GUIDELINES ON GOOD HYGIENE PRACTICES AND APPLICATION OF THE HACCP PRINCIPLES IN COLD STORES

Funded by
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EU FOOD SAFETY
AB GIDA GÜVENLİĞİ

Turkish Cypriot Community Food Safety Project

Funded under the EU Aid Program for the Turkish Cypriot community (TCc), the "TCc Food Safety Project" executed under the contract 2021/423-933 "Technical assistance to improve implementation of food safety standards and disease crisis preparedness", strives to support faster social and institutional development of the Turkish Cypriot community and higher economic growth of its agri-food chain sector. The aim is to achieve improved food safety, public health, animal health, and protection of the environment, and to mitigate the impact of potential exotic animal diseases, in particular those posing imminent threats. The project started in May 2021 and will be completed in April 2024.

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1. BACKGROUND

The "TCc Food Safety Project" executed under Contract 2021/423-933 "Technical assistance to improve implementation of food safety standards and disease crisis preparedness" strives to support a faster social and institutional development of the Turkish Cypriot community (TCc) and a higher economic growth of its agri-food chain sector.

The project aims to achieve improved food safety, public health, animal health and protection of the environment, and to mitigate the impact of an imminent threat of potential exotic animal diseases.

This document was produced within the following project activity:

Prepare guidelines for stakeholders to complement the input delivered in specific trainings, workshops, and other capacity building activities.

2. INTENDED AUDIENCE

The intended audience of these guidelines are food business operators dealing with cold stores.

Refrigerated foods are one of the fastest growing sectors of the grocery and food service industries. Continued success relies upon effective management of the 'cold chain', a term used to describe the series of interdependent operations in the production, distribution, storage and retailing of chilled and frozen foods. Control of the cold chain is vital to preserve the safety and quality of refrigerated foods and to comply with 'legislative' directives and industry 'codes of practice'.

3. AIM OF THE GUIDELINES

These guidelines aim to assist the food business operators dealing with cold stores to achieve the legal requirements for establishing, implementing and maintaining procedures based on the HACCP principles and to ensure a high level of customer protection regarding food safety.

These guidelines summarise the key recommendations for processing, handling, distribution and storage of chilled and frozen foods.

The goal of the food safety system based on the HACCP principles is to keep under control certain factors that can lead to potential food poisoning.

Food business operators and relevant control bodies should cooperate in order to prevent foodborne illness.

The guidelines are also available to the public on the project's online Food Safety Platform: http://tccfoodsafetyproject.eu/. All parties involved in the food and catering sector should find them a valuable tool in their day-to-day operations.

4. QUALITY AND SAFETY OF CHILLED AND FROZEN FOODS: A GENERAL OVERVIEW

Chilling involves reducing food temperatures to below ambient temperatures, but above -1°C. This results in effective short-term preservation of food materials by retarding many of the microbial, physical, chemical and biochemical reactions associated with food spoilage and deterioration. At chilled temperatures (generally between 0°C and +5°C) the growth of microorganisms occurs slowly, and food spoilage and deterioration reactions are inhibited to such an extent that food safety and quality is preserved for extended periods, often for a few days, sometimes for a few weeks, longer than the fresh counterpart. However, chilled foods are perishable, and they deteriorate progressively throughout their life. The growth and activity of microorganisms, which may be present in the food ingredients or may be introduced when the food is handled or processed, may cause deterioration. Safe and high-quality chilled foods require minimal contamination during manufacture (including cross-contamination), rapid chilling and low temperatures during storage, handling, distribution, retail display and consumer storage.

Freezing preserves the storage life of foods by making them more inert and slowing down the detrimental reactions that promote food spoilage and limit quality shelf life. However, it should be recognised that a number of physical and biochemical reactions can still occur and many of these will be accentuated when recommended conditions of handling, production and storage are not maintained. Although few microorganisms grow below -10°C, it should be recognised that freezing and frozen storage is not a reliable biocide. The production of safe frozen foods requires the same attention to good manufacturing practices (GMP) and HACCP principles as the chilled or fresh counterpart. A false sense of security, based on the good safety record of frozen foods, should not reduce the care and diligence when preparing, handling or distributing frozen foods.

