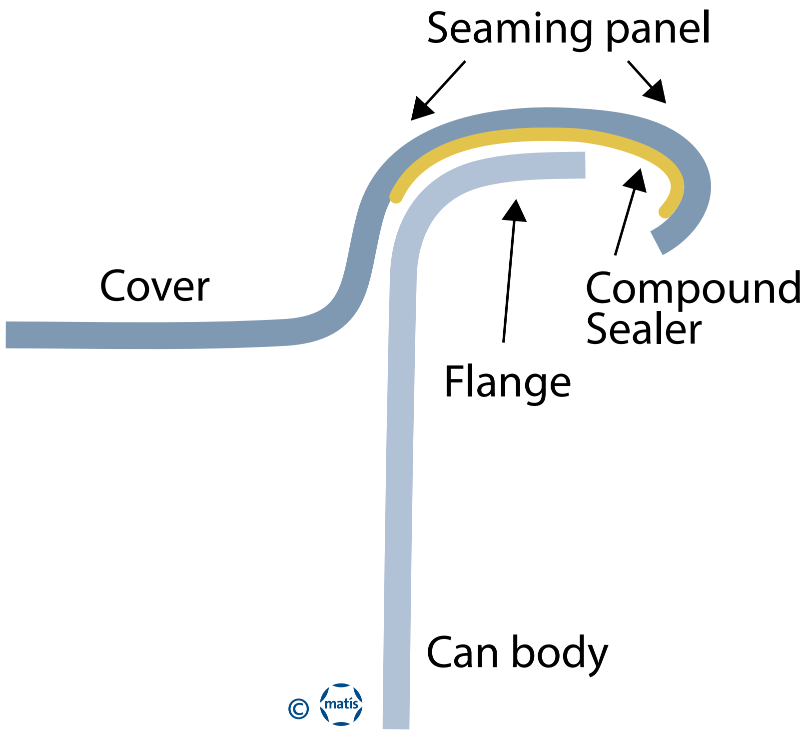
Before further discussing the double seam, the picture should be reviewed to memorise the main terms used.

The picture shows how the cover is bent over and under the body hook resulting in the material thickness of the cover (end plate thickness) becoming threefold and the body plate thickness, two fold.

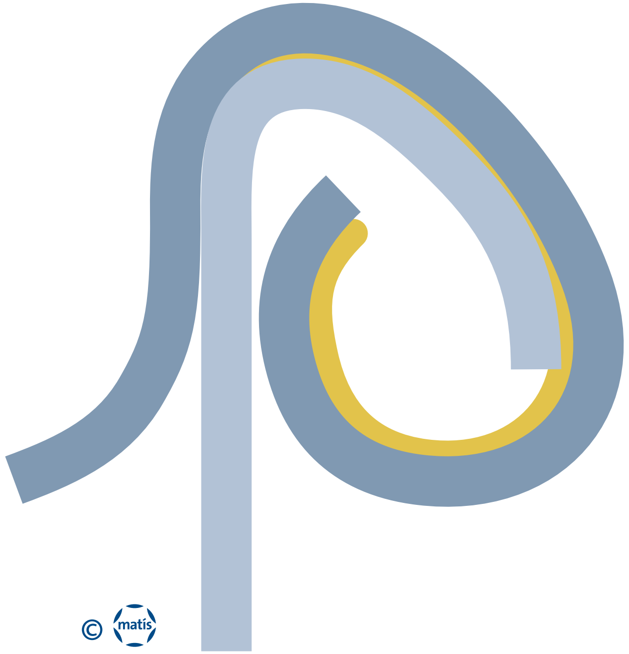
The names or terms identified in the picture are measured regularly and must apply to the limits set by the can and cover producer.

When covers are produced, a rubber layer is sprayed under the cover hook to make the double seam tighter and it is important that this rubber is distributed equally to prevent un-even seam closure.

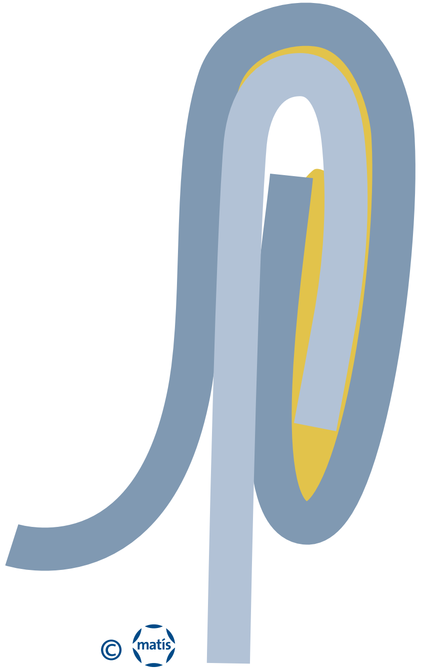
Like mentioned before, the can seam is formed in two steps and the following pages will try to explain the main issues related to can closure.



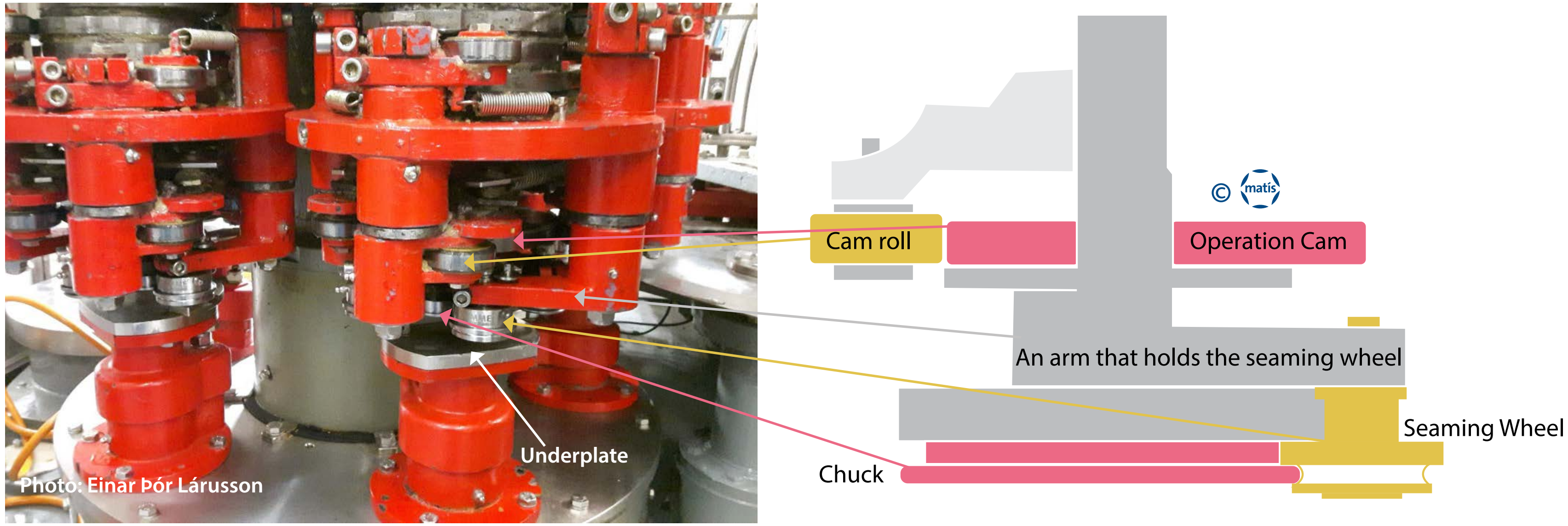
The figure shows how the cover with a rubber seal (sealing compound) is placed on the body edge (flange)



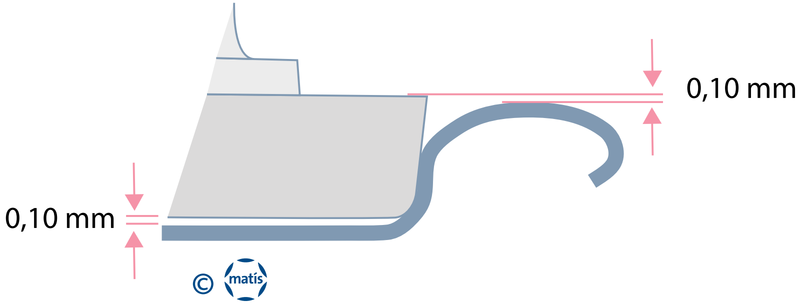
Above is a cross section of the double seam when the 1st wheel of the closing machine has bent the cover edge under the body edge.



This shows when the 2nd wheel has pressed the seam together.



Closure head of a can closing machine



Orientation of seaming chuck and cover

When discussing the closing tool, it usually refers to the operation cam (copy plate), seaming chuck, under plate and the seaming wheels for the 1st and the 2nd operation. These are the items that are linked to can sizes and need to be replaced if can size is changed.

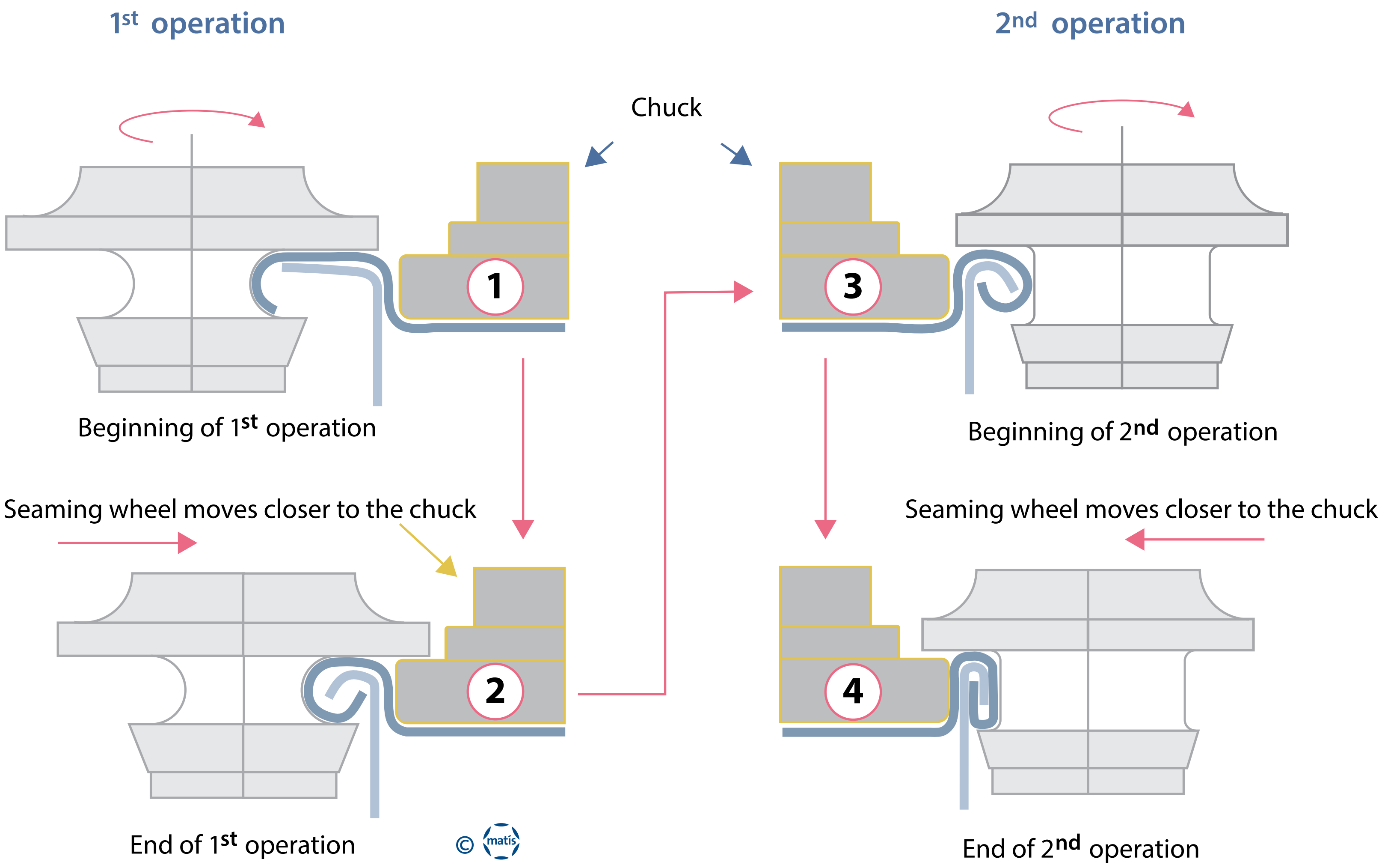
There are also other items that needs to be changed or re-adjusted if can size changes, this includes the infeed table and the same is true for the clincher if they are part of the production line.

