

Precautionary Hygiene
for Product and Plant

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Hygiene is naturally a basic necessity for bringing a drink onto the market.

For a long time, it was limited to the microbiological end product quality control of the filled product in a more or less representative number of random samples. Manufacturers often found by painful experience that this is not sufficient. Customer complaints resulted in the return of products from the market, and in some cases even microorganisms which could be detrimental to health were found. Rights for compensation and a loss of company image resulted.

In the meantime, hygiene is planned into the product. Preventive measures eliminate quality shortcomings right from the start – and the microbiological testing mainly serves to demonstrate that the preventive measures have the planned effect or success.

Recipes and product spoilers.

The composition of a beverage is the starting point for precautionary measures. It is an important factor in the evaluation of the risk of microbial spoilage of the product. The degree of risk of such spoilage differs greatly between various beverages (see Fig. 1).

Beverages with a low risk have natural protective factors which effectively suppress the growth of a large number of the microorganisms which are present, or even inactivate them.

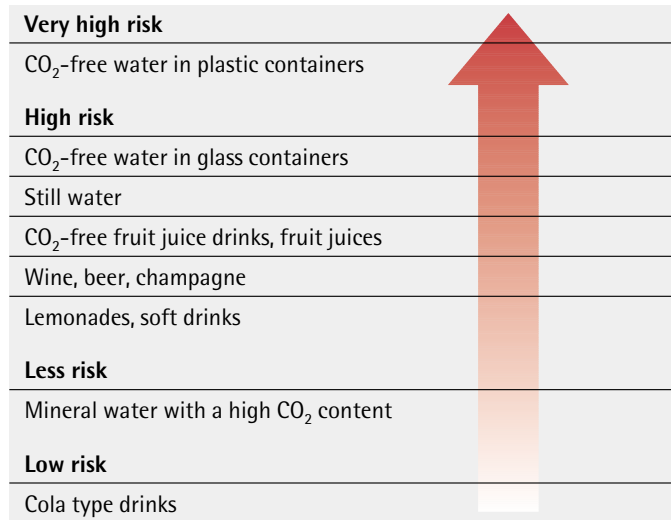


Figure 1
The microbiological risk for various types of beverages

The pH.

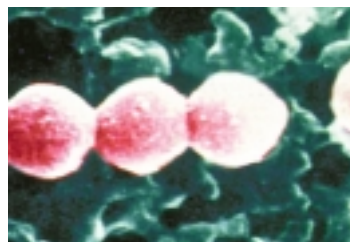
The most important of these protective factors is the pH of the beverage. As a rule, bacteria prefer pH values which are in the neutral to slightly alkaline range. Most non-alcoholic soft drinks and also juices (with the exception of vegetable juices) have a pH which is well into the acidic range, just as beer, wine and champagne do. Because of this, the greatest percentage of bacteria, including those species which cause disease or food poisoning, drop out of consideration. Only the acid-tolerant bacteria, such as acetic acid bacteria and lactic acid bacteria, are left, and with these we have named the two major groups of bacteria. Both distinguish themselves by their high tolerance to acids, as they themselves are acid formers. In addition to these two families, the yeasts and moulds groups also exhibit outstanding acid-tolerance. Like the acid-tolerant bacteria, they are dangerous to beverages as potential product spoilers. As a rule, however, they are harmless for the consumer, with the exception of those moulds which are capable of forming mycotoxins (aflatoxin, ochratoxin etc.).

Lack of oxygen.

The second most important protective factor is the absence of oxygen. It results in the exclusion or suppression of all aerobic microorganisms, and they are by far the majority. They include almost all the bacteria which are introduced with the raw material water, as waterborne bacteria are predominately aerobic. All carbonated beverages have this natural protective factor, and the CO₂-free beverages which are filled in glass bottles or cans also have it to some degree. Moulds and the large group of aerobic bacteria (which includes the acetic acid bacteria) are so eliminated. The anaerobic and microaerophilic bacteria, e.g. clostridium and lactic acid bacteria, are left, as are the yeasts, which grow slower when oxygen is lacking, but still grow.