The cold chain extends from the raw material supplier (e.g. on-farm cooling of milk) through to the consumers' refrigerator/freezer, and all the steps in between. The list below contains some of the most important 'do's and don'ts' for both the chilled and frozen food producer:

- Maintain high levels of hygiene at all stages of the product's life.
- Chill or freeze products quickly and adequately after preparation and manufacture.
- Rigidly maintain chill (<5°C) or frozen (<-18°C) temperatures, wherever possible, during storage and distribution.
- Rigidly maintain chill (<5°C) and frozen (<-18°C) temperatures in holding stores and display cabinets.
- Ensure that chilled or frozen products are transferred in a continuous operation (no stopping or delays) between temperature-controlled areas, e.g. delivery trucks to holding stores; storage areas to retail display units.
- Segregate cooked and uncooked chilled or frozen products in storage and retail display cabinets, e.g. segregate uncooked meats and ready- to-eat meat products

- Conduct frequent and systematic temperature checks on chilled and frozen food product temperatures, using appropriate and calibrated instrumentation.
- Do not overload chilled or frozen retail cabinets with product: refer to cabinet manufacturer's recommended capacity and loading patterns.
- Train and educate all personnel (including consumers) in the correct handling and storage of chilled and frozen foods. Re-educate when new practices are adopted.

The transport and distribution sections of the chill chain are particularly important to control in order to ensure both safety and quality. The major tool at our disposal is the temperature monitoring of foods at each point within the chill chain.

To preserve safety in chilled foods, maximum temperatures are prescribed. Currently, the Agreement on the International Carriage of Perishable Foodstuffs (ATP Agreement) specifies the following maxima for transportation: 7°C for meats; 6°C for meat products, butter; 4°C for poultry, milk and dairy products; 3°C for offal; 2°C for fish. These temperatures are also a good guideline to be followed throughout all stages of production, including distribution, storage and retail display.

To preserve quality and safety in frozen foods, temperature requirements exist for each major stage of the cold chain. It is recommended that stabilized food temperatures are maintained at -18°C or colder, although exceptions for brief periods are allowed during transportation or local distribution when -15°C is permitted. Also, retail display cabinets should be at -18°C, to an extent consistent with good storage practice, but not warmer than -12°C. Consideration should also be made for the likely temperatures experienced by the foods within domestic freezers – this is dependent upon the 'star rating' of the freezer; a three-star freezer is capable of temperatures below -18°C, a two-star freezer of temperatures below -12°C, and a one-star freezer of temperatures below -6°C. In the latter, the practical storage time for frozen products is limited to just a few days.

Throughout chilled and frozen food manufacturing, assurance of food safety is paramount. Combining the principles of food microbiology, quality control and risk assessment, a Hazard Analysis Critical Control Point (HACCP) approach is recommended by many regulatory bodies to assure food safety and demonstrate 'due diligence' in accordance with food safety legal texts.

5. HAZARD ANALYSIS CRITICAL CONTROL POINT (HACCP)

HACCP is an important element in the control of safety and quality in food production. When properly applied, it provides a management tool aimed at complete commitment to product quality and safety. HACCP is useful in identifying problems in food production and works well for simple products and processes. The inevitable drawback for the SME food producer is that consider able resources and expertise may be required to carry out hazard analysis on novel or complex products.

The 7 principles of HACCP, with a brief indication of necessary action are:

- *Identify the potential hazards*
    - Together with the HACCP team (including microbiologists and process engineers) construct a flow diagram for all product/process operations – list all hazards associated with each process step – list measures which will eliminate or reduce hazards.

- *Determine the critical control points (CCPs) for identified hazards*
  - Determine the CCP (a step at which control can be applied and is essential to eliminate the hazard).

- *Establish the target levels/tolerances for controlling the CCPs*
  - Establish a predetermined value for control which has been shown to eliminate hazards at a CCP.

- *Establish/implement monitoring systems for controlling CCPs*
  - E.g. set out a planned sequence of observations or measurements to assess the degree of control on identified CCPs.

- *Identify corrective action when a deviation occurs at a CCP*
  - Identify a predetermined action for when the CCP indicates a loss of control.

- *Verify that the HACCP system is working*
  - Establish and apply methods to ensure that the HACCP system is working, including documentary evidence, e.g. auditing, end product testing, process validation.

- *Establish a documentation system for procedures and records*
  - Develop and maintain procedures and practices for record keeping.

Generally, the use of microbiological tests to control microbiological hazards is both cost-prohibitive and in effective. Instead, it is desirable to measure physical or chemical parameters that can be used as an indirect measure of control. Microbiological tests can, however, establish process limits for new products or to verify existing controls, e.g., end-product sampling, challenge tests or swab tests.

Generally, prevention of microbial contamination is the best approach. In the context of chilled foods *Listeria monocytogenes* is worthy of special mention. Box 1 indicates a simple 'check-list' to be considered by the food producer:

BOX 1: Check list for control of *Listeria monocytogenes*

1. Do your raw material suppliers practice environmental monitoring and control measures for *Listeria*?
2. Are your raw materials tested for *Listeria*?
3. Are the appropriate codes of practice followed for *Listeria* control?
4. Is there efficient cleaning and biocide treatment of fridges and freezers?
5. Can pneumatic systems contaminate the factory and the process environment?
6. Is contamination between raw and cooked product prevented?

