FOOD SAFETY ISSUES IN FOOD PACKAGING - ASEPTIC TECHNOLOGY APPROACH*

Hari Yanto Tekno Yuwono
Tetra Pak Indonesia

ABSTRACT
Companies involved in processing, marketing and distributing food products are fully aware of the growing pressure on assuring food safety and quality. UHT-treated and aseptically packaged products have become popular from the viewpoint of food safety and health. Aseptic processing and packaging allows sensitive liquid foods to stay safe and fresh and gently protects the natural flavour and nutritional content of liquid products, giving consumers more quality and better taste. Since the cartons can be stored un-chilled for months, consumers will benefit from improved food safety due to less spoilage and waste.

The quality of raw (packaging) material, the UHT sterilization equipment, the aseptic packaging system, their process controls and quality system play important roles to determine food safety, quality and conformance of the finished products.

As the world's leading food processing and packaging solutions company, Tetra Pak is committed to making food safe and available, everywhere. And our commitment extends far beyond protecting the contents in a package. It also includes support for our customers' businesses, a responsibility to reduce our environmental impact, and shape a better future for all our stakeholders - from our employees, to our suppliers and the communities in which we operate.

ASEPTIC TECHNOLOGY AND ULTRA HIGH TEMPERATURE (UHT) PROCESSING SYSTEM

There are four fundamental blocks of aseptic technology. First is commercially sterile food that should be transferred aseptically into...
the sterile surrounding and meet with sterilized packaging material so that we can have a result of aseptic finished product. As we know, there several causes of food spoilage, which are microorganisms, oxygen or other gases, light, moisture, and odors. For example, in a milk product, as we can see in Figure 1, in the same period of time, the growth of bacteria is significantly different depending on the temperature. That is the reason of immediate pasteurization or cooling process of fresh milk to maintain the growth of bacteria.

![Figure 1. The amount of bacteria increases with milk temperature](image)

One of the most effective ways to reduce the load of bacteria is heat treatment, e.g. pasteurization. However, we need a sterile product, not just a pasteurized one, in aseptic technology. In a sterile condition, a product should be free from all microorganisms. But, absolute sterility is not possible because of the logarithmic heat treatment reduction of bacteria. Therefore, the process is called commercial sterility. The commercially sterile product must be free from microorganisms and toxins harmful to the health of consumers, free from any microorganisms that can liable to proliferate during storage and able to be kept without deterioration, also stable and having good commercial value during storage.

To have a good product, we have to start from raw because raw material quality is the first condition that determines the final product quality. It is impossible to produce a high quality product from poor quality raw materials, but it is quite possible to produce a poor quality product from high quality raw materials. Besides that, intermediate product quality is also important. Pre-processing should also be in control, e.g. mixing, blending, separation, sampling analysis, inspection, homogenization, and pasteurization.

In FDA regulation 853/2004, it is stated that UHT is a process involving a continuous flow of heat at a high temperature period of time (not less than 135°C in combination with holding time) so that there are no viable microorganisms capable of growing in the treated product when kept in closed container at ambient temperature. Also, the product must remain microbiologically stable after incubating for 15 days or 7 days at 55°C in closed containers or after any other method demonstrating that the appropriate heat treatment has been applied.

![Figure 2. Direct UHT, indirect UHT, pasteurization conventional sterilization system](image)
the sterile surrounding and meet with sterilized packaging material so that we can have a result of aseptic finished product. As we know, there several causes of food spoilage, which are microorganisms, oxygen or other gases, light, moisture, and odors. For example, in a milk product, as we can see in Figure 1, in the same period of time, the growth of bacteria is significantly different depending on the temperature. That is the reason of immediate pasteurization or cooling process of fresh milk to maintain the growth of bacteria.

To have a good product, we have to start from raw material because raw material quality is the first condition that determines the final product quality. It is impossible to produce a high quality product from poor quality raw materials, but it is quite possible to produce a poor quality product from high quality raw materials. Besides that, intermediate product quality is also important. So that pre-processing should also be in control, e.g. mixing, blending, degeneration, separation, sampling analysis, standardization, homogenization, and pasteurization.