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Natural protective factors in drinks and how microorganisms overcome them	
Low pH	▶ Acid tolerance
Lack of oxygen CO ₂ content	▶ Anaerobic growth
Inhibitors: such as alcohols, ethereal oils, tannin	▶ 
Lack of essential nutrients and vitamins	▶

Figure 2
Natural protective factors
in drinks

Special components.

Further important inhibitory substances in drinks which affect the metabolism of microorganisms are alcohols, ethereal oils and tannin. None of these inhibit as strongly as the previously mentioned factors, however. Nevertheless, alcohol acts strongly inhibitory to moulds, and, in increasing concentration, also to bacteria. Yeasts, acetic acid bacteria and lactic acid bacteria display a higher tolerance to alcohol, which is why they can still be present in wine and beer. Only the special fermenting yeasts are to be found in higher percentage alcoholic drinks, and, when the alcohol content is higher than 20%, viable microorganisms are not to be feared, although they certainly still have a chance of surviving as spores. Other natural chemical inhibitors such as ethereal oils and tannin, as named above, have a limited preserving effect.

Lack of nutrients.

In many lemonades, the lack of essential nutrients and vitamins negatively influences the growth of demanding bacteria and so excludes many lactic acid bacteria. It also even causes problems in starting fermentation with high-yield but low-content types of grapes.

The producer who knows the composition of his product as well as the growth characteristics of the most important microorganisms can therefore very quickly estimate the degree of risk for his product, and which are the major potential spoilers he must look out for.

The natural exclusion of the majority of the product-spoiling bacteria has the result, however, that "specialists" which can overcome the limitations can grow to tremendous numbers, just as can pests in the unnatural monocultures of modern agriculture.

Hygiene-relevant bacteria.

Regardless of the subsequent composition of the product, the hygiene of the water for beer, and for non-alcoholic beverages whose major component is water, must be carefully looked after. Even when faecal bacteria would not survive long in the product, they can on no account be tolerated. The quality of the raw material water is the foundation in the production of non-alcoholic beverages and beer. High counts of bacteria in the production process are an unmistakable indicator of processes which are not hygienically flawless. Rinsing, cleaning, flushing out and spraying-down require water which at least complies with the Drinking Water Regulations, or those for mineral water and table water. Internal company limits for water, both as a raw material and for cleaning purposes, are frequently even more stringent than the official requirements.

Basic and raw materials for the production of beverages, e.g. syrup, sugar, essences and others which the producer purchases, can be given limits for colony counts and problematic microorganisms which must be held by the supplier for a batch or delivery to be accepted. A certain sense of proportion must be maintained here, however. Limits which can hardly be met, or cannot be met, in practice (e.g. no yeasts in 10 g of sugar) cause an increase in raw material costs and are unrealistic as well as often unnecessary. Parallel to the supplier, the receiver should also carry out tests on random samples to check compliance with the limits. Methods and evaluation criteria must be agreed upon by both parties to avoid misunderstandings. Some basic ingredients, such as syrups or essences, are microbiologically very stable because of their nature. This means, however, that on mixing – and dilution to the drink concentration – they can assist any product spoilers which have survived in them to grow at a dangerous rate.

The production process.

The colony count can increase during the production process itself. This fact must be taken into consideration from the start, and the process correspondingly monitored. Storage tanks, for example, are always potential danger points in the production process. Water treatment, in particular iron or sulfur removal, always carries a high risk, because here the water is led over large surface areas under the addition of oxygen. An abrupt growth of flora, even by as much as a power of ten, can occur, and unwanted bacteria such as coliforms also have a good chance to grow. The microbiological, hygienic monitoring of such procedures is a necessity.

There are many points in a beverage producing company where samples must be repeatedly taken during the day, in order to be able to timely recognize a trend towards an increasing bioburden. A good, accustomed routine shows such trends, and enables the process step in question to be found and the problem to be remedied in advance, before alarmingly high values have been reached. A representative sample volume is important for this, so that, for example, successively increasing colony counts can be immediately recognized. One should not depend here on the detection of limiting values, these can be sufficiently well covered by qualitative determinations such as liquid enrichment according to the Mineral and Table Water Regulations. Quantitative tests must also be carried out.

Test methods.

