Shelf life as requirement for quality of milk products

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Summary

In the complete assessment of the quality of milk and milk products, one of the important elements influencing the quality of the product is its storage stability e.g. shelf life.

The quality is not a matter of choice, but impertive for survival on the market due to economical reasons as well as international regulations. Durability of a product is the consequence of the collection of milk, processing, distribution and storage in retail stores.

The quality should be seen in connection with the highest satisfaction of consumers requests and improvements of manufacturing procedures. Modern concepts of management, control (TQM, QSA, GMP, LISA, HACCP) and observation of regulations of the International Standardisation Organisation (ISO: 9000, 9011, etc) are of great importance in reaching the adequate shelf life for each product.

Key words: milk quality, shelf life, durability, chemical and microbiological quality, stability

Introduction

Under the influence of market competition and the increasing number of regulations concerning quality, the traditional approach to evaluate the quality of food is undergoing constant changes. This is particularly pronounced in the area of milk and dairy products. Because of the number of approaches, the term of quality is becoming very complex. Within certain limits of pre-given tolerance, it can, however, be easily defined. One of the important basic indicators for the quality of milk and dairy products is its shelf life that represents an answer to the classic and simple question: How long is a product maintaining its basic sensory properties, e.g. how long can a product be stored?

Of course, the answer is not simple and includes a number of factors. The consumer is the one who sets much higher requirement on shelf life than

earlier. This demand can be achieved only by fulfilling conditions like specialised stores for dairy products, sections in the big markets observing adequate storage donditions and instructions on storage in household.

In some countries distinction is made between easy perishable food and food that remains unchanged under certain storage conditions. For example, in some countries, easily perishable foods are defined as having a shelf life of up to 6 weeks and are labelled with "sell-by-date", while those with a longer shelf life are marked with "best before date". In Croatia all products were for a long time labelled with "date of production" (occasionally still in use, with the consequence that everything is left to customers knowledge). Recently "to use by" is increasingly common. This new proposed regulations enable the producers to set a date limit for himself as well as the consumers. This labelling is in accordance with the legislation of the European Community and with Codex Alimentarius.

When speaking of shelf life, we have to keep in mind all phases of milk manipulation: the quality of raw milk, steps in milk processing, level of recontamination after pasteurisation, packaging technology and material, storage conditions, care during transportation, handling by the retail trade and handling by the consumer. Each category of dairy food has its unique shelf life based on the aforementioned. For example, it is expected that liquid milk remains fresh for 12-14 days if kept below +4°C, while yoghurt and similar fermented products should remain fresh for 30-40 days under the same storage conditions. Some types of cheese, properly prepared and packaged to prevent mould growth, are expected to retain their texture and specific sensory characteristics during several months if kept at +4°C. The acceptable shelf life of a product is determined by the time it starts to loose its basic sensorial qualities. During storage, a product may become unpalatable in sense of toxicity by contamination with harmful microorganisms. It has been shown that the presence of pathogenic microorganisms in dairy foods is not correlated with microbial spoilage causing sensorial changes in products.

Microbiological spoilage of dairy foods is characterised by gustative and odour changes such as sour, putrid, bitter, malty, fruity, rancid etc... This type of spoilage may also lead to undesirable changes in body, texture and consistncy. Physical and chemical factors like oxidation, irradiation, lipolysis, heat, light, metal ions or temperature increase during processing and storage may also be responsible for taste deterioration. In addition chemical processes also may bring about changes in physical properties like viscosity and separation (sedimentation).

The microbial and physical quality of the raw material often determines the shelf life of a food. Processing parameters e.g. type and extent of heating

and cooling, degree to which the food is concentrated, fermentation, incorporation and distribution of ingredients such as salt, sanitation of equipment and environment, packaging, storage temperature, humidity and exposure to odours can also influence the shelf life. By increasing the volume of production, the demands on shelf life is becoming more strict.

Microbiological changes

Milk and dairy foods are suitable media for the growth and development of all kind of microorganisms. Because of the temperature sensitiveness, storage conditions are decisive for the proliferation of microorganisms i.e. for the shelf life. By exposure to high temperature during manufacture and in combination with other relevant procedures the shelf life of the products can be extended. Low temperature storage minimises microbial growth in raw milk until processing and is favourable to extend the shelf life on non-sterile dairy foods. Pasteurisation as a moderate heat-treatment eliminates pathogenic microorganisms without causing significant physico-chemical damage of milk constituents.