The operation cum is to line up the seaming wheel, so they follow the shape of the can.

The seaming chuck must fit exactly to the cover and the cover should stick to the cum when pressed to the cover. The thickness of the seeming chuck should be 0,1 – 0,2 mm thicker that the countersink depth.

If the countersink depth of the cover is 3 mm, the thickness of the seaming chuck should be 3,15 +/- 0,05 mm and the sides of the seaming chuck should be conical and usually around 4°. The top edge of the chuck should be sharp and if the top edge is worn it can cause problems in closure and the seam can become loose.

The under plate must have the same size as the bottom of the can to guide it safely to the seaming chuck.



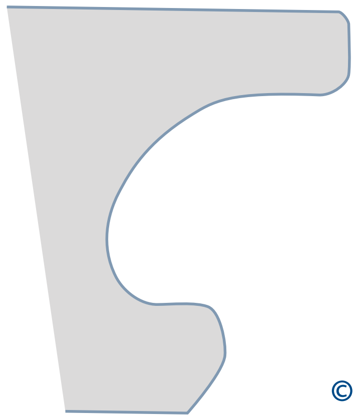
The pictures show the closing process. The first picture shows when the cover falls onto the body flange, on the cover there is small hook that is formed during the production of the cover.

This hook is even the whole circle on cylindrical cans, but on square cans the material is a bit thinner on the corners.

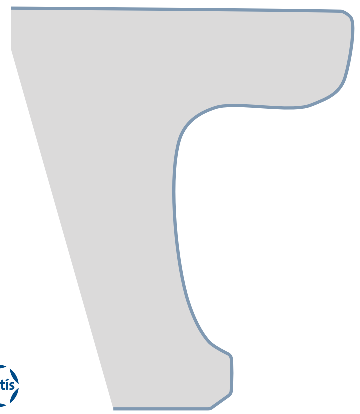
The seaming chuck holds on to the cover and the can is pressed upward by the under-plate.

The can does not rotate, but the closing wheels do while moving closer and the 1st operation wheels bend the cover edge under the body flange.

When the wheels of the 1st operation have done their work, they move away from the can and wheels of the 2nd operation move closer and finalize the double seam be pressing it together.



First operation wheel



Second operation wheel

Tracks or cross-section of closing wheels must match the cans to be closed and then the material and shape of the cans are of great importance.

If the importance of the closing wheels for the 1st and 2nd operation are to be evaluated, then the wheels of the 1st operation are much more important as it forms the cover hook; i.e. bends the cover edge under the body flange.

The main role of the closing wheels for the 2nd operation is to press together the seam formed by the 1st operation. The wheel of the 2nd operation can never fix a bad performance of the 1st operation.

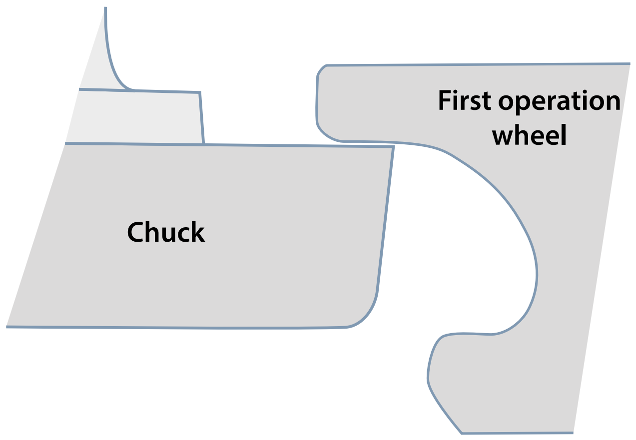
It cannot be expected that the closing wheel can last forever and therefore their conditions must be monitored and always keep spare wheels on stock.

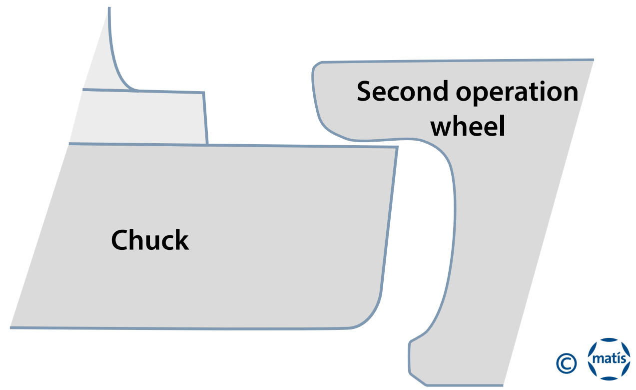
When the height of the closing wheels is adjusted the upper track of the wheel should just fits over the seaming chuck, when the wheel is in the position closest to the plate in the closing cycle.

For the wheels of the 2nd operation the adjustment should be similar, but the wheels can be a bit higher as if it is too low the wheels could scrape the top of the seam and form what is called "sharp" seam.

But the wheels of the 2nd operation cannot be too high because then the seam will be too high and the countersink to big and the cover- and body hook will be too short.

If the wheels of the 2nd operation are too high the seam might be pressed upward and over the edge of the seaming chuck, causing the can to stick to the plate when under pressure is released.



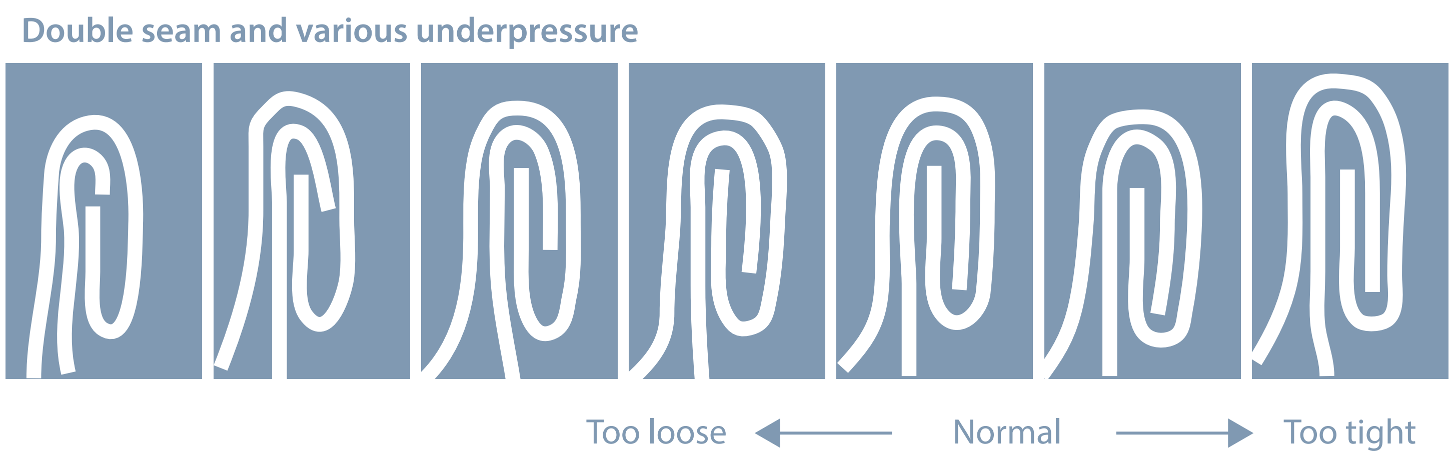


The positon of the seaming wheels to the chuck

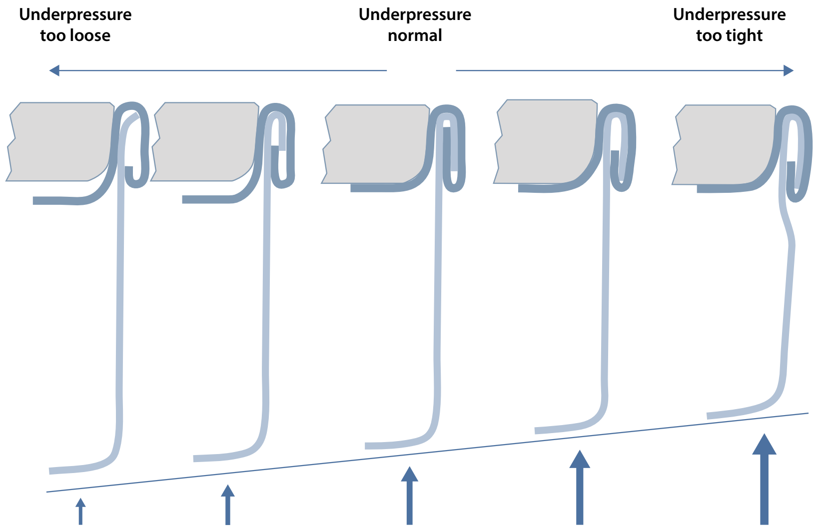
When a can closing machine is adjusted it is important to proceed systematically.

It is best to start with the wheel of the 1st operation, adjust the height and distance from the seaming chuck or the wheel pressure and at the same time check the under pressure.

When these adjustments are considered satisfactory then the 1st operation is tested, and the seam inspected to see if it is normal.



These pictures show how the double seam changes with increase and decrease of under pressure, the closing wheel of both 1st and 2nd operation are correctly adjusted, only the under pressure changes.



If a closing machine has many wheels in the same operation, each wheel must be adjusted separately, and all adjusted in the exactly the same way.

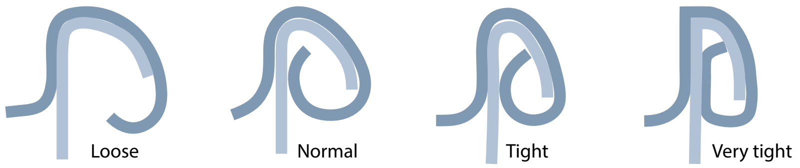
It is important to finish the adjustment of the wheels and under pressure of the 1st operation before starting to adjust the 2nd operation.

The under pressure is adjusted in the 1st operation but it is nevertheless important to check the under pressure again when the wheels of the 2nd operation are adjusted.

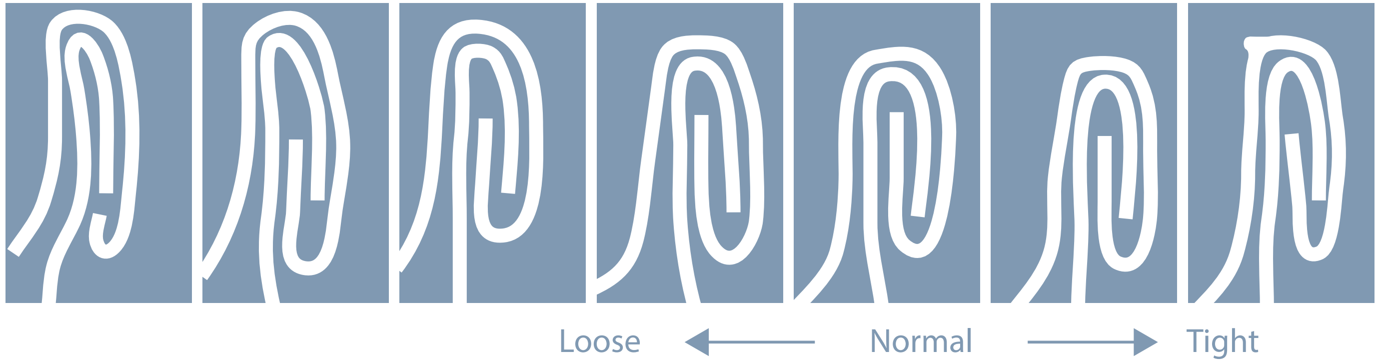
Wrong under pressure is often the cause of a bad seam, as too little pressure causes the body hook to be too small and the countersink depth too big and the can will be too high.

The under pressure is generally correct when the height of a closed can is equal to a can without a cover.

The countersink depth of the cover can also be measured but it should be similar or a bit bigger after closure or 0,2 – 0,3 mm, but the thickness of the seaming chuck can matter.