6. CHILLED FOODS – SOME POINTERS FOR SUCCESS

There are major attractions with the freshness, quality, safety, and convenience of chilled foods. Increased sophistication of the chilled foods industry has led to many breakthroughs in chilled food technology, but diligent controls are needed at all times. These include microbiological safety, extended quality shelf life, temperature control, and the retention of nutrients.

Two principles dominate control of quality and safety in chilled foods: PPP (product-process-package) and TTT (time-temperature-tolerance).

PPP factors need to be considered at an early stage in the production of chilled foods, as they dictate the likely commercial success of the product. In this category, a useful 'rule of thumb' is to consider that any processing or handling step will take away some of the food material's inherent natural characteristics and qualities. Generally, quality cannot be gained from processing, but it certainly can be lost. High quality chilled foods require high quality raw materials and ingredients. The product development team needs to consider the interaction between ingredients and components of formulated foods. The PPP factors are:

- Product
  - Raw material quality.
  - Quality and suitability of ingredients, including additives/enhancers.
  - Product formulation – how the component parts integrate to form the final chilled food product.

- Process
  - The speed and effectiveness of the chilling operation.
  - The use of additional processes, e.g. heating, pasteurisation.

- Package
  - 'Ordinary' packaging, offering physical, chemical and barriers.
  - 'Advanced packaging', including Modified Atmosphere Packaging.

A useful step in processing of chilled foods is the use of 'hurdle technology'. Hurdles are cumulative steps, each of which has the effect of reducing microorganisms within the food. Well-known hurdles are:

- Physical hurdles
  - Heat (e.g. blanching, pasteurising, canning).
  - Cold (e.g. chilling and freezing).
  - Packaging (e.g. vacuum, aseptic, MAP).

- Physio-chemical hurdles
  - Salt, sugar, dehydration, water activity.
  - Acidity (acidulants, fermentation).
  - Sulphur dioxide, smoke, gases, ethanol.
  - Chlorine.

- Microbially-derived hurdles
  - Competitive flora within the food micro-environment.
  - Starter cultures.
  - Bacteriocins.

In cold chain applications, temperature is the most important hurdle. Control of temperature is, therefore, essential.

TTT factors maintain quality and safety during storage and offer guidance on how to deliver foods with long quality shelf life. TTT concepts refer to the relationship between storage temperature and storage life. For different foods, different mechanisms govern the rate of quality degradation and the most successful way of determining practical storage life is to subject the food to long term storage at different temperatures. TTT relationships are also able to predict the effects of changing or fluctuating temperatures on quality shelf life.

Chilled foods are easily temperature-abused and temperature control and monitoring is an important factor in the control of safety and quality. There is also the need to maintain awareness for potential growth of microorganisms such as *Listeria, Yersinia* and *Aeromonas* at chill temperatures. In summary, the following factors are important in relation to achieving the necessary temperature control for chilled foods:

In chilled food production and storage:

- Use product temperatures as 'critical control points' in the HACCP plan.

In chilled food distribution:

- Prior cooling of the distribution vehicle is necessary to achieve the appropriate temperature during the entire distribution process.
- Product and environment temperatures should be closely monitored and recorded during the distribution process. Systems available include data loggers (both in-situ and portable).
- Time-temperature indicators (TTIs) are an emerging technology for food product monitoring: a British Standards Document has been compiled (BS7908, 1999).

In chilled food retail display:

- Introducing warm products into chilled food cabinets can cause a general temperature increase: it should be noted that cabinets are intended only for holding and are not designed for cooling foods.
- Poor cabinet stocking and stacking arrangements and inadequate servicing can cause significant problems with maintaining low temperatures.
- Iced-up cooling coils in cabinets indicate the need for proper defrosting regimes and correct setting of thermostats.
- Interference with cabinet design can disrupt the flow of cool air through the cabinet and cause a rise in temperature.

7. FREEZING FOODS FOR OPTIMUM QUALITY

Freezing can preserve the taste, texture and nutritional value of foods better than most other preservation methods. However, such qualities depend upon the careful choice of food materials, use of appropriate pre-treatments, the choice of freezer and frozen storage options and the use of appropriate packaging.