Changes of microbial origin that influence the shelf life of milk products can be manifested as:

Post-acidification: Lactic acid producing bacteria may further ferment lactose leading to an unacceptable acid taste. Cold storage minimises or even prevents microbial growth, thus avoiding overacidification.

Malty flavour and odour: These defects occur in milk and other dairy foods when *Streptococcus lactis* var. *maltigens* converts amino acids to aldehydes and alcohols and as a consequence 2-methylpropanol and 3-methylbutanol as the principal components of malty flavour are formed. It can be prevented by cooling the milk to 5°C or below.

Fruity flavour: Fruity flavor in dairy foods is the result of ethyl ester formation usually by esterases from psychrotrophic or lactic acid bacteria. Ester formation by *Pseudomonas fragi* involves liberation of butyric and caproic acids from triglycerides and the subsequent esterification with ethanol. Adequate pasteurisation can protect the products from this defect.

Proteolytic changes

The flavour defect in milk and other dairy foods described as putrid, bitter and unclean may be caused by the biochemical activity of the species Pseudomonas, Aeromonas, Flavobacterium, Acinetobacter, Bacillus, Micrococcus and others. The optimum growth temperature is in the range of

25 do 30°C, but they grow also at or below 7°C. Their presence in dairy foods results from inadequate cleaning and sanitation of the processing and packaging equipment as well as recontamination after pasteurisation. Heat stability is a common characteristic of some proteases produced by *Pseudomonas sp.* and as a consequence, the pasteurisation of the milk for cheese manufacture is not sufficient for inactivating these proteases.

Recontaminantion during processing and packaging can result in the presence of proteolytic psychrotrophic bacteria and potential shelf life problems. It has been shown that proteases of psychrophilic bacteria selectively attack particular fractions of casein, resulting in decreased stability to gelation and precipitation. Psychrotrophic *Bacillus sp.* also can cause spoilage of liquid milk. As an example, the "sweet curdling" with proteolytic enzymes of *B. cereus* is mentioned. This occurs without appearance of acid taste in milk. These enzymes can also cause a decreased cheese yield, defective body and texture, bitterness in cheese, and whey separation in cultured dairy products.

Lipolysis

Some of the Gram-negative psychrotrophic bacteria found in milk and dairy products, e.g. *Pseudomonas fragi, P. fluorescens, Achromobacter lipolyticum, Flavobacterium sp., Alcaligens sp.,* and *Acinetobacter sp.* produce enzymes which are heat stabile and active at ambient or even refrigeration temperatures. Butter made from cream containing such lipases becomes rancid within two days, cheese after four months and UHT milk develops a rancid flavour in one to seven months. Other flavour problems during the storage of products may be caused both by Gram-positive and Gram-negative psychrotrophic bacteria.

Chemical and physical changes affecting the shelf life of dairy products

Raw milk quality

For the shelf life of dairy products it is important that milk used for manufacture has normal sensory characteristics. Various flavours can be transmitted into milk already by the respiratory or digestive system of the cow. Certain volatile compounds can be removed during processing, excessive defects, however, will lead to undesirable sensory characteristics in the

products. Milk with high salt content is the result of disorder in the secretion of milk. A high number of somatic cells, combined with salty and rancid flavour may result in decreased shelf life.

Milk diluted with water tastes flat and dairy products with mild flavours usually absorb strong aroma components from the environment. Milk should, therefore, be protected from extraneous volatile flavour compounds already on the farm and throughout processing and distribution. Properly designed packaging is protecting dairy products from undesired off-flavours.

