FOOD, AGRICULTURE AND FISHERIES, AND BIOTECHNOLOGY

FRISBEE

Food Refrigeration Innovations for Safety, Consumers' Benefit, Environmental Impact and Energy Optimisation Along the Cold Chain in Europe.

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Temperature controlled incubators

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Distribution List

- On the project Portal
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1. Introduction

In the FRISBEE project, simulations of the different reference cold chains as will be defined in D 3.1.1 “Definition of reference cold chains using general assumptions, refined towards EU situations”, will be carried out. More precisely, kinetic models that are needed in the Quality Energy Environment Assessment Tool (QEEAT) but do not currently exist, will have to be developed by doing experiments at static conditions using the facilities of the respective partners as part of D. 3.2.4.5, D 3.2.4.6, D 3.2.4.7 and D 3.2.4.8. NTUA, VCBT, SINTEF, ACTIA and KUL have to provide temperature controlled incubators to be used in the different experiments.

2. Temperature controlled incubators – KULeuven

2.1. Description and technical specifications

Five temperature controlled incubators (4 Termaks series 6000 and 1 series 8000) are available at the KULeuven facility (figure 1). The specifications are shown in the table 1. These incubators are very suited to do measurements at different constant temperature levels. Moreover, simple temperature profiles consisting of a sequence of ramps and constant levels are possible as well.

Figure 1. The temperature controlled incubator (Termaks, series 6000)

Table 1. Technical Specifications of the temperature controlled incubator (Termaks)

Series		6000	8000
Temperatur control			
Temperature fluctuation/time		+/- 0.1°C	+/- 0.1°C
Temperature variation/interior		+/- 0.2°C	+/- 0.2°C
Readability/setability		0.1°C	0.1°C
Temperature range		0 – 70°C	-9 – 70°C
Sensor		Silicone	Type K
Controller		P + I	P + I + D
Display		LCD	LCD
Timer			
Number of setpoints		4	4
Number of changes per cycle		16	16
Stop time, max number of hours		168	168
Ramping			
Step per interval		0.1°C	0.1°C
Interval settable	either	0 – 999min	0 – 999min
	Or	0 – 999 sec	0 – 999 sec
Heating/cooling			
Heating up time 0 – 70°C		34min	34min
Cooling up time 70 – 0°C		66min	66min
Alarm			
Display and acoustic		Yes	Yes
Alarm limit		Setpoint +/- 2°C	Adjustable
Safety thermostats			
Temperature fluctuation/time		+/- 3°C	+/- 3°C
Sensor		Silicone	Type K
Setpoint		Analog	Automatic setting/adjustable
Shelves			
Standard/max		4/14	3/14
Dimensions in mm		430 x 430	500 x 450
Load per shelf		20kg	20kg
Permitted total load		80kg	120kg
Power consumption			
Nominal power		1000W	950W
Nominal voltage		230V, 50Hz, 1~	230V, 50Hz, 1~
Dimensions			
Exterior mm	W, D, H	845, 615, 1280	680, 580, 1430
Interior mm	w, d, h	450, 450, 745	520, 451, 777
Volume litres		151	182
Weight			
Net		110kg	95 kg
Shipping		130kg, 790dm^3	120kg, 803dm^3

2.2. Use in FRISBEE

The temperature controlled incubators will be used to develop the complete kinetic models for describing different apple quality indicators: (i) Firmness as a function of maturity at harvest, storage time, temperature and atmosphere conditions, (ii) Colour as a function of maturity at harvest, storage time, temperature and atmosphere conditions, (iii) Aroma through the combination of volatile analysis and sensory panel scoring. This was concluded as a result of D 3.2.4.1. The use of the temperature controlled incubators at KULeuven and at VCBT (see next section) is essential to come to D.3.2.4.5 “Validated kinetic models of chilled apple quality”.

3. Temperature controlled incubators – VCBT

3.1. Description and technical specifications

At the VCBT two cool rooms are available for the FRISBEE project in which temperature and relative humidity can be controlled as well as the oxygen and carbon dioxide levels (Figure 2). Temperature and humidity control is realised using indirect cooling and warming with heat exchangers containing glycol solution. Oxygen and carbon dioxide concentration is controlled using active carbon scrubbers. The ranges of possible set points are listed in table 2. Besides controlling constant set point levels some additional functionality is available. The cool rooms are able to simulate a cooling system with direct expansion and on off control. It is also possible to program a temperature profile in time with a resolution of 1 minute.