The major considerations for optimum quality of frozen foods can be described under pre-freezing, freezing and post-freezing stages of manufacture. The boxes below show some considerations for three major food categories:

Step 1: considerations prior to the freezing process

PRE-FREEZING CONSIDERATIONS

FRUITS & VEGETABLES	MEATS	FISH
1. High quality raw materials, including elimination of foreign bodies.	1. High quality raw materials, including microbial status (mesophilic, psychotrophic and pseudomonas).	1. High quality raw materials, including microbial status (TVC, coliforms and Staphylococus).
2. Suitable cultivars for freezing/frozen storage.	2. Livestock breeding/diet	2. Fish species variability of sensory, odour/ flavour
3. Safety aspects, e.g., removal of pesticides, foreign matter	3. Chilling and ageing, accelerated conditioning.	3. Handling-induced damage, e.g. filleting.
4. Measurement of quality attributes, e.g., sensory, nutritional, colour.	4. Measurement of quality attributes, e.g., rancidity, meat-fat ratio, texture.	4. Chilling-as rapidly as possible, sanitation.
5. Industry specifications.	5. Industry specifications.	5. Measurement of quality attributes, e.g., texture, histamine levels.

Step 2: Understand the effects of some common pre-freezing treatments

PRE-FREEZING CONSIDERATIONS

FRUITS & VEGETABLES	MEATS	FISH
1. Cutting contributes to cell rupture and reduced shelf life.	1. Cooking of meat helps increase shelf life.	1. Whole and eviscerated fish have longer quality shelf life than cut/minced.
2. Blanching or chemical treatments help to avoid browning and off-flavours.	2. Herbs and spices can contain substances to control rancidity in meat.	2. Complete and effective 'gutting' helps to remove the enzymes responsible for spoilage and rancidity.
3. Immersion treatments, e.g. sugar solutions, can reduce evaporation and texture changes in the cold chain	3. Smoking meat increases quality shelf life and can have antioxidant effects.	3. Cryoprotectants, e.g., carbohydrates and polyphosphates can minimize disruption to textural properties.
	4. Cutting contributes to reduced shelf life.	
	5. Oil and salt uptake can lead to increased rancidity	

Step 3: Understand the needs of the freezing process

FREEZING CONSIDERATIONS

FRUITS & VEGETABLES	MEATS	FISH
1. Freeze immediately after preparation or pre-treatment.	1. Freeze immediately after preparation or pre-treatment.	1. Freeze immediately after preparation or pre-treatment.
2. Avoid slow freezing, e.g., within cold stores.	2. Avoid low freezing, e.g., within cold stores.	2. Avoid slow freezing, e.g., within cold stores.
3. Promote rapid freezing to retain moisture, minimize cellular damage and preserve nutrients and structure, e.g., within commercial freezers.	3. Promote rapid freezing to retain moisture, reduce protein denaturation, reduce 'toughening', e.g., use commercial freezers.	3. Promote rapid freezing to retain texture and flavour, minimise chemical and enzyme reactions leading to spoilage.
4. For large products, too rapid freezing rates can induce mechanical damage, e.g., cracking.	4. Faster freezing promotes smaller ice crystals which scatter light more effectively and give a lighter, more glossy product.	4. Faster freezing promotes smaller ice crystals which reduce ice-induced physical damage and retain the characteristic flesh texture.

For frozen storage, practical storage times for various foods at a freezer temperature of -18°C are given in Table 1.

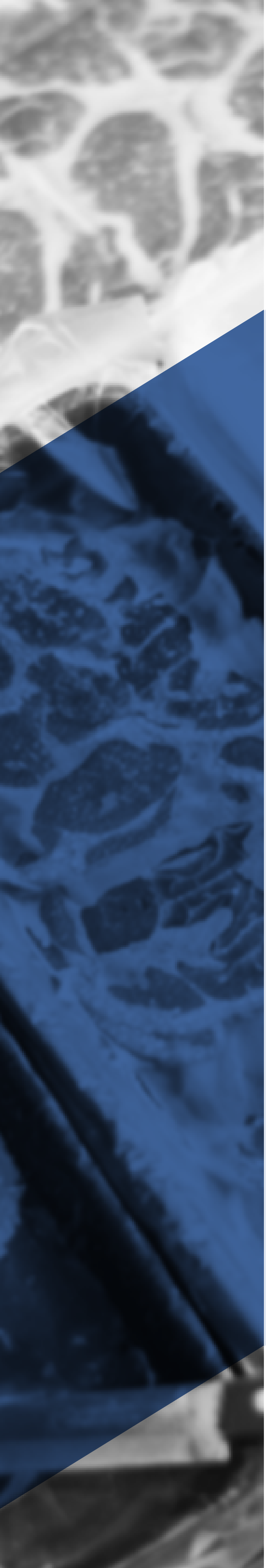


TABLE 1: SUGGESTED MAXIMUM STORAGE TIMES FOR FROZEN FOODS AT -18°C

PRODUCT — **PRACTICAL STORAGE LIFE (MONTHS)**

VEGETABLES

Broccoli	18
Green Beans	15
Carrots	18
Cauliflower	15
Corn On The Cob	12
Peas	18
Potato Chips	24
Spinach	18