Heat-induced flavor and browning

Heating flavour is acceptable to most consumers, but more severe heat treatments give rise to flavours described as caramelised or scorched which are less acceptable. The thermal processing used in condensing, sterilising and drying operations causes various intensities of these flavour defects. Condensing and spray drying can be performed with relatively moderate flavour damage and reconstituted milks are well accepted by consumers. The heat required for sterilisation results in more extensive flavour changes and milk sterilised in cans is used mainly for cooking, infant formulas or in situations where refrigeration is not available. It should be noticed that UHT treatment results in a low heating flavour. The thermal processes involved (condensing, drying) can initiate Maillard reaction. This reaction itself and other reactions following, continue during storage and can result in the development of brown colour, changes in solubility, loss of nutritional value (reduced availability of lysine) and stale flavour, thus, limiting the shelf life of sterile concentrates and powders.

Sulphur compounds dominate the flavours produced by mild heat treatments, while autoclaving of milk gives rise to glyoxal and methylglyoxal through a carbonyl-amine reaction. These carbonyls react with methionine and cysteine to produce many of the sulphur compounds identified in heated milk. Many of the sulphur containing flavours that are produced during heating are capable of further reaction, particularly with carbonyls leading to further gustative changes.

Rancid flavour

This off-flavour can occur in milk as a result of the activity of milk lipases gaining access to triglycerides after homogenisation, foaming and destabilisation of the fat globule membrane. Rancid flavours result from free

short chain fatty acids, and as recent research indicates, minor branched chain fatty acids in milk fat may also play a role. Rancid flavour is generally undesired in most dairy products, with exception of some cheeses, where free fatty acids contribute to characteristic flavour. Milk lipases are inactivated by pasteurisation.

Oxidation flavour

Oxidation of the unsaturated fatty acid group with molecular oxygen leads to the formation of hydroperoxides and, consequently, to sensory changes which are unplesant. The primary role in the development of oxidation flavour play polyunsaturated fatty acids. Vinyl ketones play a dominant role in oxidation flavour and the off-flavour is described as metallic flavour. Intensive research has been carried out also on the role of copper and iron as fat oxidation catalysts.

Oxidation in dairy products can also be initiated by exposure to light, but flavours produced in this way are significantly different from those produced by metal-catalysed oxidation.

Riboflavin is the primary agent involved in light-induced flavour and in presence of methoinine, sulphur compounds methyl mercaptan and other sulphides are formed.

Light-induced flavour is often the most common defect in liquid milk because of the insufficient protection of milk in translucent polyethylene packages as well as well-lighted grocery stores. This problem can be solved by the use of opaque or with brown pigments tinted packaging material. Consumers, however, prefer packages that allow them to see the product inside. In powdered milk this off-flavour can be important and depends on the amount of free fat on the particle surface, the water content of the powder, the kind of packaging used, storage temperature, exposure to light and addition of antioxidants. The oxidation of spray dried powders may be harmful to health.

Texture changes

Other factors limiting the shelf life and acceptability are changes in viscosity of fermented dairy foods and precipitation and gelation of concentrated sterile milk. Holding the concentrated products under cold storage conditions before canning results in more rapid gelation. Occasionally,

gelation can be observed in UHT milk and, although the cause of these changes is not definitely established, the incomplete inactivation of the heat stabile milk protease plasmin might be the reason. This enzyme exists predominantly in the inactive form plasminogen and the conversion to plasmin as well as the attack of plasmin on proteins appears to be influenced by several activators and inhibitors. However, the storage of UHT sterilised milk is often accompanied by proteolysis that leads to aggregation of casein micelles and finally to gelation. The mentioned changes in viscosity are affected by extent of concentration, season and location of milk production, intensity of heat treatmant, temperature of storage, pH and addition of polyphosphates and other ions.

Current practices to extend the shelf life of dairy foods

Raw milk

The microbial quality of raw milk is important as the numbr and kind of microorganisms, as well as the manipulation with milk from milking throughout processing may influence the shelf life of liquid milk.

Liquid milk and cream

Pasteurised milk has, by applying "Good manufacturing Practice" a shelf life of 10-14 days. It is customary to note the date of expire on the package. If these products are stored at 4°C or less, they will last seven days past this date. To evaluate the shelf life of liquid milk and cream, processors usually use both microbial and organoleptic methods.