Figure 2. CA cool rooms at the VCBT

Table 2. Set point ranges for the VCBT cool rooms. These technical data are specific for an empty cabinet and ambient temperature of 23°C.

Temperature control	Range
Temperature	-5 -35°C
Relative humidity	50 – 100%
Oxygen	0.5 – 20 kPa
Carbon dioxide	0.5 – 20 kPa

3.2. Use in FRISBEE

Please refer to section 2.2.

4. Temperature controlled incubators – SINTEF

4.1. Description and technical specifications

4.1.1. Chilling cabinets

- Two climate cabinets, model KB 8400 F from Termaks (Dipl.ing.HOUM as, Oslo, Norway). Temperature control between -9 °C and + 70 °C. Volume is 400 liters (Figure 3).
- Two climate cabinets, model KB 8400 FL from Termaks (Dipl.ing.HOUM as, Oslo, Norway). Temperature control between -2 °C and + 70 °C, and relative humidity control between 1 and 99 at temperature range +4°C and +55 °C. Volume is 400 liters.

Figure 3. Chilling cabinet at SINTEF

4.1.2. Chilling rooms

- Room 9 at SINTEF laboratory (Figure 4). Operating temperature + 2°C, but can be lowered to -2°C. Area is 15 m^2. The cooling agent is R507.

Figure 4. Chilling rooms at SINTEF

In addition there are several standard “home” refrigerators available in the laboratory.

4.1.3. Freezing cabinets

- Two Ultra-low temperature freezers from Thermo Electron Corporation (Marietta, Ohio, USA). Model: Forma ULT Freezer from the 700 series (Figure 5). The freezer has a microprocessor temperature control from -50°C to -86°C and capacity of 652 liters. Four interior compartment doors reduce cold air loss. The refrigeration system is cascade.
- One Ultra-low temperature freezer from FMC Food Tech AB. Model Hetofrig CL 410. Operating temperature is -80°C and capacity is 410 liters.

Figure 5. Freezing cabinet at SINTEF

In addition there are several “standard” freezers down to -18°C and -24°C and -40°C.

4.1.4. Freezing rooms

- Room 6 at SINTEF laboratory. Operating temperature is -25 °C and total areal is 12 m^2.
- Room 10 at SINTEF laboratory. Operating temperature is -10 ± 0.6 °C, but can be lowered to -20°C, and total areal is 15 m^2. The cooling agent is R404a.

Figure 6. Impingement freezer at SINTEF

Figure 7. Mobile ice slurry unit using sea water and having a 1000 L buffer tank

4.2. Use in FRISBEE

The incubators will be used for chilling and superchilling of meat and fish products to simulate and model existing cold chains and compare with optimum cold chains for fresh foods. Further work within FRISBEE will also focus on crystallization and several of the chilling and freezing cabinets will be in use.

SINTEF will also look at the step pre-incubation, that is chilling and freezing of the products ahead of incubation. SINTEF possesses different freezing and chilling equipment, e.g. impingement freezer (-44 °C), mobile lab-scale freezing tunnel (-35 °C), slurry equipment (-2 °C) and RSW (-10°C, brine), amongst other.

In WP5, SINTEF will identify optimum preservation process conditions for superchilling of pork and salmon, including ice content, temperature level and cooling rates, and assess effect of process conditions on quality (SINTEF, D5.1.1.2). During March-July 2011 and autumn 2011, experimental work in lab- and pilot scale will be performed on pork and salmon, respectively. Planned activities are measurements of temperature, ice content, microbial load and quality measurements due to different chilling technologies through cold chain to retail cabinets for;

- Traditional chilled pork in refrigerated rooms.
- Quick-chilled pork in air blast tunnels.
- Superchilled pork in air tunnel
- Superchilled pork in impingement freezer.
- Traditional chilled salmon.
- Superchilled salmon in impingement freezer.
- Superchilled salmon in CBC (Contact Blast Chiller)

The results from these experiments will be used in attempt to complete final models for safety and quality aspects of chilled and superchilled pork and salmon as function of time and temperature.