Double seam with different tight first wheel operation



The drawings above show how the double seam changes when the pressure of wheel in 1st operation are decreased and increased, the wheel of the 2nd operation is unchanged as well as the under pressure.

The 1st operation bends the cover edge under the body flange, the 1st closing wheel is specially designed for that.

The design and the shape of the wheel also depends on what kind of can is being processed.

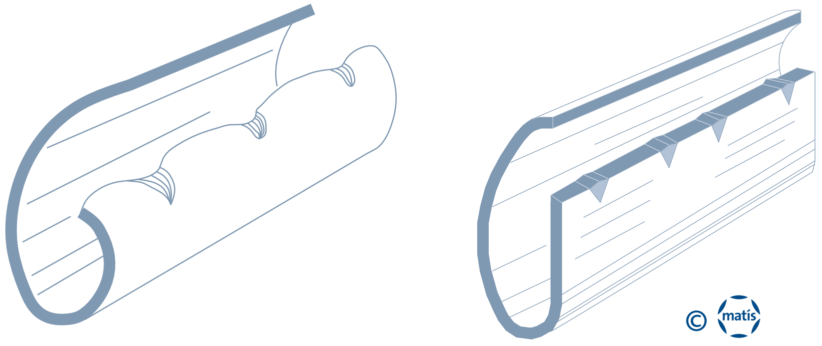
The pressure must be correct or how close the wheel is to the seaming chuck so that the seam is neither too stiff nor too loose.

Here it matters to have the height clearance of the wheel and the seaming chuck correct, under pressure correct and that the distance of the wheel from the seaming chuck or the pressure of the wheel is suitable.

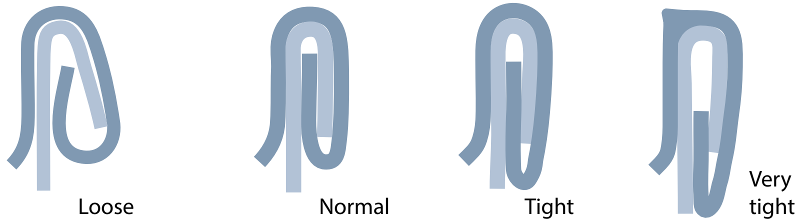
When the wheel of the 1st operation has bent the cover edge under the body flange the wheel moves away from the seam and the wheel of the 2nd operation takes over.

When the wheel of the 1st operation forms the seam, waves or wrinkles are formed on the cover hook which the wheel of the 2nd operation will even out.

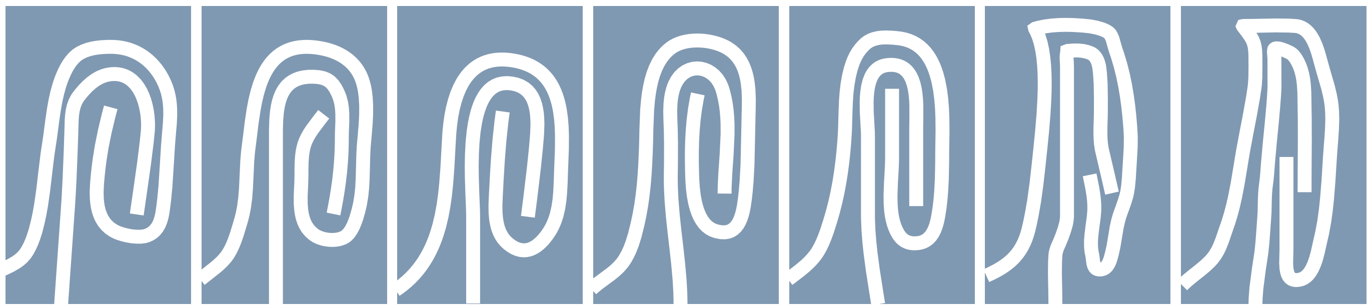
Too many waves indicate that the seam is not correctly formed and that can happen for example if the wheels is worn out. These waves can also cause a leaky seam.



To left it can be seen how waves have been formed on the cover hook after the wheel from the 1st operation, to the right it can be seen how the wheels of the 2nd operation has smoothen out the wrinkles.



Double seam with differnt tight secodn operation



The wheel of the 2nd operation has a considerably different cross section than the previous wheel. But it is intended to clamp the seam formed be the wheel of the 1st operation and to even out the waves that occurred and lastly to form a tight seam that fulfils all criteria.

How successful the 2nd operation is depends totally on the quality of the seam from the 1st operation. The 2nd operation can never fix seam faults from the 1st operation.

The wheels and their shape, both in 1st and 2nd operation is very critical, the wheels must be according to the requirements set by the producer of the can body and cover.

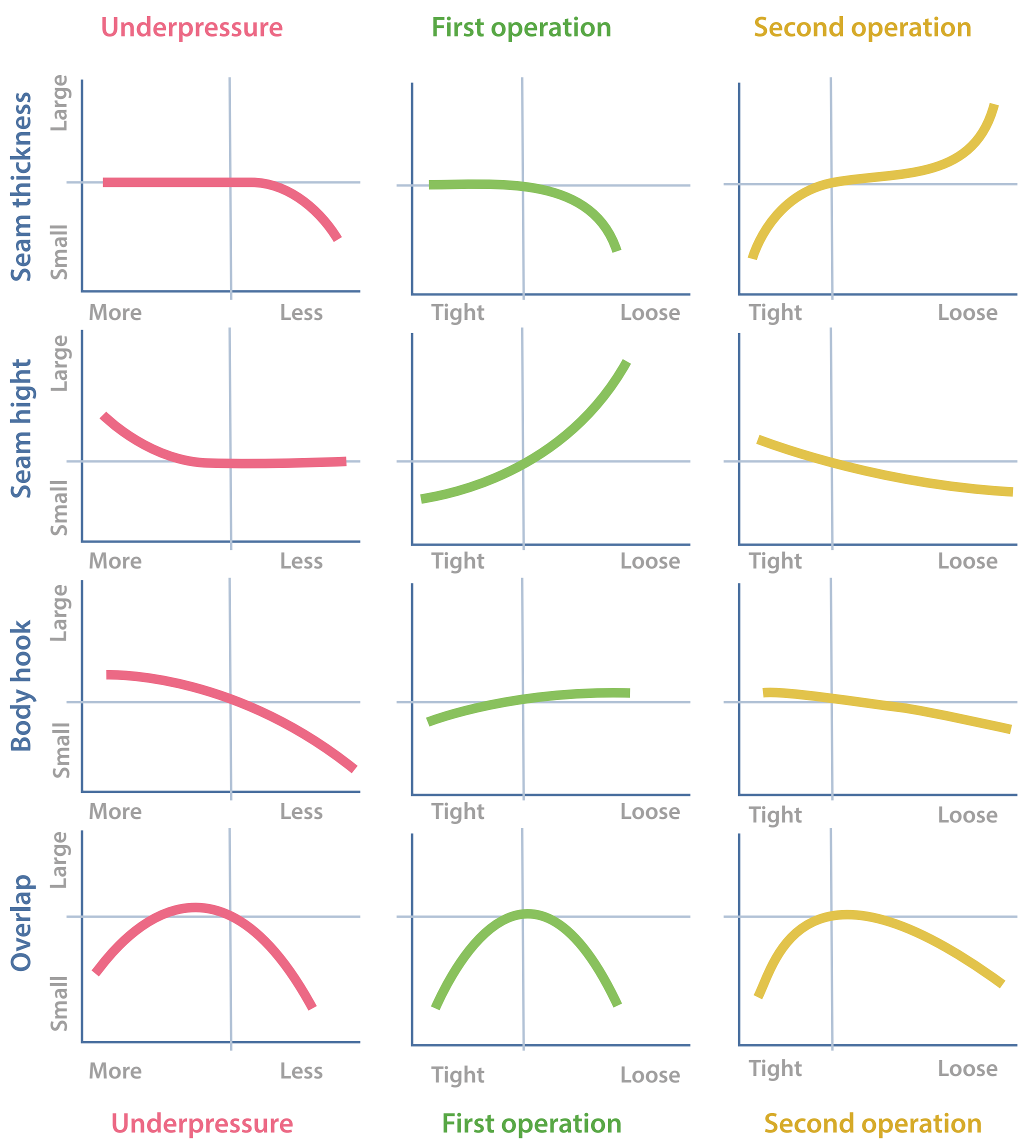
It is very important that worn wheels are not used because it prevents forming a seam that fulfils set criteria.

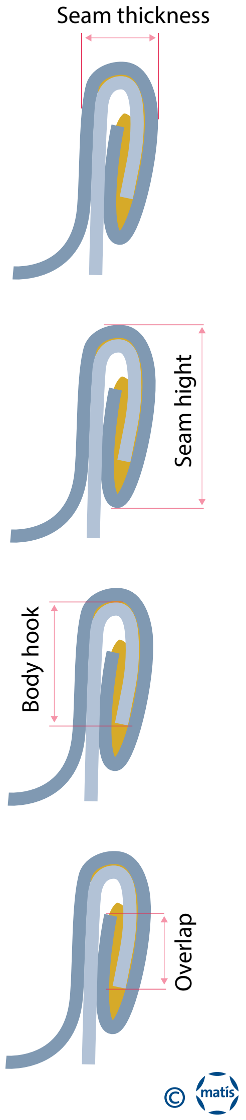
The wheels in the 2nd operation need to clamp the seam sufficiently for the sealing compound to spread evenly and fill all possible wrinkles formed.

Now we have reviewed the three main things that control the quality of the double seam.

It is worth noticing that these items are all connected, which makes the adjustment of a closing machine considerably complicated.

It is important that you only work with one variable at a time and use the exclusion method instead of dealing with all the settings at the same time.





The graphs on this page show how changes in settings affect different values of the double seam.

Where the light blue lines intersect is the target value. Then, the coloured broad lines show how the values for seam thickness, seam height, body hook and overlap change as the under pressure is increased or decreased, or if the seaming wheel are tightened or loosen.

Few examples on how to use this picture:

“The body hook is too small and the same applies for the overlap”

If the two charts at the bottom left are examined, it will be observed that increased under pressure may have a considerable impact

Regarding other variables such as seam height, it would have no change, but the seam thickness could move closer to the preferred value.

So, the answer in this example and from these graphs is that it is reasonable to increase the under-pressure slightly before changing other settings.

Akraborg ehf. sponsored the English translation of this handbook.

Some possible seam defects

As with other productions, you must closely monitor and conduct quality assurance of responsibility and determination. If preserved products are not properly handled in production, a significant risk may arise for the consumers.

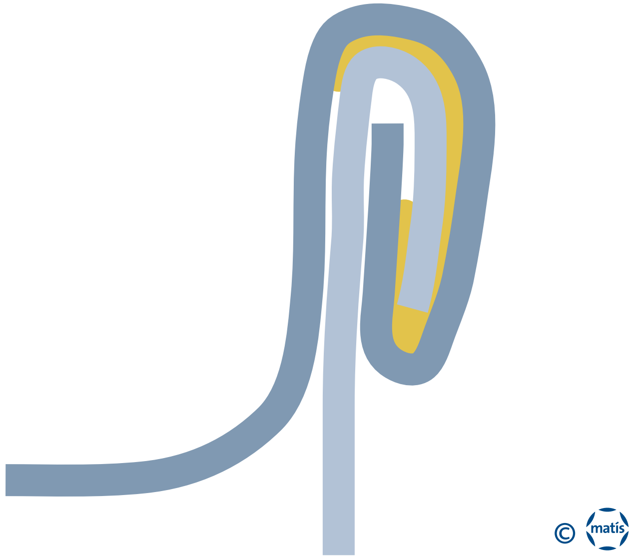
The double seam and closure of the package play one of the primary role in the safety of preserved products, therefore it is important to closely monitor the closure of cans and have the knowledge, skills and last but not least, tools to detect defects quickly and safely.