The membrane filter method is always the most effective way to microbiologically test drinks. As a rule, any size volume can be examined, so that even trace infections of a few bacteria in a whole bottle of a filled drink can be brought to light. The second great benefit of the membrane filter method finds too little attention: When the filter is rinsed with sterile water after filtration of the sample, any inhibitory substances and preservatives coming from the product are washed out of the filter, so that the microorganisms concentrated on it have better growth conditions.

The filtration of drinks containing CO₂ and of fruit-turbid drinks is often slow or even only possible for small volumes, however, as the pores of the filter quickly become blocked by the gas bubbles or by solids in the drink, e.g. fruit pulp or thickening agent. In this case, a few tricks can frequently enable the sample volume to be increased to an acceptable value:

- Increase the filter area by dividing the sample over several filters.
- Use a larger pore size filter, or a special High-Flow membrane.
- Prefilter to remove coarse fruit pulp.
- Use emulsifier for drinks with a high content of ethereal oils.
- Enzymatically decompose the solid substance when the drink contains thickening agent based on cellulose or hemicellulose.

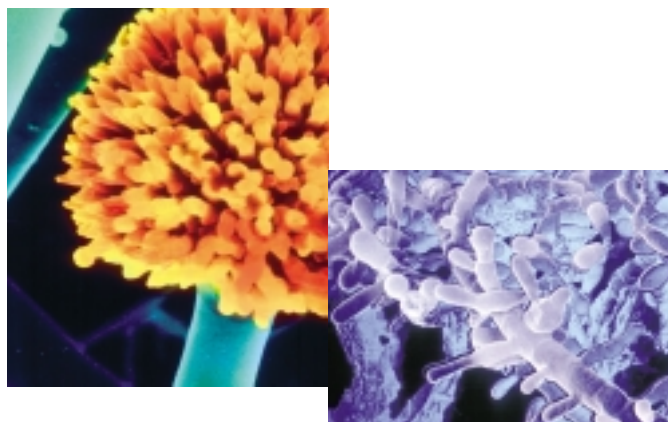
The choice of suitable nutrient medium is of great importance. Ready to use media such as Nutrient Pads are cost-saving because they eliminate the time, energy and materials otherwise needed for media preparation, as well as possible mistakes in the preparation. Their stability and storage are no problem. Each lot of end product is controlled with the relevant test strains so that the recovery for the type of microorganisms tested for is guaranteed. This benefit should not be underrated! It is namely hardly possible to check the suitability of self-made media with test bacteria in a beverage industry microbiological laboratory. Not only is there no time for this, there is also generally no official authorization for working with microorganism cultures.

In-house controls.

How often, how much and where? These are the fundamental questions in the microbiological control of a plant. The answers to them must always be based on a consideration of the product itself and the degree of risk it carries, as previously described, and also of the particular conditions prevailing in the plant. As the results of microbiological tests are always delayed, unlike those from chemical and physical tests, the processing steps and procedures must be safeguarded in advance.

Occasionally, filling plants have extremely long distances over which the product or components of it are led. Branched and ring piping keep production variable and allow a change of sort and deviation to another filling line, but there is a certain amount of risk in such complicated piping systems. A segment with a blind end can easily become a source of infection! A short piece of piping which is by-passed during steaming or hot water sterilization can lead to spreading of infection. Finding such sources in a complicated piping system is difficult, time-consuming and needs the intuition of a detective. Good co-operation between the engineer who planned, or is in charge of, the plant and the microbiological assurance staff is of decisive importance for the quick finding of a solution to a problem which has appeared, rather than making the tracing and solving more difficult by accusing each other of being responsible for it.

All raw materials are routinely examined: raw water, treated water, essences, syrups, sugar and other components. Whenever possible, each lot or delivery must be individually examined. Large tanks which are tapped over a long time period must be controlled more often, however. Once daily when production is continuous. Samples of end product must be taken from the start, middle and end of the production day run.