5. Temperature controlled incubators – NTUA

5.1. Description and technical specifications

In the Laboratory of Food Chemistry and Technology, School of Chemical Engineering of National Technical University of Athens (NTUA) the following incubators and freeze cabinets are available:

- 5 temperature controlled incubators Sanyo MIR-153 of 126 litres capacity and recommended storage range from -15°C to 50°C, fully programmable by unlimited step-wise steps allowing simulation of dynamic and cold-chain conditions (Figures 8, 9)
- 1 cooled incubator MIR-154 of 126 litres capacity and recommended storage range from -15°C to 50°C, fully programmable by unlimited step-wise steps allowing simulation of dynamic and cold-chain conditions
- 2 cooled incubators MIR-253 of 254 litres capacity and recommended storage range from -15°C to 50°C, fully programmable by unlimited step-wise steps allowing simulation of dynamic and cold-chain conditions (Figure10)
- 1 super-cooled incubator MIR-553 of 406 litres capacity and recommended storage range from -40°C to 50°C, fully programmable by unlimited step-wise steps allowing simulation of dynamic and cold-chain conditions (Figure 10, 11)
- 7 freeze cabinets Whirlpool AFG 543 equipped with programmable 3-step operational function with microcomputer control of 400lt capacity and recommended storage range from -30°C to -5°C fully programmable by unlimited step-wised steps allowing simulation of dynamic and cold-chain conditions (Figure 12) and
- 6 freeze cabinets Whirlpool AFG 541 of 400 litres capacity and recommended storage range from -30°C to -5°C (not equipped with programmable operational function as AFG 543, but may work at constant preset temperatures).

Figure 8. SANYO MIR-153 cooled incubator

Figure 9. SANYO MIR-153 cooled incubator

Figure 10. SANYO MIR-253 cooled incubator

Figure 11. SANYO MIR-553 cooled incubator

Figure 12. WHIRLPOOL AFG543 freeze cabinet (left) and display detail (right)

Figure 12. WHIRLPOOL AFG541 freeze cabinet (left) and display detail (right)

Technical specifications: 230 V, 50 Hz, 1,2 A, 158 - 332W.

Properties
Some of the features of the above SANYO MIR incubators include:

High-precision Temperature Environment Microprocessor Control with Feed forward Function
SANYO Cooled Incubators incorporate a high precision microprocessor temperature control combined with a heater PID and compressor ON-OFF system. This system has a feed forward function that inputs the operating conditions of the compressor beforehand, ensuring accurate temperature control of the chamber. In a wide temperature range of from –10°C to 50°C, the heater PID exhibits temperature fluctuations of only ±0.2 degrees, and the Compressor ON-OFF controls only ±1 degree. In addition, the fluctuations of temperature uniformity in the chamber is within ±0.5 degrees, allowing a full range of precise experimentation from microorganism cultures to various types of incubation.

Energy Savings
Because heater output and compressor on/off are microprocessor controlled, optimum automatic operation according to ambient temperature and fluctuation of chamber load is possible, resulting in high-energy savings.

CFC-free Foamed-in-place Rigid Polyurethane Insulator
CFC-free Foamed-in-place polyurethane is used for the chamber because of its high thermal retention and energy saving properties.

Triple-pane Glass Observation Window plus 15W Fluorescent Lamp
An easy-to-observe triple-pane glass observation window and 15W fluorescent lamp are provided for sample observation during experimentation. When observation is not required, a light shielding plate (MIR-153/253) can be easily attached.

Alarm and Security System to Protect Sample Safety Automatic Setting Temperature Alarm
When the chamber temperature deviates more than ±2.5 degrees, all the digits of digital indicator flash and after 10 minutes a buzzer sounds. This system also automatically allows programmed operation or setting value changes.

Independent Over-temperature Protection Device
This incubator incorporates an excessive temperature prevention circuit that protects experimentation materials in the rare event that a temperature abnormality does occur. Isolated from the main circuit, this exclusive circuit and sensor operate even if the temperature sensor or micro-processor malfunction, activating an exclusive lamp and buzzer for notification. This system turns off the heater and chamber fan motor when over high temperature is detected (setting temperature range: 15°C~55°C), and turns off the compressor when over low temperature is detected (setting temperature range (–15 to 20°C). Remote alarm contact is provided for monitoring alarm from a remote location.

Programmable 3-step operational function with microcomputer control
Combining flexible Temperature (T) and Time (H) control, a maximum 3-step plus constant operation or max. 3-step repeating operation can be programmed according to the experimentation requirements. The one-step setting time ranges from 0.0 to 99.5 hours in increments of a half hour. A program can be set to repeat for a minimum of once up to a maximum of 99 times. Program input is simple and the steps during each operation are indicated by a lamp. This incubator accommodates a range of diversified experimentation requirements, and is ideal for experimentation during night time or holidays, experimentation that requires settings to be changed, and microorganism culture and preservation. Constant operation mode without step operation is also available.