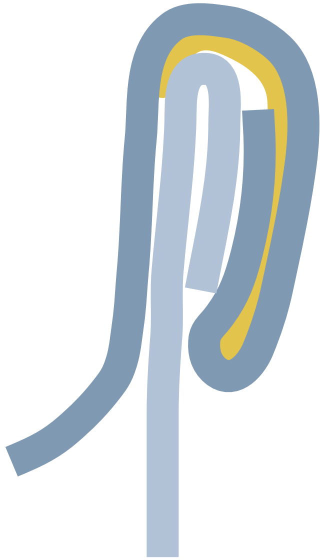
Following is a discussion on some seam defects and how to react. But it should be mentioned that some defects are visible on the outer part of the seam while other defects are not seen unless the seam is cut open and its cross-section viewed and measured

A false seam

An example of how all external measures indicate that everything is in order, this defect, where the cover and the cans do not hook together, does not appear until the seam is cut open and its cross-section inspected. Causes may include:

- Damaged can flange (body hook)
- Body hook too curved
- The can is not correctly placed in regard to the seaming chuck

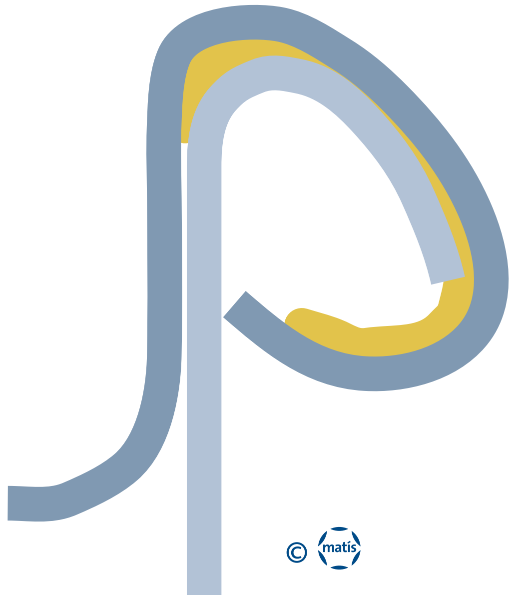




1st operation too loose

Compared to the picture, the 1st wheel is too loosely adjusted, and the cover hook does not bend sufficiently under the body flange. This can have the following consequences for the seam:

- Cover hook too short
- Seam height to high
- Sharp waves or wrinkles can form on the cover hook



Tight 1st operation

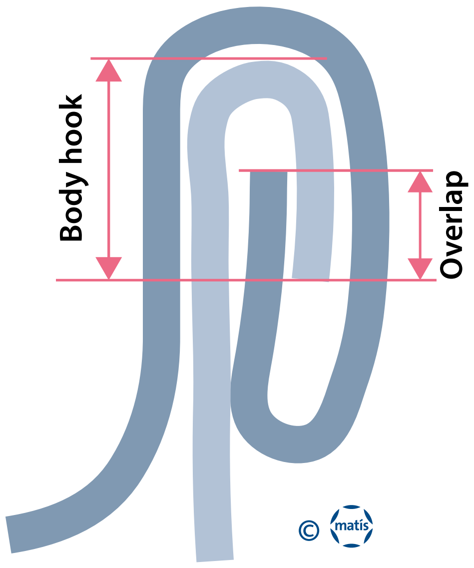
Compared to the picture, the setting of a 1st wheel is too rigid, and the cover hook bends to far under body hook. This can have the following consequences for the seam:

- Body hook too short
- Cover hook will be too big
- The seam height becomes too short

Small body hook and small overlap

When these two things go together, it may be considered that:

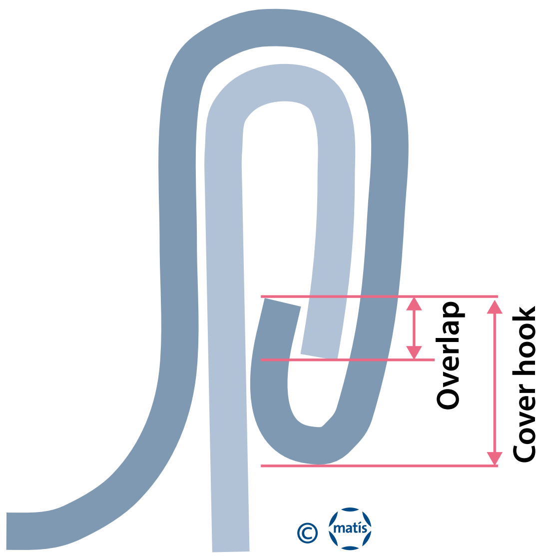
- Not enough under pressure
- Too high pressure on 1st wheel
- Too low pressure on 2nd wheel
- The seaming chuck is set too high



Small cover hook and small overlap

When these two things go together, it may be considered that:

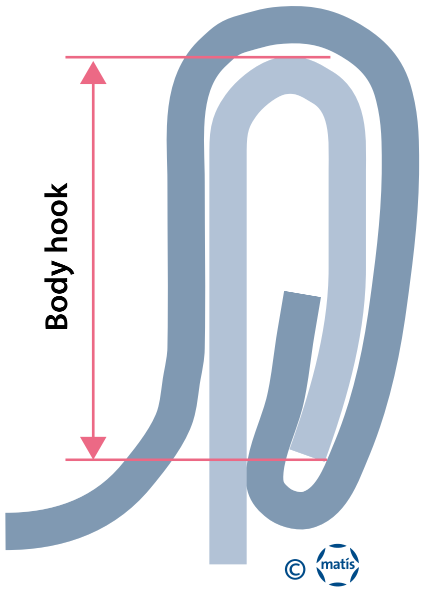
- The pressure of the 1st wheel is too small
- 1st wheels are worn
- Under pressure is too high



Big body hook

When the body hook becomes too big, it may be considered that:

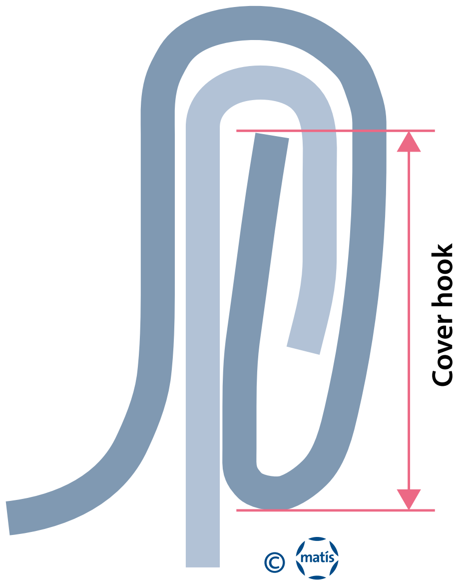
- Too low under pressure
- Seaming chuck set too high
- Pressure of 1st wheel too small
- The 2nd wheels are set too high.



Cover hook too big

Þegar þetta gerist þá er líklegast að:

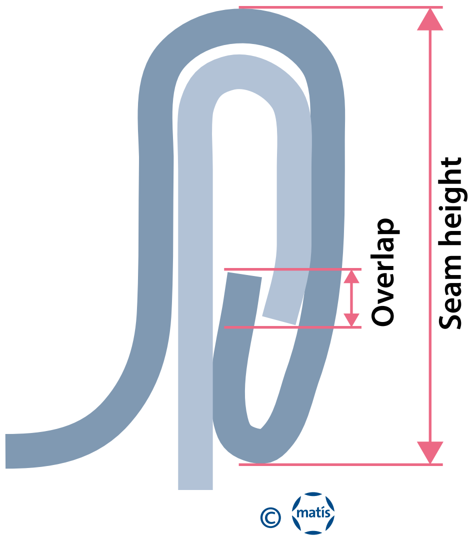
- The pressure of the 1st wheel is too great
- Cross section of the 1st wheel is not correct.



Seam height to high and overlap too small

When these two things go together, it can be expected that:

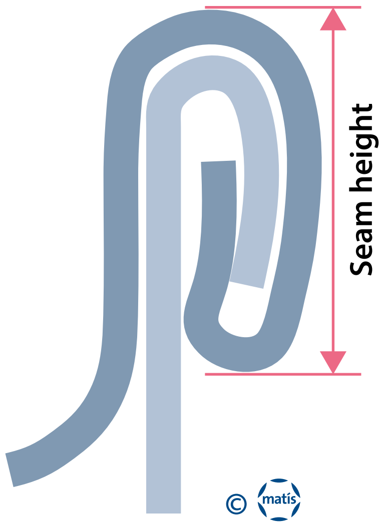
- The pressure of the 1st wheel is too small
- Pressure of 2nd wheel too much
- 1st and/or 2nd wheels worn



Seam height too small

The reason this might happen may be that the:

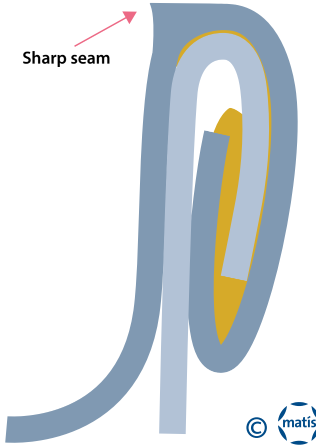
- Pressure of the 1st wheel is too great
- Pressure of the 2nd wheel is too small



Sharp seam

The upper edge of the seam is flatten-out and the material can push into the upper edge of the seaming chuck and in the worst cases the metal can break and a crack is formed. This may occur if:

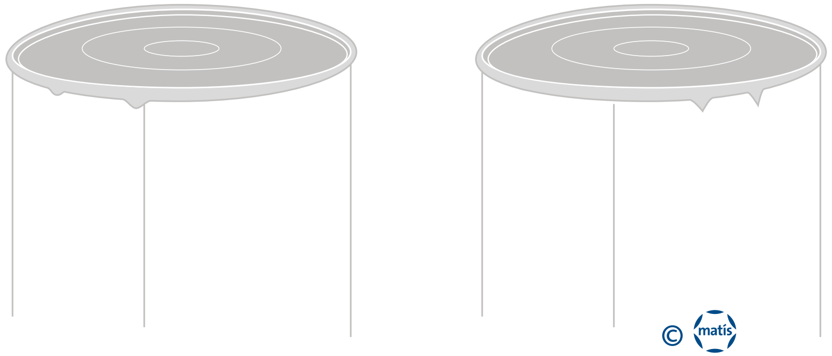
- The over-plate is worn
- 1st and/or 2nd wheel worn
- The pressure of the 1st and/or 2nd wheel is too high
- Height adjustment of the 1st and/or 2nd wheel incorrect
- The correct type of closing wheels are not being used.



Tongue or mouse teeth

Unevenness at the bottom of the seam can be soft and are then called tongues, but they can also be sharp and then named mouse teeth. This may be caused by:

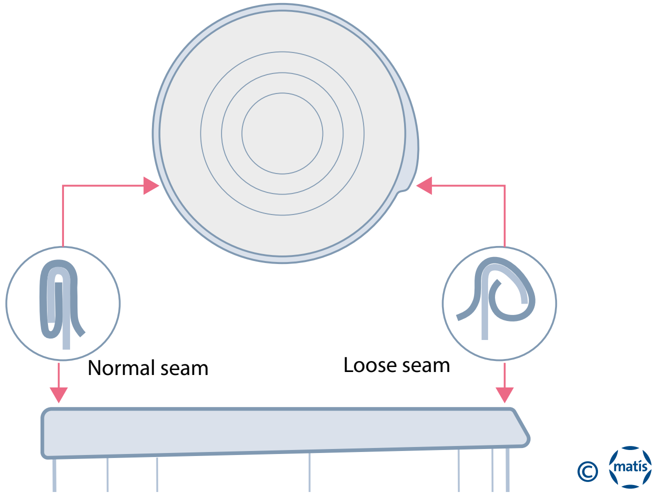
- Body hook too big
- Pressure of 1st wheel too small
- Uneven distribution of the sealing compound
- 1st wheel worn
- Damage to the body flange



Twisting

The seam is incomplete in part, and the seam thickness is not equal the entire circle, this can happen if round cans turn, for example, while the closing wheels are shaping the seam. The causes may include:

- Not enough under pressure
- The wheels are not spinning, are stuck
- Worn seaming chuck or not of the correct size
- Oil or grease on the seaming chuck
- Closing wheels not correctly adjusted



Swollen cans, it requires great overpressure to decompose cans in this manner, but the microorganisms will easily manage that, given the chance.

Seam inspection

The closure of cans is one of the most important processes for canning processors. If the closure is not safe, it can create a significant risk for consumers. Therefore, monitoring and managing the closure of cans is extremely important. The manufacturers of cans and covers set the limits of measures for the double seam and it is necessary to guarantee that the closing machines are operating under the set criteria.

To secure the safety of the double seam, it is necessary to work systematically and record all inspections and measurements.