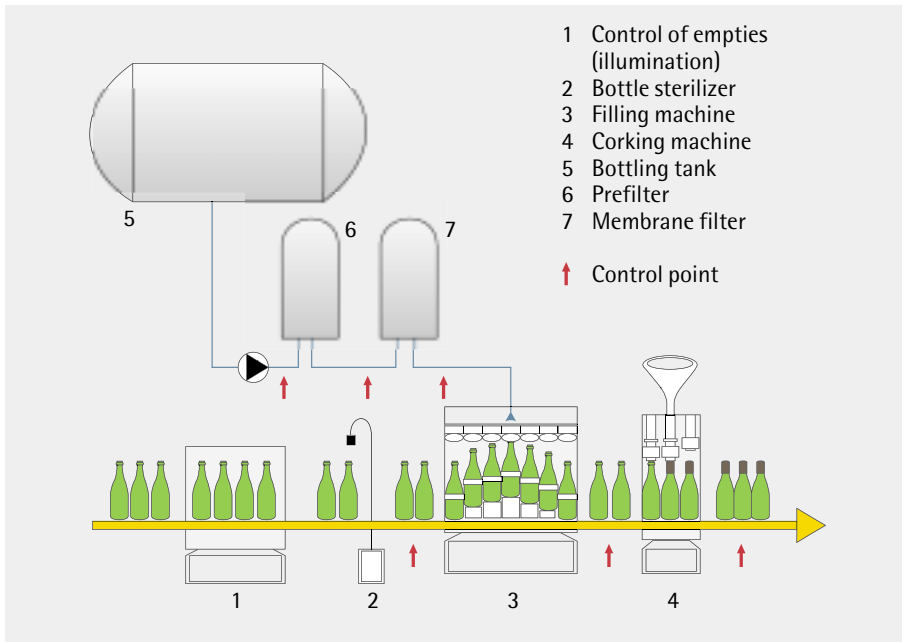


Figure 3
Where to control a bottling line (example for wine)

A once daily control of process water, rinsing and flushing water has proved itself in practice. Containers which are not steamed must be controlled once daily. Containers which are steamed can be controlled at longer intervals, e.g. once weekly, as long as a new container is always filled. A daily control is necessary for containers which are repeatedly filled. The filler is the most frequent cause of non-sterile products, so that frequent swab-testing is essential, several times each day is best.

A CIP-system can cause an explosion of high bacteria counts when plant-specific bacteria are given the opportunity to develop resistance against a disinfectant. Regular monitoring of the CIP-system can avoid such trouble. Several points in the piping system between filler and storage tank should be accessible for taking samples, whether for routine testing or for when problems arise, i.e. when a scattered infection must be tracked down.

bottle, is recommended, whereby the degree of risk associated with the composition should also be considered.

Weighing up the risk.

All of this information is naturally dependent on many in-plant circumstances and should therefore not to be taken as absolute. It should be rather seen as a guide to help you to think about your own production. What appears to be sufficient for one plant may be too little for another one. When controls constantly show good microbiological-hygienic results, then the number of samples taken and tested can be reduced. Particular conditions and the quantity which is daily produced, as well as special risks associated with a less than optimal routing of empties, seasonal risks or risks associated with the plant location – all of these can make it necessary to deviate from guidelines which have proved themselves in other plants and to adhere to special rules.

Internal limiting values of a soft drink plant

Sample	Colony count	E. coli	Coliforms	Yeasts	Moulds
Raw water	max. 100/ml	0/100 ml	0/100 ml		
Process water	max. 50/ml		0/100 ml	0/100 ml	0/100 ml
Table water	max. 50/ml	0/250 ml	0/250 ml	0/100 ml	0/100 ml
CIP rinse water	max. 50/ml			0/100 ml	0/100 ml
Final rinse water, empties	max. 100/ml	0/100 ml	0/100 ml		
Syrup				max. 5/5 ml	
Drinks + CO ₂				max. 5/5 ml	
Empties	max. 50/pc				
Air	max. 500/m ³			max. 125/m ³	max. 125/m ³

Figure 4
Microbiological limits

The sample volume is dependent upon the particular character of the sample, the result which is normally to be expected and the degree of risk. A large volume of end product is required, as often a few bacteria have good chances of propagating over long storage times. Although the regulations require 1 ml for the colony count in bottled water, this is not representative. Volumes of 100 ml are the minimum for testing product, rinse water and raw water for E. coli, coliforms and other pathogens. For problem-causing microorganisms (yeasts and lactic acid bacteria) at least 100 ml, but better the whole

A well functioning precautionary hygiene for product and plant is becoming increasingly important, especially with respect to the new Food Hygiene Guidelines 93/43EEC and the HACCP concept.

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