FISH AND SHELLFISH

Oily Fish (E.g. Herring, Salmon, Mackerel)	4
Whitefish (E.g. Sole, Plaice)	8
Flatfish (E.g. Sole, Plaice)	10
Prawns, Lobster, Crab	6
Clams, Oysters	4

RAW MEAT AND MEAT PRODUCTS

Beef Joints, Steaks	12
Beef Mince	10
Lamb Joints, Chops	10
Pork Joints, Chops	6
Sausages	6
Bacon	2-4
Whole Chicken	18
Chicken (Portioned)	18
Whole Turkey	15
Whole Duck/Geese	12

OTHER FOODS

Ice Cream	6

8. TEMPERATURE ABUSE AND SHELF LIFE OF CHILLED AND FROZEN FOODS

Temperature control within chilled foods is most important from a food safety perspective. Abuse of temperature is likely to lead to increased occurrence and growth of pathogenic bacteria. Table 2 shows the minimum growth temperatures (MGT) of six, recognised pathogenic genera:

TABLE 2: MINIMUM GROWTH TEMPERATURES OF SOME BACTERIA FOUND IN FOODS

CLASS	BACTERIA SPECIES	MINIMUM GROWTH TEMPERATURE (°C)
Mesophilic	*Salmonella*	5.1°C to 8.7°C
	Staphylococus aureus	9.5°C to 10.4°C (for growth) 14.3°C (for toxin production)
	Escherichia coli	7.1°C
Psychrotrophic	*Listeria monocytogenes*	-0.1°C to +1.2°C
	Yersinia enterocolitica	-0.9°C to -1.3°C
	Aeromonas hydrophilia	-0.1°C to +1.2°C

It should be noted that chilled foods are easily temperature abused in comparison with frozen foods as the temperature of the former can rise quickly. The ice in the latter 'protects' them in safety terms and from quality loss for brief periods at less-than-ideal temperatures. Awareness of the need for temperature control at all stages in the chill chain and for a low initial bacteria count (e.g. less than 10^3 per gram) is of paramount importance to all involved with the handling of chilled foods - including the consumer.

In addition, temperature control also preserves both sensory and nutritional qualities, e.g. vitamin C losses in vegetables can be up to 10% per day when stored at a temperature of 2°C; however, vitamin C loss can increase to over 50% per day when stored at temperatures of +20°C.

Freeze damage occurs by a number of mechanisms that results in loss of quality in a product after thawing. Loss of quality may be seen in the frozen product, e.g. freezer burn, discoloration, mechanical damage, but in many cases the loss of quality is not noticeable until after thawing and cooking. Most of the mechanisms of quality loss are determined by storage temperature and are accelerated with time spent above the recommended value. They are also promoted by temperature fluctuations.

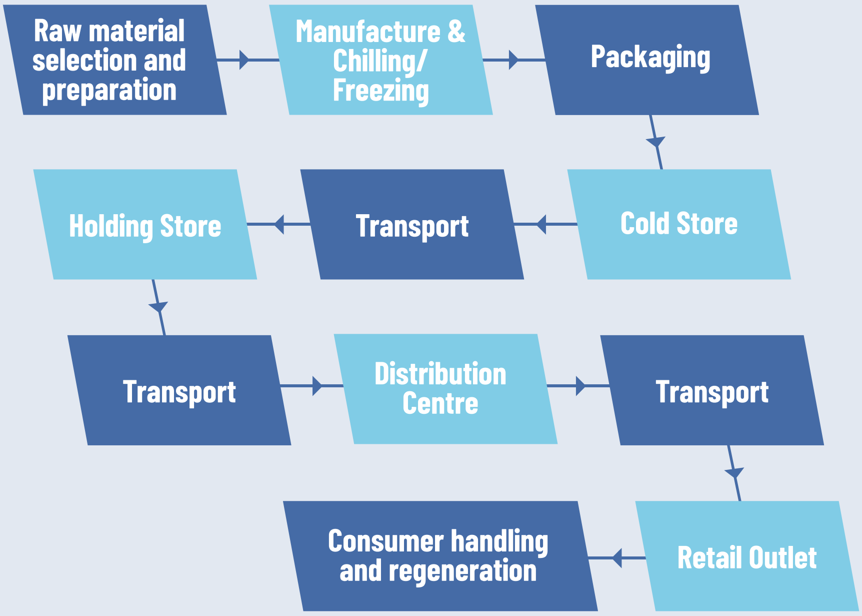
Ice and water can damage food materials in many ways, including:

- Unfrozen water. Even below -18°C, up to 10% water can be unfrozen and take part in physical and biochemical reactions.
- Freezing damage - the expansion of water as it turns to ice can cause structural damage to the food. This is often the cause of large void sand excessive drip loss in frozen materials after thawing. The effect can be minimized by freezing rapidly and maintaining low and consistent temperatures during frozen storage.
- ‘Ostwald ripening’ - this is the tendency for large ice crystals to grow at the expense of smaller ice crystals. The effect is to induce freezing damage. It can be minimized by maintaining low and consistent storage temperatures.
- Accretion - the joining together of two adjacent ice crystals, leading to increased ice crystal size and freezing damage. Again, it can be minimized by maintaining low and consistent storage temperatures.
- Vapour migration - this is most apparent on the surface of frozen foods as the buildup of ice on the interior of packaging and on food surfaces. If unchecked, this can lead to freezer burn and associated changes in color and texture. It is caused by temperature gradients between the surface and center of the product and can be minimized by maintaining low and consistent storage temperatures.
- Solute concentration and osmotic dehydration - during ice formation, the concentration of solutes in the un frozen water increases, leading to in consistency through out the product and damage to the cell membranes. Also water and solutes can leach out of cellular structures, causing loss of turgor and internal damage. These effects can be minimised by low storage temperatures.

9. A PRACTICAL GUIDE TO THE COLD CHAIN FROM FACTORY TO CONSUMER

The sequence of events within a typical cold chain is illustrated in Figure 1 :

FIGURE 1. A TYPICAL COLD CHAIN



Increasingly good temperature control is being achieved throughout the cold food chains as a result of improved equipment design, quality control and heightened awareness of issues surrounding food safety and quality. However, it is important to avoid complacency and to integrate temperature monitoring.

Transfer points, e.g. chiller/freezer to cold store, factory to distribution vehicle, retail cabinets to consumers' refrigerators, are well known problem areas. A useful concept is that of the 'relay system', where the baton (the food product) is transferred safely from one responsible per son to another, and where a signing-over system includes information on product temperature and history. Such a system necessitates thorough education and training of staff likely to come into contact with the food product.

Monitoring the cold chain requires detailed information on food product temperatures. Temperature monitoring includes both measurement and recording.

Defining the temperature monitoring system:

- What is the required temperature range and likely operating temperature range for the instrument?
- Do we need to measure product temperatures? Ambient temperatures? Package temperatures?
- Do we need to measure or measure/record temperature?
- Do we need to measure time and temperature combination? What sampling frequency is required?
- Does the system need to provide a permanent record of temperatures?
- What is the required accuracy?
- What is the required response time?

- If electronic, does the battery life compromise the application?
- What shape of probe is required? A long flat probe to reach between packages?
- Is water proofing of the probe/electronics required?
- Can the temperature data be imported into commercial data analysis spreadsheets or software packages?
- Does the system allow ease of calibration?

Temperatures can be measured directly (contact with the food) or indirectly (measuring the environment or between packages). The common stages of investigation for temperature checks are:

- Inspect air temperature recorders and thermometers to ascertain the temperature history of the product.
- Visually check the product appearance, looking for signs of thawing. These may include: evidence of drip loss, ice on the inside of the package, soiled packaging.
- Undertake a non-destructive investigation by measuring the temperature between adjacent packages or boxes.
- Undertake measurements with a pre-cooled probe and ensure good surface contact. Ensure the probe has good thermal conductivity and a low heat mass.
- Apply sufficient pressure between the probe and the package to obtain a good measurement. The probes should be inserted to a depth sufficient to immerse completely the temperature-sensitive part of the probe, and also to minimise errors from heat conduction from other areas.
- The probe should be held in place for a time sufficient to obtain a steady, non-fluctuating indication of temperature. Measurements should be taken at several points if possible, moving quickly from one point to another.
- If any of the above tests indicate that temperatures are too high, an invasive test may be required. Reference should be made to the food producer and relevant EU Directives (e.g.92/2/EEC for official procedures for measurements, 93/43/EEC for hygiene of foodstuffs).

10. THE ROLE OF FOOD PACKAGING IN THE COLD CHAIN

Packaging plays a key role in protecting the product from contamination by external sources and from damage during its passage from the food producer to the consumer. The choice of packaging is dictated primarily by economic, technical and 'legislative' factors. Also, a well-designed and consumer-appealing package will help to portray an image of high quality and responsible food production to the consumer.