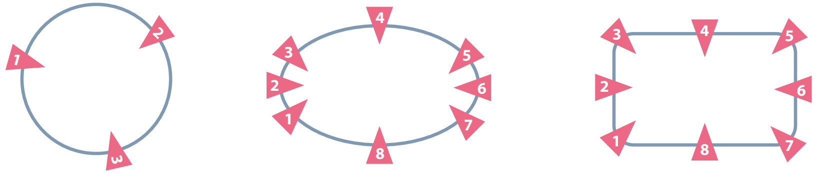
Inspection of cans after closure can be divided in two parts, the first is to do a visual evaluation and secondly to measure predetermined items of the double seam and the can.

Visual evaluations can be performed frequently and periodically as the cans are not destroyed during those inspections. Few cans are selected, and the fingers used to sense the seam and checked to see if:

- The edge is sharp
- The 2nd wheels have finished their work (twisting)
- If a false seam is present
- Tongues or mouse teeth visible
- Inner part of the seam is okay, the seaming chuck can damage, or foreign material be present such as parts of cover that got stuck in the machine.
- Dents or scratches on cans or seam are present

Under pressure is generally correct when the height of the closed can is equal to the height of a can without the cover.

It is not enough to handle and sense the cans in order to assess whether everything is indeed fine, it is necessary to measure the seam both outside and inside.



Different measuring places on different shapes of cans

Photo: Páll Gunnar Pálsson

For the measuring devices to set limits for seam thickness, the material thickness of the can and cover must first be measured

As in all quality control, it is important to work orderly and record all measurements in a proper manner, and then work with the data in order to evaluate trends or changes, not to mention to check whether individual measurements are within set limits.

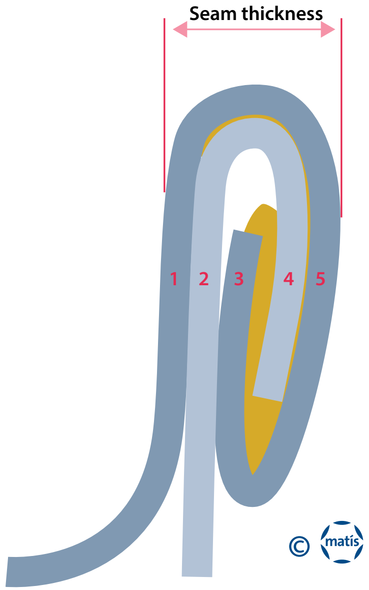
All can types have their specific limits, that are set by the manufacturers of cans and covers. These values must be measured to verify that the double seam is correctly formed and safe.

Photo: Páll Gunnar Pálsson

Sem thickness measured and the values are automatically recorded in the quality control database

In quality control the can measurements are done on filled cans, but when working on adjusting closing machines, the cans are kept empty, it also applies when the intention is to check the wave formation or when the can is pressure tested.

It is not enough to cut and measure the double seam in one place on the can, because as it has



The seam thickness is 2x material thickness of the cans + 3x material thickness of cover + approximately 15% due to the sealing compound.

Photo: Páll Gunnar Pálsson

To be able to assess the internal measures of the double seam, it is necessary to cut the seam open and analyse the seam in a can seam projector.

been explained, defects may be localized on the seam. Common practise is that cylindrical cans are cut up at three places, while the square and oval cans are cut up at eight places.

These are many measurements but fortunately the technology has advanced and now you can get measuring devices that measure and record the values quickly and show the results on all sorts of visual forms.


Photo: Páll Gunnar Pálsson

After sawing, a cross-cutting of the seam is examined in a can seam projector, which displays an image on the screen and records all values automatically.

When adjusting closing machines, you work with empty cans. When the can pressure tested, it is processed with empty, clean and dry cans, because leakage may be present without noticed in a pressure test if the cans are wet.

In general, it is assumed that closed cans withstand an overpressure of 1.5 to 3 kg/cm² (that corresponds to about 20-50 psi), different numbers apply for different types of cans, material thickness

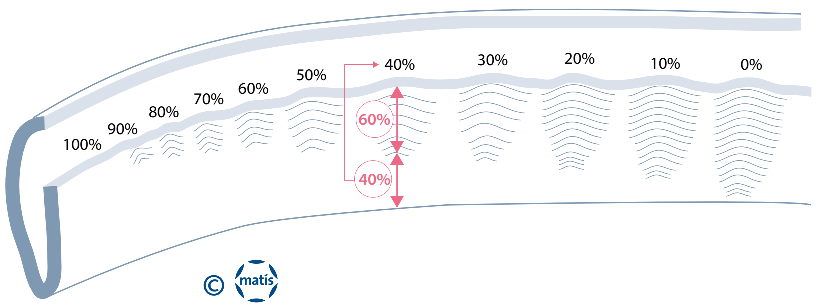

Photo: Páll Gunnar Pálsson

The cover hook is then released, and waves evaluated and their magnitude.

in cans and material type i.e. whether the material is a steel or aluminium.

Although a can passes a pressure test, it is not a health certificate for the seam and the can closure. The pressure test only confirms if the seam is tight or not tight.

The pressure test is usually done by placing a closed can in special equipment and a needle, that air is pumped through is stabbed through the cover.



Evaluation og waves

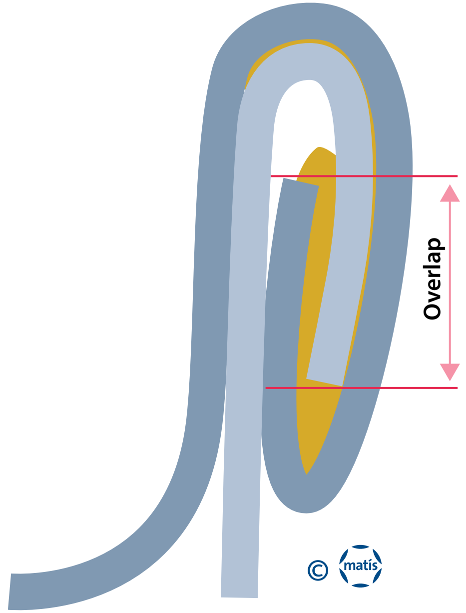
The can is securely fastened and then immersed in water and air pumped slowly to the target pressure and check if bubbles become visible.

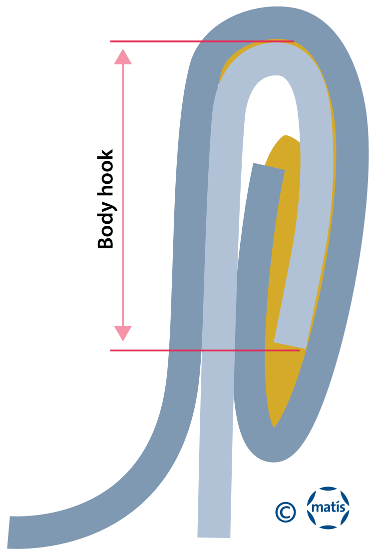
To evaluate waves or wrinkles on the cover hook, it is better to have an empty can. The can is opened, and the seam cut to release the cover hook, then it is possible to evaluate how big the waves are and how successfully the 2nd wheel was in pressing the seam together.

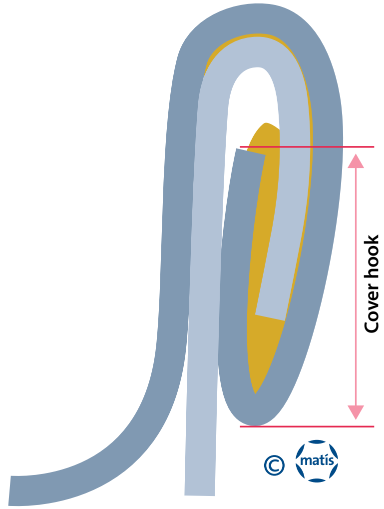
There are always some waves on all cover hooks, especially if can corners are sharp.

When checking whether the seam is adequately pressed together, it is necessary to measure the seam thickness, but it is determined by material thickness of the cover and the can body. When viewing the cross-section of the seam, the thickness should be close to a double material thickness of the can body plus triple material thickness of the cover.

In a three-piece can where the body is welded together on the body side, the seam thickness at







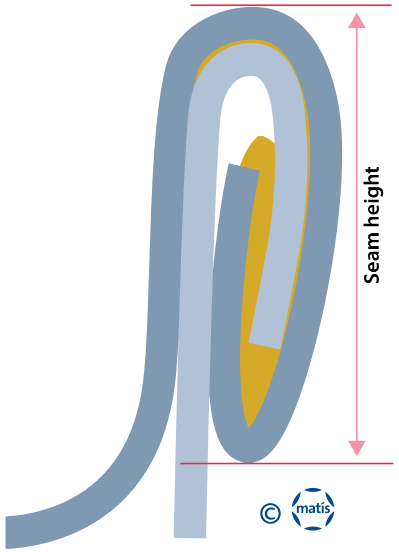
that point should be four times the thickness of the can body plus three times the thickness of the cover. This point must be measured specially.

Once there were cans available that were opened with a special key, which was tucked to a tongue that belonged to the cover. The tongue was part of the seam that made the material thickness of the cover fourfold while the material thickness of the body was double.

To calculate the seam thickness the following formula can be used:

Calculated seam thickness = (2 x material thickness of body + 3 x material thickness of cover) + 15%

This is an example of a 15% addition to the calculated seam thickness, and this is to accounts for the sealing compound. This addition may vary depending on the can and cover producers, who will inform what the measurements should be.



The equation can be used to assess whether the compression of the seam is high or low. If the measured seam thickness is less than the calculated seam thickness, then the seam is extensively compressed, but if it is the reverse and the measured seam thickness is greater than the calculated seam thickness, the seam is loose.

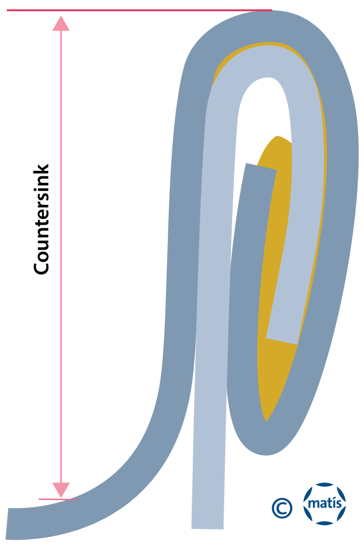
To measure the overlap and other internal measures the seam must be cut open and that needs to be done at several places. Cylindrical cans are usually cut open at three places with equal distances while square cans are cut open on at least eight places.

The cross-section of the seam is viewed in special measuring instruments that enlarge the image of the seam and the latest measuring devices measure all the components automatically and records all values automatically into an inspection database and generally images are also stored.

Can where a special key is included to open the can. At the tongue in which the key is placed, the material of the cover is quadrupled in the seam instead of being triple.

The overlap determines the strength and density of the seam, but it also tells quite a lot about the adjustment of the closing machine, such as if the under pressure is correct or whether the wheels of the 1st operation are correctly configured. The overlap depends to a large extent on the size of the cover hook and it can be different throughout the seam circle.

The can flange and the under pressure mainly determines the size of the body hook, while the



size of the cover hook is determined by the size of the cover edge and the adjustment of the 1st wheel.

The seam height is mainly determined by the size of cover edge and adjustment of 1st wheel, this measurement indicate if the closing wheels are correctly adjusted or if they are of correct type.

The countersink should not be deeper than 0,2 – 0,3 mm after can has been closed.

The height of a closed can should be close to the height of a can without a cover. If the height is more it could mean that the closing wheels are adjusted too high, the seaming chuck too thick or the under pressure too little.