Sour cream, yoghurt, and cultured buttermilk should have a shelf life of at least 30 days if the equipment and environment of production are properly cleaned i.e. good sanitary practices, good manufacturing procedures and adequate refrigeration during storage are observed. These products have a shelf life advantage because of their high acidity and presence of secondary metabolites produced by starter cultures. Secondary metabolites are bacteriostatic, thus, inhibiting many spoilage microorganisms. Micro-organisms that are critical for the shelf life of cultured dairy products are yeasts and moulds. Yeasts contamination can result in yeasty and fermented, alcoholic flavour with gas producion. Mould growth on the surface of the cultured foods may cause coloured, fuzzy spots.

Cheeses

Cheese producers and marketers all over the world, work hard to produce and market cheeses of high quality. There are several types of defects that may influence the shelf life of cheese and affect flavour, body and texture.

It is generally accepted that there is no substitute for good quality raw milk, proper pasteurisation, sanitation, personnel hygiene, active starters, proper salt and moisture concentrations and adequate storage. Each type of cheese has its particular problems affecting shelf life.

Sterile, condensed and dried milk

The traditional process for in-can sterilisation of concentrated milks supplemented with stabilising salts results in products having stability for over one year. The major determinants to shelf life are: moisture for dry products, microbiological status, types of packaging, browning and loss of available lysine.

Final comments

Finally, we consider it necessary to point out that the shelf life of dairy products is one of the basic parameters of quality for successful acceptance on the market. Shelf life as the result of all factors in the production chain, i.e. zootechnical, productional and economical depends on the quality of raw milk, on the implementation of scientific knowledge, as well as microbiological, physical and chemical changes which are particular for each product. As a market category it has its basis in the evaluation of the quality of products from the point of view of the consumer.

Practically it depends on the consequent and efficient supervision and control, primarily the application of the principles of GMP (Good manufacturing Practice) during all phases of production, as well as strict implementation of generally accepted international quality standards and the necessity of HACCP (Hazard Analysis of Critical Control Points) beginning at the farms and throughout to the to final products including transportation and storage. These points should cover the animal genetics, feeding, use of additives, potential pollution, medical tretment of animals, hygiene and the technology during the processing and storage.

From the standpoint of the producer, quality is not a matter of choice any more, it is a condition for the existence. Better shelf life of products means implementation of modern productional principles, good management and control and reflects the total level of the quality of the final products.

At the end, we consider it necessary to emphasise that regarding shelf life, the present international standards are not satisfying. We suggest:

- general division of dairy products according to their shelf life
- generally accepted way of shelf life coding
- compulsory coding of the way of storage and maximum shelf life of the products under given conditions

ODRŽLJIVOST KAO UVJET KAKVOĆE MLIJEČNIH PROIZVODA

Sažetak

U ukupnoj ocjeni kakvoće mlijeka i mliječnih proizvoda jedan od sastavnih elemenata koji određuju kvalitetu proizvoda je održljivost ili vijek trajanja. Kako kakvoća nije stvar izbora već uvjet za opstanak na tržištu zbog ukupnih ekonomskih razloga i uvjetima Europskih propisa valja inzistirati na objektivnim mogućnostima vijeka trajanja pojedinih mliječnih proizvoda. S ozirom na narav i mogućnosti čuvanja u smislu maksimalno dozvoljenog vremenskog roka, a u kojem neće doći do nepoželjnih promjena, koje su uvjetovane najčešće mikrobiološkim i fiziklano kemijskim čimbenicima. U tom je smislu održljivost posljedica svih faza proizvodnog lanca od proizvodnje, sakupljanja, prerade i korištenja mlijeka, uključujući i raspodjelu i prodaju mliječnih proizvoda te čuvanju u prođajnoj mreži uz odgovarajući nadzor i kontrolu. Kakvoću treba promatrati u skladu s maksimalnim zadovoljavanjem zahtjeva potrošača i poboljšanja materijalnih pokazatelja proizvođača. Najvažniju ulogu u postizavanju odgovarajuće održljivosti čine suvremene koncepcije upravljanja, kontrole i nadzora (TQM; QSA; GMP; LISA; HACCP), a u smislu propisa Međunarodne organizacije za standardizaciju (ISO: 9000, 9011, idr.)

Ključne riječi: kakvoća mlijeka, održivost - vijek trajanja, kemijska i mikrobiološka kvaliteta, stabilnost.

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