The primary function of food packaging is to protect the food from external hazards. Similarly, the package itself should not affect the food in any way, as indicated by European Directives on food contact materials, including migration limits.

Package barrier properties protect the food from ingress of gas, light, and water vapour, each of which can result in deterioration of colours, oxidation of lipids and unsaturated fats, denaturation of proteins and a general loss of characteristic sensory qualities. Similarly, barrier properties protect against the loss of moisture from the food to the external environment there by eliminating dehydration and weight loss.

A wide range of materials is used for food packaging, including plastic, metals and paper/card. Plastic packages can provide a wide variety of properties, depending on the requirements of the food material and the cost of the package. Table 3 shows some comparisons of barrier properties for arrange of common package materials:

TABLE 3. RELATIVE OXYGEN AND WATER VAPOUR PERMEABILITY'S OF SOME FOOD PACKAGING MATERIALS

Package material	Relative permeability	
	Oxygen	Water vapour
Aluminium	<50 (barrier)	<10(barrier)
Ethylene vinyl acetate (EVOH)	<50 (barrier)	variable
Polycarbonate (PC)	200-5000 (medium barrier)	100-200(high)
Polyester (PET)	50-200 (semi-barrier)	10-30(semi-barrier)
Polypropylene (PP)	200-5000 (medium barrier)	10-30(semi-barrier)
Polyethylene (PE)		
High density (HDPE)	200-5000 (medium barrier)	<10(barrier)
Low density (LDPE)	5000-10000 (high)	10-30(semi-barrier)

As a means of further enhancing material properties, laminates can provide a combination of 'ideal' package properties. However, it is generally true that improved package properties incur increased costs. Board and paper packages are often laminated with synthetic plastics to improve barrier properties.

Additional requirements are that the food package should be both physically and chemically stable over the required temperature range (which may extend from freezer temperatures to oven temperatures), be compatible with common packaging/filling machinery, and provide 'consumer appeal'. A key requirement is that the package also needs to comply with environmental directives, the essential requirements of which are:

- Packaging must be minimal subject to safety, hygiene and acceptance for the packed product and for the consumer.
- Noxious or hazardous substances in packaging must be minimised in emissions, ash or leach ate from incineration or land-fill.
- Packaging must be recoverable through at least one of the following: material recycling; incineration with energy recovery; composting or biodegradation.
- Packaging may be reusable.

11. A BRIEF GUIDE TO GMP FOR THE COLD CHAIN

Good Manufacturing Practices (GMP) intends to give the best guidance available on practical means of achieving and maintaining high quality chilled and frozen foods. There are key guidance points given for each stage of the operation:

Step 1: Raw materials and packaging

- Set product specifications, e.g. microbiological, temperature, quality, hygiene.
- Adopt 'approved suppliers' and incoming product inspection regimes.
- Comply with packaging directives, e.g. food contact materials, environmental.
- Ensure packaging meets technical requirements, e.g. barrier, insulation.

Step 2: Control the manufacturing operation

- Use appropriate freezing equipment to maximise quality pass through 'zone of crystallisation' as quickly as possible.
- Regard freezing as complete only when product reaches -18°C throughout.
- If manufacture requires heating, cool as soon and quickly as possible.
- Ensure storage and transportation of chilled foods is below 4°C.
- High risk categories require special (segregated) manufacturing conditions.

Step 3: Maintain the appropriate storage conditions

- Maintain primary and secondary freezer stores at between -20°C to -28°C.
- Maintain frozen product temperatures at less than -18°C.
- Maintain chill stores at between 0°C and 8°C.
- Maintain chilled products that spoil rapidly at between -1°C and +2°C.
- Maintain microbiologically susceptible products at between 0°C and +5°C.
- Minimise air temperature variations in cold stores.
- Ensure optimum stacking patterns in storage regimes.
- Monitor and record air temperatures in warmest part of the storage facility.
- Provide alarms to indicate temperature abuse.

Step 4: Distribution of chilled and frozen foods

- For primary frozen distribution, temperatures between -12°C and -18°C.
- For local frozen distribution, -12°C to -15°C.
- For chilled foods temperatures control, ensure.
- Category 1 (-1°C to +2°C): fresh meat, poultry, offal's, comminuted meats, fish and shellfish, smoked fish.
- Category 2 (0°C to 5°C): pre-cooked foods, cured meats, sandwiches, pasteurized milk/cream.
- Category 3 (0°C to 8°C): fruit and vegetables, fermented meats, hard cheese, bakery products, butter/margarine, spreads.