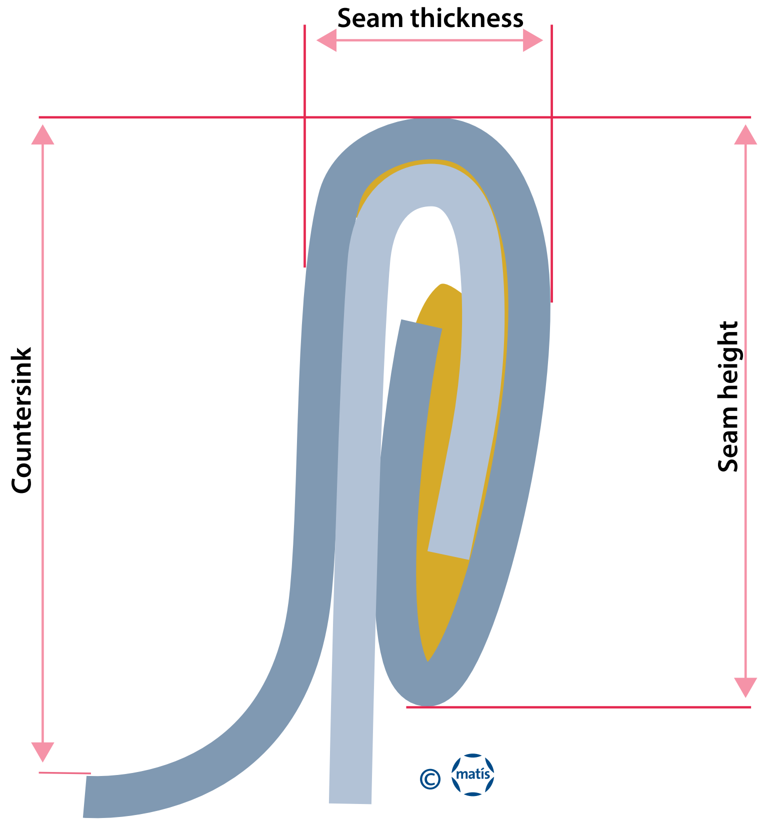
It should be noted that all measurements must be performed using good instruments to avoid decisions being made based on poor methods or measurements.

As the body in a three-piece can is welded together, the material thickness becomes double as the material at this place overlaps, this is reflected in the thickness of the seam at this point.

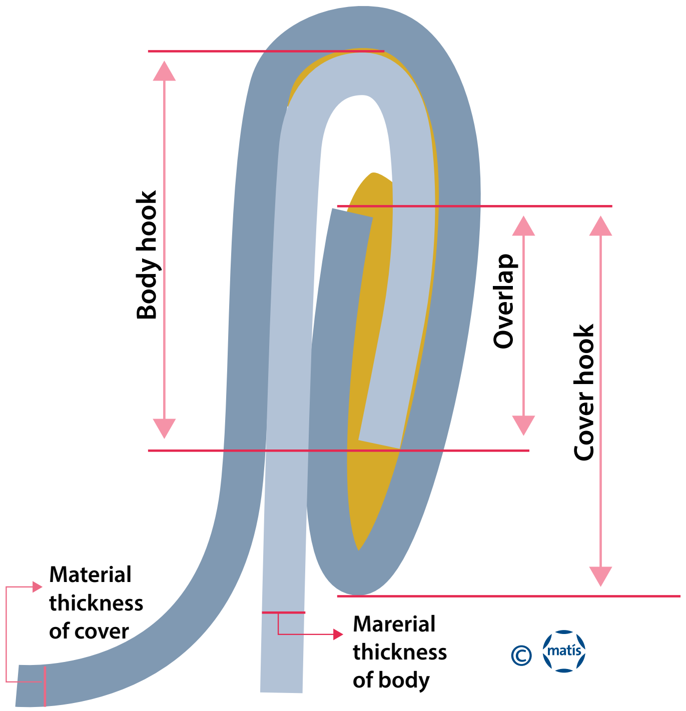
Many things need to be considered when selecting types of cans, above two types are shown, which hold the same quantity, both are from aluminium and one-piece cans. The shape of the one to the left in the picture is what is called conical and can be stacked into each other. While the other have straight sides and therefore take up more than double the space in transport, when empty.

The following are measured during regular inspection; 1. Countersink - 2. Seam height – 3. Seam thickness – 4. Body hook – 5. Cover hook – 6. Overlap – 7. Material thickness of cover and body. These measurements are conducted on full cans. When closing machines are adjusted, empty cans are used. Pressure tests and wave evaluations are done on empty cans.

External measurements



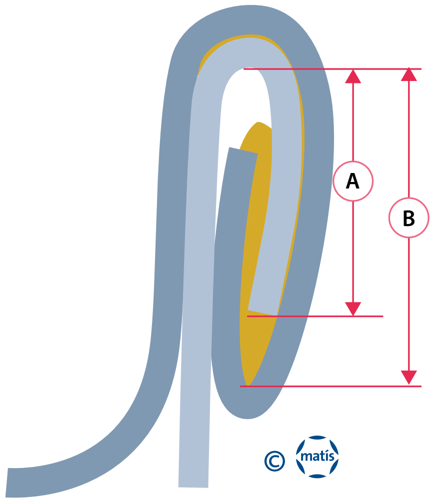
Internal measurements



One additional measurement

The relative Body Hook Butting (BHB) is in fact one additional method to assess the quality and intensity of the seam.

Here the inner height measures of the seam are evaluated, namely "B" on the drawing below and the relative length of the body hook off the inner seam height.



Body Hook Butting is calculated in percentages as:

A/B x 100 = % BHB

Glass packaging

Glass containers are more pronounced in certain product groups, marinated herring is for example, mainly in glass jars, the same applies to jam and jelly of different kind, caviar is usually produced in small glass jars, although it is also known to have caviar in metal cans. Prepared and canned baby food was most common in small glass jars.

Glass packaging may be useful for small producers that are taking their first steps in bringing new products to market. It is relatively easy to obtain small amount of glasses and these containers tolerate heating or to be filled with hot foods. Glass is good for acidic foods and in general, glass containers provide good protection for all kinds of foodstuff.

Closing glass packaging is very safe, the closure is reinforced by generating under-pressure in the air space between the product and the cover. The simplest way to achieve under-pressure is to fill and close the glass jars at high temperatures. Therefore, when the product cools and shrinks, it forms an under-pressure that strengthens the closure.

Under-pressure can also be achieved by blowing hot steam over the surface of the product in the jar, thereby getting hot air at the top of the glass

Photo: Páll Gunnar Pálsson

Marinated herring in glass jars

before the cover is screwed on. When the hot air at the top of the glass cools, the under-pressure is formed.

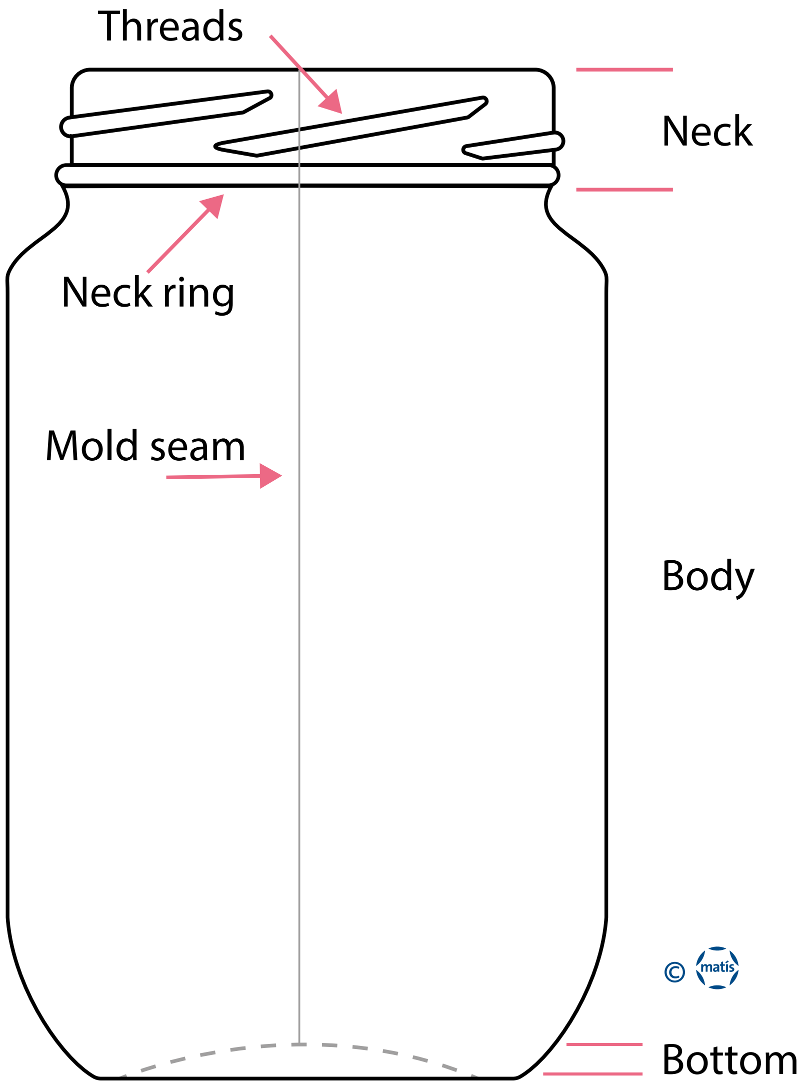
Not all product can tolerate the use of heat or hot air for closing and for those products there are machines that can form under-pressure in the jars in a special vacuum chamber before the cover is place on the jar.

The covers are most frequently from metals, that contain a soft sealing compound on the inside, kind of gasket, to secure tight closure.

In the case of glass jars and glasses, there are three main parts, namely the neck, the body and the bottom. The neck is sometimes referred to as the "finish" as this was the last part formed when the glass jars were hand made in the olden days.

The neck is formed in a variety of ways depending on the type of cover to be used and therefore one must be careful when choosing the cover and jar as they must fit together.

Where the neck and the body meet there is neck ring the whole circle which has a technical purpose



when the jars are being manufactured in automatic machines, and the jars are being transferred automatically.

The body of a glass jar is the biggest part and it is formed in various ways. On the body there is a small wrinkle or a line (mold seam), coming from the mold that forms the jar.

Bottom of glass containers can be designed for the purpose of making it easy to stack them in retail stores, but first and foremost, the bottom must be so strengthened that it can withstand the load needed and expected when the jar is full of food

Glass jars are rather stiff, which prevents them from floating through the production lines without exertions, therefore they are often coated with surface materials or lubricants to prevent the glass from scratches and the loss of clarity. This needs to be considered in production, closures and labelling.

When glass jars are closed with metal covers where the under-pressure is most important, there are usually two types of closing procedures:

The first is called a "Lug type Closure", which refers to a notch (Lug) that is located on the lower edge of the cover. This closing method is most commonly used when there is an under-pressure in the jar as well as it is easy to unlock the glasses and to close them again if they are reused.

As can be seen in the picture below, there is a notch that has been formed on the lower edge of the cover, and these notches can be 4, 6, or 8 depending on the jar diameter. Inside the lid is a sealing compound or a gasket that presses firmly to the edge of the glass.

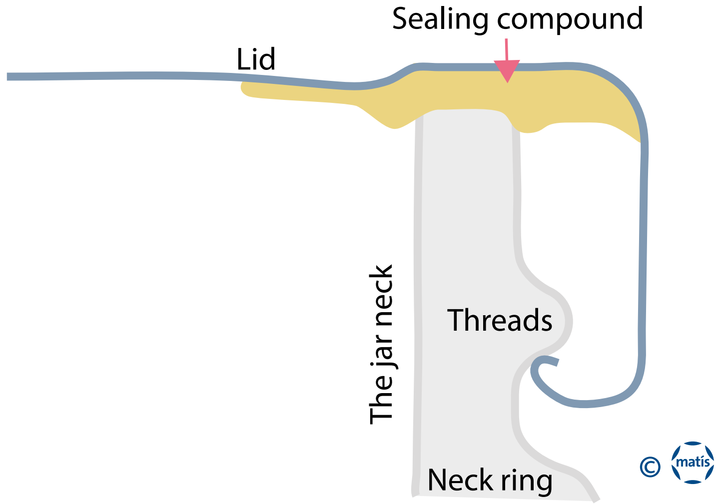
When the jar is closed, a hot steam is blown over the surface of the contents and the lid immediately screwed on, so it fits correctly to the threads on the neck of the glass jar.

The sealing compound inside the cover sits tightly to the upper edge of the jar, but often the cover and the sealing compound is heated by steam before closing so that the seal will be soft and forms easily to the edge of the container and forms a tight closure.