5.2. Use in FRISBEE
With the described chilled and frozen range controlled storage cabinets isothermal and dynamic experiments in the freezing range for the frozen spinach and ice cream selected as case studies in WP3 will be conducted. The effect of storage temperature on spinach vitamin C retention, correlated with other quality indices such as colour, texture etc will be studied. Contribution of data with regards to shelf-life determination and factors that affect vitamin C oxidation, such as packaging material, water content trapped in the package and other quantifiable important quality loss indices (sensory characteristics – colour, flavour, texture, overall acceptability- by sensory evaluation tests, and colour –by CIELab colour parameters and measuring the chlorophyll content) will be performed.

As far as ice cream is concerned, ice recrystallization and texture deteriorations, phenomena mainly attributed to storage temperature and its fluctuations during the cold chain of ice cream, will be studied. Determination of ice cream shelf-life will be performed, based on different time-temperature profiles of storage and distribution of ice cream.

All the above pre-described incubators may be used for the chill chain simulation. The studied products will be stored in conditions simulating the real chill chain from production to the point of consumption. The simulated chill chain conditions will consist of different time-temperature scenarios, with different effective temperatures, $T_{eff,}$ as estimated by the cold chain data collection (WP2). The experiments will be conducted in the programmable temperature cabinets (Sanyo MIR 153, 154, 253, 553, Sanyo Electric, Ora-Gun, Gunma, Japan) and the freeze cabinets (Whirlpool AFG 543, 541). Products will be split at a designated point of the simulated chill chain, specific time from packaging (corresponding to the distribution centre) and will follow a simulated path to a “local” and a “distant” market.

6. Temperature controlled incubators / dataloggers – ACTIA

6.1 Description and technical specifications

The following incubators and dataloggers are available at **ACTIA-Aérial.**

Type	Reference	Reference	T°C min	T°C max	Volume (L)
Incubator	Dagard + Axima		2	10	23000
Incubator	Sanyo	MIR-553	-10	50	406
Incubator	Sanyo	MIR-553	-10	50	406
Incubator	Analis	Freez 1	7	26	93
Incubator	LMS		-5	26	48
Datalogger	AES	Memodata thermo II			
Datalogger	Elpro	EHT-1			
Datalogger	Elpro	TP4-L			
Datalogger	AES	Tomprobe			

Dagard + Axima

SANYO

LMS

Analis

The incubators and dataloggers of **ACTIA-ADRIA** are given below:

Equipment	Label	Model	T(°C)min	T(°C)max	Volume(L)
Incubator	AES-MMM	FRIOCELL	0	99.9	222
Incubator	AES-MMM	INCUCELL	28	70	222
Incubator	AES-MMM	BINDER KBE	10	70	720
refrigerated room	DAGARD (isolation) / Frigabohn (cooling)		0	10	16200
refrigerated room	DAGARD (isolation) / Frigabohn (cooling)		-25	-15	16200
Datalogger	AES-MMM	EVISENS			
Datalogger	DATAPAQ	DATA PAQ 9000			
Datalogger	ELLAB	EVAL			

FRIOCELL

INCUCELL

BINDER

DAGARD

6.2 Use in FRISBEE

All the above incubators may be used for the chill chain simulation. The studied products, RTE pork meals, will be stored in conditions simulating the real chill chain from production to the point of consumption. The simulated chill chain conditions will consist of static time-temperature scenarios for reference kinetics curves. The experiments will be conducted in the programmable temperature cabinets.

It is of interest to see whether the cold chain may have an impact on the development of the bacterial composition (spoilage and pathogen bacteria) and whether this influences the safety and thereby organoleptic quality of the Ready to eat pork product.

Based on Deliverable 3.2.4.2, ACTIA will identify new data and/or models to be developed inside the FRISBEE project. The temperature controlled incubators will be used to develop the complete kinetic models for describing different pork and RTE pork meals quality and safety indicators; two food types were chosen as model systems for pork meat: raw, salted and smoked ham including bacon; pasteurized ham and pate.

1. Behaviour of *L. monocytogenes* and spoilage lactic flora as a function of factors pH, aw, lactic acids, storage time, temperature and atmosphere conditions.

2. Characterization of texture and water retention during storage time, temperature and atmosphere conditions.

3. Characterization of odour.

This was concluded as a result of D 3.2.4.2. The use of the temperature controlled incubators at ACTIA is essential to come to D.3.2.4.6 “Validated kinetic models of chilled and frozen meat quality and safety”.