***Step 5:** Ensure appropriate conditions for retailing/foodservice*

- Inspect and measure incoming food for temperature control.
- Monitor in-house cold store facilities.
- Operate retail display cabinets according to manufacturer's guidance.
- For cook-chill and cook-freeze products, ensure a minimum reheating operation of 70°C for 2 minutes is achieved.
- Maintain food temperatures above 63°C for food service.

Doubts on the integrity and control of food temperatures at any stage of the cold chain can be allayed or confirmed by the following simple sequence of checks

1. Inspect air temperature recorders and thermometers to determine temperature history of product
2. Visually check product appearance
3. Conduct non-invasive temperature measurements (e.g. between packs)
4. If the above tests indicate excessive product temperatures, conduct invasive food product temperature measurements

A useful 'rule of thumb' is the **NEVER WARMER THAN** rule for any point within the cold chain: -18°C for frozen foods, +4°C for chilled foods.

12. GLOSSARY OF TERMS AND FREQUENTLY ASKED QUESTIONS

This section offers an explanation of some of the key terms used throughout this document and answers some of the questions most frequently asked by the food producer and consumer:

COLD CHAIN: the sequence of temperature-controlled events from raw material supply, through production, manufacture or slaughter, to the presentation of the product for final consumption.

CHILLED FOODS: Perishable foods which are maintained at temperatures in the range -1°C to +8°C, to retain their quality shelf life, wholesomeness and safety.

COOK-CHILL AND COOK-FREEZE: a system based on the cooking of foods (to time-temperature combinations of 70°C for 2 minutes, or equivalent), before rapid chilling or freezing and storage at chilled or frozen temperatures respectively.

DISTRIBUTION: A business system concerned with the physical transportation of foods, including the 'handover' of foods between different links in the cold chain, e.g. producer to delivery truck, delivery truck to retailer.

FOOD SPOILAGE: The deterioration of foods resulting in undesirable sensory quality loss. Spoilage can occur by microbial or physio-chemical means.

FROZEN FOODS: Foods which are maintained at temperatures below -18°C, to retain their quality shelf life, wholesomeness and safety.

HIGH RISK FOODS: Foods which have the highest potential for causing food poisoning and require to be manufactured within production areas designed and maintained to very high standards of hygiene, and all operations are managed to minimise contamination.

HOW LONG CAN FROZEN FOODS BE KEPT?

This depends on the type of food and the storage temperature. Most foods obey the rule, 'the colder the better', and commercial freezer stores should operate at temperature of -18°C (0°F) or below. Retail display freezers also need to maintain -18°C or below. Domestic freezer temperatures depend on the 'star rating', as described earlier. Practical storage lives range from 12-18 months for fruit and vegetables to c.6 months for fish, shellfish and ice cream.

THAWED FOODS, CAN THEY BE FROZEN AGAIN?

Refreezing of thawed foods is not advisable for both safety and quality reasons. Foods labelled as 'quick frozen' must be labelled as 'do not refreeze after thawing'. The main reason is to avoid the risk that consumers may use in appropriate thawing methods.

THAWED FOODS, WHAT STORAGE LIFE CAN BE EXPECTED?

Thawed frozen foods need to be treated as carefully as chilled foods, i.e. kept at refrigerated temperatures. Care needs to be taken with storage conditions to avoid the possibility of cross-contamination.

WHAT CAN CONSUMERS DO TO KEEP CHILLED AND FROZEN FOODS AS FRESH AS POSSIBLE?

There are some simple steps that the consumer can take to ensure that chilled and frozen foods are as safe, high quality and nutritious as possible. These include:

When shopping: try to purchase chilled and frozen foods at the end of a shopping run and pack chilled and frozen foods in separate bags (preferably insulated) to keep them cool or frozen.

On returning home: pack the chilled and frozen foods away first - ensure they are put in the chiller/freezer as soon as possible "don' t wait- refrigerate!"

At home: purchase and use a refrigerator and freezer thermometer. Check the operating temperature of the refrigerator and freezer. Are they operating below +4°C (refrigerator) or below -18°C (freezer)?

13. CONCLUSION

The transport and distribution sections of the chill chain are particularly important to control in order to ensure both safety and quality. The major tool at our disposal is the temperature monitoring of foods at each point within the chill chain. To preserve safety in chilled foods, there are prescribed maximum temperatures.

14. REFERENCES

GENERAL PRINCIPLES OF FOOD HYGIENE - CXC 1-1969, Codex Allimentarius, Adopted in 1969. Amended in 1999. Revised in 1997, 2003, 2020. Editorial corrections in 2011.

Guide to Good Hygienic Practice for establishments of storage and distribution of chilled, frozen foods and dry grocery - EU Register of national guides to good hygiene practice.

Guideline for Good Hygiene Practice in cold stores, - EU Register of national guides to good hygiene practice.

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