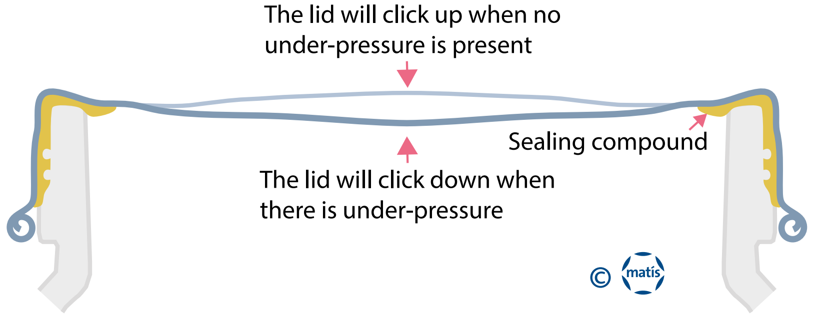
The notches on the cover and the threads on the glass as well as under-pressure in the container keep the cover in place and here the under-pressure is the most important.

“Press on Twist off closures” is most frequent

Typical lid for glass jars



Cross section of a “Lug type closure”



Cross section of a “Press on Twist off closure”, It can be seen how the sealant presses against the threads.

Photo: Páll Gunnar Pálsson

Caviar in glass jars, presumably pasteurized i.e. heated to at least 72 °C after closure, then stored in a refrigerator 0-4 °C.

when it comes to baby food in glass jars. The covers, in these cases, do not have any notches and the inside of the cover a sprayed with a sealing compound that extends down to the inner edge of the cover and eventually will press against the edge of the jar and partly down to the top part of the neck and the threads under the lid edge.

These lids always have a “click” that drops down in the middle of the cover when there is an under-pressure in the jar and click up when the jar is opened.

The covers are heated with steam just before closing so that the sealing compound becomes soft, but these covers are pressed to the glass, not screwed, simultaneously a hot steam is blown over the surface.

An under-pressure is formed inside the jar when it cools, and the cover sits tight. Also, the sealing compund is shaped to the threads that will make the closure even better. However, it is the under-pressure that is most important in this closing method.

To complete this review of different closures, the third method of closure should be mentioned.

The coveers then have a continuous thread and

Photo: Páll Gunnar Pálsson

This closure, that is twisted covers is common in home processing of different kinds, such as jams.

inside the cover where it rests on the edge of the jar, is a sealing compound that presses tightly against the jar edge. This kind of closure can be used whether a steam is blown over the content or not.

As stated, there are a few ways to how the glass jars are closed, but all the covers have some kind of a sealing compound on the inside to ensure safe closures. These sealants may be different, depending on the kind of production involved.

Therefore, it should be considered during procurement, whether the intention is to pasteurize the product, heating up to 72°C or heat the product to over 100°C for some amount of time.

Baby food in glass jars, closed with a procedure called: "Press on Twist off closures"

Since the under-pressure is important to maintain safe closures, some covers are designed in such a way that the centre of the cover presses or clicks down when there is enough under-pressure.

In production it is possible to automatically monitor whether the centre of the cover is sufficiently curved. When the consumer opens the jar the centre of the lid clicks up, which is a sign that the closure was good.

When packages like jars and covers are procured, guidelines from the producer on how to handle the product correctly must be available and include information on what should be inspected and measured to secure safe closure.

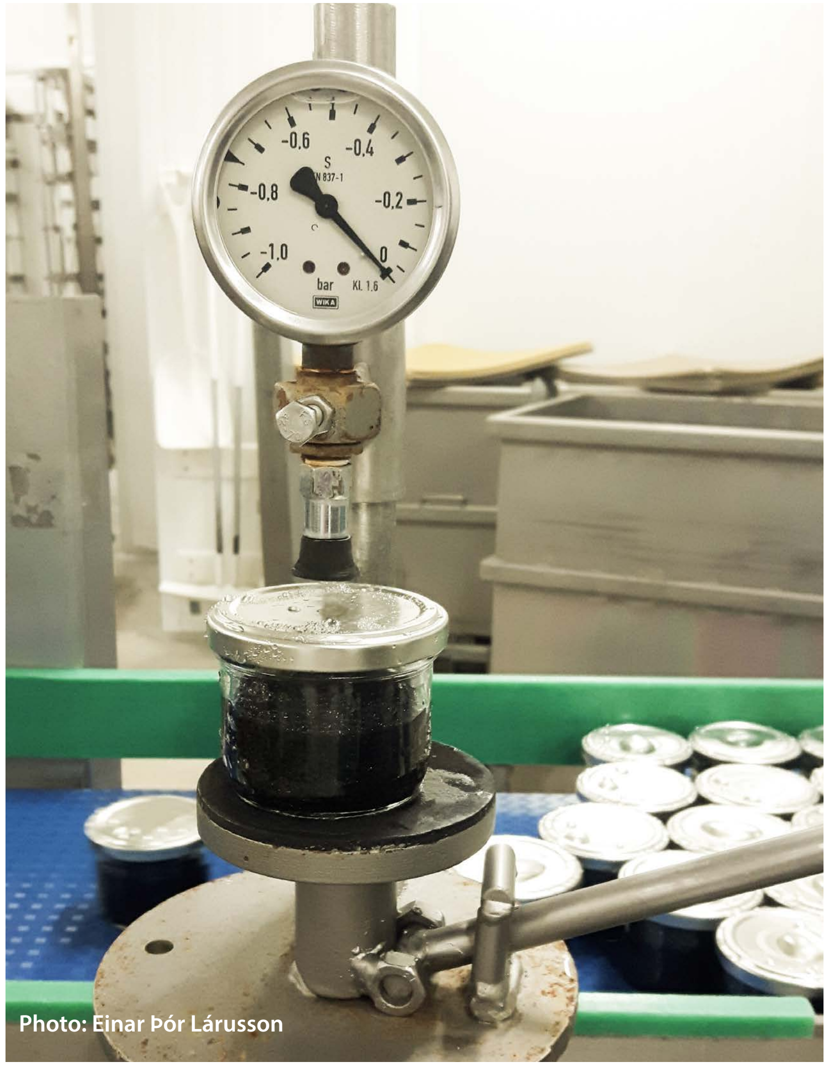
Ideally, the following issues can be mentioned as they do matter and are worth inspecting to ensure safe closure:

As under-pressure is important for the closure of the glass containers, it is necessary to monitor whether the under-pressure is in accordance with the packaging manufacturer's instructions and criteria's.

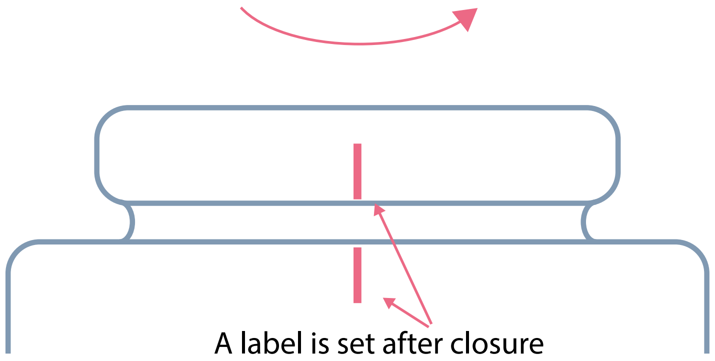
A product like this is best fitted in glass jars.

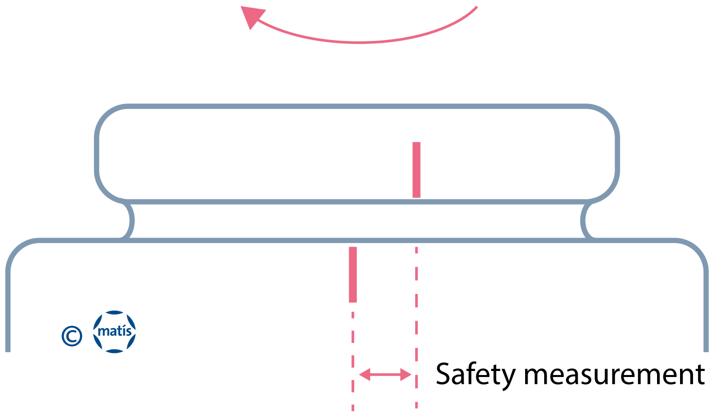
A quick and simple method is to fill some glasses with cold water and slide them through the closing machine and then measure the under-pressure. This must be done when the machines are started after a break or when making changes.

It should be monitored whether the cover is



Facilities to measure the under-pressure in a jar with caviar, in this case the target is - 0.2 bars





sitting correctly on the jar and does not tip up. Here it is important to look at the bracket that is located where the neck and body meet and use the bracket as a guidance to see if the cover is sloping or not.

It is obvious that when the cover tips up the edge of the cover is not going under the threads in the neck of the jar and the sealing compound or gasket is not pushing against the glass edge.

The sides of the cover can be damaged during closure so that the cover does to tip up but the side of the cover is not able to reach under the threads on the glass neck.

The threads of the glass jar can break when the cover is pressed on, if that happens the sides of the cover will stick out.

Under-pressure is seen when the centre of the cover is pressed down and after cooling it should be even clearer in terms of this. The centre of the cover should not lift until the lid is released and air penetrates into the container.

The under-pressure needed in the jar depends on the product involved, processing method and the criteria set by the packaging manufacturer.

The temperature shall be according to the product and the processing method, but the temperature needs to be monitored to secure under-pressure.

Headspace (air space), in most cases the headspace under the cover shall not be less than 6% of the internal volume of the glass jar at the temperature of filling and closure. When the headspace for a given product has been decided, it should be monitored.

The headspace should be enough to accommodate the steam needed to form a sufficient under-pressure when the product cools.

The volume of the head space is also important if the product is heated after closure as the product needs space when it expands when heated. If the head space is not enough the lid could come off when the product expands.

The sealing compound inside the cover need to be monitored and when cover is removed, a clear mark must show that the edge of the jar has been in contact with the sealing compound the whole circle.

A defect is known where the edge of the jar cuts through sealing compound inside the cover and to the metal of the cover, this causes a leaky closure an must be corrected without delay.

A pressure gauge can measure the force needed to twist a lid from a jar and can be a part of the quality control, but the strength of the closure can change during storage.

Height from the bracket - as mentioned earlier there is a bracket running around the jar where the jar body meets the neck. The distance from this bracket to the top edge of the cover can be used to evaluate how well the lid is placed on the jar.

Safety measurement of the closures (see picture on previous page) can be performed by placing a vertical strip on the side of the cover and down onto the body of the jar and then release the cover until the under-pressure disappears. Then screw the cover on again by hand and check whether the line on the cover is on the right or left of the line on the body, this deviation can be measured.

If the line on the cover goes past the line on the body and more to the left, the closure has been too loose but if the line is to the right the closure has been too tight.

All these measurements and inspections need to be evaluated in cooperation with the package's manufacturer and as always, inspection of packaging materials before use is a good practice to minimize complications from the packages during production.


Photo: Kristín Edda Gylfadóttir

It is ideal to use a glass packages for small production lots.

ORA sponsored the English translation of this handbook.

Preserves in plastic

As technology and development of plastic packaging advanced, the possibility of heating food at high temperature in plastic bags became available. Such products first came on the market in Japan and Europe around 1970.

Additionally, there are all kinds of plastic packages that store ready-to-eat food of various types. Miscellaneous ready-to-eat dishes are available for consumers, salads in transparent plastic trays, sauces in plastic bottles, herring in plastic jars, etc.

Very popular the last few years are small pouches with a nozzle containing commercially sterile (canned) baby food of various kinds and these products are generally named "Squeezes"

It appears that baby food is developing into these packaging instead of the small jars, which dominated the market a few years ago.

The commercially sterile pouches also have food for adults, which often is marketed as nutritious and easy to grab for outdoor activities.

The use of bags for commercially sterile products instead of cans or glass jars have many advantages and the following may be mentioned:

1. The bag shape makes it possible to heat the content in a much shorter time and therefore the processing time is shorter and energy is saved.
2. A shorter heat treatment results in less loss

"Canned" baby food in plastic packaging

of nutrients and taste, colour and texture is better maintained.

3. For consumption the bags only need to be heated for 3-5 minutes for serving a hot meal.

4. Products in bags uses similar storage space as cans or glass but after use the bags take up much less space.

5. Shelf life of products in bags is comparable to cans and glass.

6. The surface of the bags does not corrode and the probability that the plastic inside the bags will contaminate the product is very low.

7. Generally, it may be considered that the bags are less expensive than metal cans and glass.

8. Bags, as empty packages use much less space and are lighter than cans and glass. This can save a lot in transport and storage. Bag containers weigh less as a percentage of packaged product which in turn can save considerably in transport.