In FDA regulation 853/2004, it is stated that UHT is achieved by involving a continuous flow of heat at a high temperature for a short period of time (not less than 135°C in combination with a suitable holding time) so that there are no viable microorganisms or spores capable of growing in the treated product when kept in an aseptic closed container at ambient temperature. Also, the products should remain microbiologically stable after incubating for 15 days at 30°C or 7 days at 55°C in closed containers or after any other method demonstrating that the appropriate heat treatment has been applied.

One of the most effective ways to reduce the load of bacteria is heat treatment, e.g. pasteurization. However, we need a sterile product, not just a pasteurized one, in aseptic technology. In a sterile condition, a product should be free from all microorganisms. But, absolute sterility is not possible because of the logarithmic heat treatment reduction of bacteria. Therefore, the process is called commercial sterility. The commercially sterile product must be free from microorganisms and toxins harmful to the health of consumers, free from any microorganisms that can liable to proliferate during storage and able to be kept without deterioration, also stable and having good commercial value during storage.
There are two available UHT systems, which are indirect systems and direct systems. Indirect systems usually use plate heat exchangers which is cheaper comparing to tubular heat exchangers, tubular heat exchangers which is more effective for product with particles, and scraped heat exchangers which is used for quite thick product. Comparing to indirect systems, direct system can produce higher quality of product because it has a less effect to product's nutrition. There are two systems, which are steam injection and steam infusion. Figure 2 shows the difference between direct UHT, indirect UHT, pasteurization, and conventional sterilization system. Basically, we can kill all kind of microorganisms by UHT system, except the spores. We can only force the spores in dorm condition.

To get a commercial sterile product, we also need to know the nature of the product. It can be divided into two types which are high acid product and low acid product. Product with pH below 4.6 is considered as high acid product, while product with pH above 4.6 is considered as low acid product. Naturally, high acid product has no growth of pathogenic bacteria, no spore germination, no public health risk, and can be commercial sterilized by pasteurization 90-130°C for 30 seconds. Meanwhile, low acid product is more sensitive and can be commercial sterilized by sterilization or UHT treatment 135-140°C for 2-4 seconds. The examples of low and high acid beverage processing can be seen in, respectively, Figure 3 and Figure 4.
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ASEPTIC PACKAGING SYSTEM

Aseptic packaging system is a packaging process by which microorganisms are prevented from entering into the package during filling process or after packaging process. This definition applies independently of the packed product, so aseptic packaging is possible whether the product is sterile or not.

Aseptic Packaging Material

Tetra Pak packaging material consists of 6 layers. As seen in Fig. 5, the first layer, from the outside, is polyethylene followed by paper, polyethylene, aluminium foil, polyethylene and polyethylene. Each material that we used in Tetra Pak packaging material is compliant with European Framework Regulation and United States Law & Code of Federal Regulation (FDA, 21 CFR).

Production of packaging material consists of 3 step processes which are printing, coating, and slitting. Packaging material quality also determines the final product quality. To maintain the quality, we should keep the storage premises clean and store raw material, packaging material, and finished product separately. The temperature and the relative humidity should be, respectively, 10-30°C and 40-65%. The plastic wrapping should not be removed and partially used reels should be wrapped. Using a FIFO system, cleaning, and disinfecting hands before handling the packaging material are also important to maintain the quality.

Aseptic Filling System

As seen in Fig. 6, it is the features of Tetra Pak fill. From the packaging material reels, the packaging longitudinal seal strip and hydrogen peroxide system. Sterile system in Tetra Pak filling machines can be seen in the filling system with seal regulating. The types of seal, which are transversal seal and longitudinal, is applied for covering the part of sealing to ensure that it does not soak the seal.