9. Bags can easily tolerate retort temperature, which usually is heating to 108-121°C.

10. Bags have good barriers properties against oxygen and moisture.

The bags thus have many positive properties and meet most requirements that packages need to have to protect the food during transport and storage and lasts throughout the product shelf life.

The bags protect the product from contamination, prevents access of microorganism and oxygen and secures the safety of the food. The bags can tolerate considerable load and simultaneously they protect the food from chemicals, which could affect taste and odour.

In contrast to these positive aspects, plastic as a single use package has lately received negative coverage due to the contamination that plastic packages are causing. The bags are designed to resist considerably more load than common plastic and will therefore last into the distant future and long after the content has been used if the bags are not routed into a right re-cycling.

Aa wide range of different "squeezes" in retail stores

Glass and metal can easily be directed to reuse or recycling.

The retort bags are made of many layers of different plastics and this has made the recycling possibilities difficult and complex.

To motivate modern consumers the ideas of sustainability and reuse needs to be considered. Unfortunately, the plastic is not scoring high when these concepts are considered.

To motivate modern consumers the ideas of sustainability and reuse needs to be considered. Unfortunately, the plastic is not scoring high when these concepts are considered.

Larger and more productive producers receive the material for the bags on rolls and form them as soon as the filling occurs, while other smaller producers purchase ready-to-bag bags where one side is open.

Very noticeable the last few years are small retort pouches with a nozzle and the manufacturer fills the bags through the nozzle and then fastens a tight tap onto the nozzle. The baby food seems to be going into these containers instead of small glass jars.

Plastic trays should also be mentioned, which often have few compartments. In processing a hot ready-to-eat food of various kinds are placed into these compartments before a film is fasten to the edges of the trays. After closing it is common to heat the tray and its content to 72-75°C. These products are then distributed as refrigerated products to retail stores and the consumer only needs to heat the product in packages in boiling water or in a microwave.

Understandably, safe closure is of utmost importance as for all other packages used for preserves. In the case of bags, which are to be resistant to heating, they are coated on the inside with “polypropylene” or PP and during closing this plastic is being melted to form a tight closure. The same kind of plastic or PP is in the interior of all these food trays, and the film used to close them is the same type.

All these plastic containers have multiple layers, but the general rule is that the food contact surface is PP and it is also the plastic that is melted to form a safe closure of the bag and tray.

Then there are layers that are to prevent flow of gas compounds like oxygen or water vapor over the film, such films can be made of aluminium, EVOH (ethyl vinyl alcohol), silicon oxide or aluminium oxide. The outmost layer can be made from nylon or polyester. To keep all these different layers together to form a complete film a glue is used based on polyurethane.

In retail stores various kind of food in plastic packages can be found in different sizes and types.

Triton sponsored the English translation of this handbook.

TRITON ltd

a leading exporter of preserves since 1977

Weighing and e-rules

Preserved products are usually packed in retail packages and therefore go directly to the consumer after short stop at retail store or catering kitchens. Therefore, it is ideal to end this review by discussing the main rules regarding weighing and e-labelling.

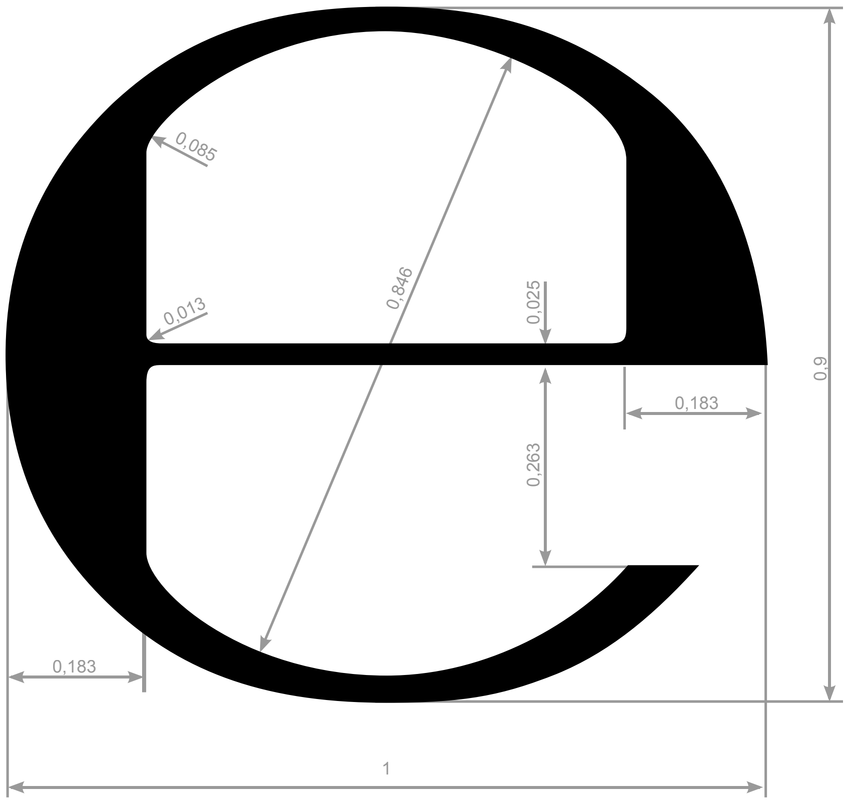
When a product is labelled by weight or number, there are in most of our market countries certain rules on the minimum content of packages relative to labelling and in most cases these rules are set out in laws and regulations.

The purpose of these rules is to safeguard the interests of consumers (buyers), and to take into account the interests of producers.

In past years, it was generally assumed that every pack would contain at least a marked weight, this was very good for the purchaser but not as favourable for the producer since he had to ensure correct weight by putting extra weight into the package, i.e. to have a certain overweight. The quantity of overweight was highly dependent on the precision of the weighing and filling method.

It is practically impossible not to give some overweight, despite the most advanced scaling equipment it will never be completely avoided.

But there are several methods to minimize overweight and some of which do not cost much other than a little work and examination of how the weight has been lately. Such an examination mainly involves analysing the weight distribution and if it



The e-label must of course fulfil certain criteria.

Nominal quantity in g or ml			Tolerable negative error As a % of nominal quantity	g or ml
5	to	50	9	--
50	to	100	--	4,5
100	to	200	4,5	--
200	to	300	--	9
300	to	500	3	--
500	to	1.000	--	15
1.000	to	10.000	1,5	--
10.000	to	15.000	--	150
	Above	15.000	1	--

Allowed deviations depend on the marked weight of the units

is possible to reduce the overweight without the risk of breaking any of the weight rules.

Most often, there are certain product specification (packing rules) available before the product is produced, and these product specifications are a kind of an agreement between the manufacturer and the buyer on which conditions the product should meet.

General official regulations, whether they are weight regulations or others, indicate minimum standards. Buyers can set stricter standards for their products or process specifications, a criterion that must then be considered when pricing the product.

Icelandic rules:

With the implementation of EU Regulation, No 1169/2011, the following national rule was inserted into the Icelandic Regulation No. 1294/2014:

4. gr. – NET weight.

NET quantity of food, in. Article 23 European Parliament and Council Regulation (EU) No. 1169/2011, shall be as follows:

a) Exact quantity: Each unit of the product is measured and then marked and priced by quantity. The requirement for accuracy depends on the requirements, which are made for certified measuring devices for such purposes.

b) Average quantity: If production lots are packed by average quantity, the provisions of the regulation. 437/2009 for e-labelled pre-packages shall be followed, in respect to authorized negative deviations

c) Minimum Quantity: Specify specifically that this is a minimum quantity with the meaning of "at least" or "minimum" before the net quantity on the pre-packaged product.

Here the marked weight is 115 g e and according to the table on this page, the allowed deviations are 4.5% of the market weight or 115 x 0.045 = 5.2g

About 1980, the e-rules took effect in the European Union (EU) where the marked weight is based on the average weight (average system).

EU rules require that the product passes a reference test, but the rules also offer a special control of filling and the manufacturers of such products can then mark their product with an e-label.

Such labelling means that the product has a kind of passport within Europe, so it will be legible in all the countries.

This principle has been incorporated into Icelandic regulation, as was stated above.

The three e-rules:

There are three basic principles that producers should comply with in addition to regular inspection.

Rule 1: The contents must not be on the average less than the labelled weight.

Rule 2: Up to 2.5% (1 of 40) units may be lighter than the labelled weight minus the allowed deviation, T1 (see example later). Those units are called "non-standard".

Rule 3: No unit may be lighter than the labelled weight minus the double-allowed deviation T2. Such units are called "inadequate" (not acceptable)

- **Examples of the use of these rules:**
- The package is labelled to be 115g, it means according to the table above that the allowed deviation is 4.5%.
- "Non-standard" units are those units that are lighter 115g – (115 x 0.045) = 115g – 5.2 = 109, 8g and the units that are "inadequate" (unacceptable) are lighter than 115g-2 x 5, 2g = 104, 6g.
- In order to follow the three rules, the average must be more than 115g and only 1 in 40 (2.5%) units may be lighter than 109, 8g and lastly, no package may be lighter than 104,6 g.

Canned product in a restaurant window offering a variety of tapas dishes made from canned products

To obtain a responsible conclusion and to confirm that the product or production lot meets these requirements of weight, then accepted method of sampling must be followed for example, the size and number of samples..

In communications between buyers and producers these rules are often referred to, and it is very common to talk about T1 on the one hand and the T2, on the other.

T1 in the example above corresponds to 109, 8g and T2 is 104, 6g.

It should be kept in mind that individual buyers may have stricter requirements than these above and that must then be consideration when determining the weight.

Some of the modern scale equipment has the e-rules programmed into their memory and therefore control the correct weight into the packages, but nonetheless monitoring is needed, and samples should be taken to prevent claims caused by incorrect weight.

The e-rules are not the only requirements on the market and therefore the different criteria for different markets need to be evaluated before setting the weight for a given product.

In the US, rules can be found at „National Institute of Standards and Technology" where weights rules can be found in „Handbook 133 – 2018; Checking the Net Contents of Packaged Goods".

Photo: Páll Gunnar Pálsson

Example of plastic packaging material for marinated herring

Vignir sponsored the English translation of this handbook.

Struvite or glass fragments

Some years back a valuable product was wasted in Iceland as it was believed that glass fragments had been found in a batch of herring fillets that was used for canning. The responsible persons for that process had never heard about "struvite crystals" in canned fish so very costly actions were taken like wasting considerable amount of product.

A certain thing is that these were the first encounters of this producer of struvite crystals and therefore the reaction taken at that time is understandable. It is easy to confuse struvite crystals and glass fragments together if one does not know better.

The formation of struvite crystals is rather rare and the probability of finding such crystals are small. Since they are not hazardous, no action has been taken to prevent their formation. It is possible to bath the fish in a phosphate solution or adding aluminium sulphate to reduce the likelihood, but it is not worth the bother and additionally the use of additives can have negative effects.

Struvite is a natural substance called magnesium ammonium phosphate ($NH_4MgPO_4 \cdot 6H_2O$) and may form a noticeable crystal in certain conditions. These crystals are transparent and tasteless, their size may vary from being like fine salt to a 5-6 mm long.

Struvite is mainly found in canned fish and especially in canned salmon, tuna, mackerel, herring and shrimp. These crystals are not dangerous and the materials in them are everywhere in nature. When eaten they do not dissolve in saliva, but if they reach the acid in the stomach they will dissolve.

If there is any doubt about whether the crystals are glass or struvite, then it can be placed in a weak acid such as vinegar and heated for five minutes or so. Struvite crystals dissolve while the glass does not change, furthermore it is easier to break or squash struvite crystals than the glass fragments.

Struvite was sometimes noticed in canned "kippers"

References

The author of this Handbook on preserved product, worked as a quality and production manager in Norðurstjarnan Ltd for nearly six years, and gathered considerable experience and knowledge in the production of preserved products. During these years, the author participated in compiling a publication on “Quality control in the preserved product industry”, 1985. This background has been useful for the compilation of this handbook.

Einar Thor Lárusson, an expert at ORA Ltd, has many years of experience in production and product development of preserved products. Einar has been actively involved in reviewing the material, providing materials and images for this publication.

The following references have additionally been useful in the compilation of this handbook:

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