The whole system is called Tetra Pak roll/tube benefits are saving space before and after filling, sterilization surface of packaging material, simple filling system that is hygienic, totally filled packages for high product quality, distribution, and head space possibility using inert gas. It enable shaking, better pouring, and new volume creati. Overall, the benefits of aseptic products packed in Tetra P are reduced need for chilled storage and distribution, long shelf-life, any preservatives, high quality products with 'gentle' treatment, convenience, and practical.

Figure 5. Tetra Pak Packaging Material

Figure 6. Main features of Tetra Pak filling machine
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Aseptic Filling System

As seen in Fig. 6., it is the features of Tetra Pak filling machine. From the packaging material reels, the packaging is filled into longitudinal seal strip and hydrogen peroxide system and sealed. Sterile system in Tetra Pak filling machines can be seen in Fig. 7. Induction heating is used in sealing the packaging. There are two types of seal, which are transversal and longitudinal seal. LS-strip is applied for covering the part of sealing to ensure the liquid product does not seak the seal.

Figure 6. Main features of Tetra Pak filling machine

The whole system is called Tetra Pak roll/tube concept. The benefits are saving space before and after filling, sterilizing whole surface of packaging material, simple filling system that gives high hygiene, totally filled packages for high product quality and good distribution, and head space possibility using inert gas injection that enable shaking, better pouring, and new volume creation product. Overall, the benefits of aseptic products packed in Tetra Pak packages are no need chilled storage and distribution, long shelf-life without any preservatives, high quality products with ‘gentle’ UHT heat treatment, convenience, and practical.
Quality Parameters

**Hydrogen Peroxide (H₂O₂)**

Hydrogen peroxide is used to kill bacteria in sterilization of the packaging material and filler. The qualification is food grade, aseptic grade, and packaging grade. The concentration of the solution is 35-50% w/w with maximum residue 0,5 ppm on the package.

**Sterility**

Sterility has to be maintained during the entire length of the intended production run. It is important to avoid recontamination of product and packaging material. Pressure in aseptic chamber and sufficient H₂O₂ temperature and concentration are also needed. Sealing supervision to ensure the production of tight packages is also part of the parameter.

**Product Evaluation**

The procedure of quality control consists of sampling and evaluation. There are two types of sampling, which are random (time based) and aimed. The evaluation includes pH measurement, package integrity, and microbiological testing. Integrity is quite difficult because the checking procedure is subjective, so the test methods usually are careful visual dye testing, conductivity measurement, dissolving of seals, and tear down procedures.

**Cleaning**

There are four important parameters (four Ts) cleaning in place, which are temperature, time, turbulence titration (concentration). The efficiency of mechanical cleaning mainly depends on the mechanical treatment, appropriate tools must be available. The verification result consists of visual check, microbiological test, and ATP luminescence test (adenosine triphosphate bioluminescence).

**Storage, Records, and Documentation**

Finished product storage applies FIFO principle release system, proper storage control, and suitable drain. Proper drainage. Meanwhile, record and documentation are for quick and efficient dealing with process deviations.
Sterile System in TP Filling Machines

Figure 7. Sterile system in Tetra Pak filling machines

Quality Parameters

Hydrogen Peroxide \( (H_2O_2) \)

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Product Evaluation

The procedure of quality control consists of sampling and evaluation. There are two types of sampling, which are random (time based) and aimed. The evaluation includes pH measurement, sensory evaluation, package integrity, and microbiological testing. Package integrity is quite difficult because the checking procedures are very subjective, so the test methods usually are careful visual examination, dye resting, conductivity measurement, dissolving of transversal seals, and tear down procedures.

Cleaning

There are four important parameters (four Ts) to control cleaning in place, which are temperature, time, turbulence (flow), and titration (concentration). The efficiency of mechanical or manual cleaning mainly depends on the mechanical treatment. Therefore, appropriate tools must be available. The verification of cleaning result consists of visual check, microbiological test, swab test, and ATP luminescence test (adenosine triphosphate bioluminescence).

Storage, Records, and Documentation

Finished product storage applies FIFO principle, positive release system, proper storage control, and suitable flooring and proper drainage. Meanwhile, record and documentation are essential for quick and efficient dealing with process deviations and troubleshooting.