Second International Conference on Organic Food Quality and Health Research

Influence of processing on food quality with focus on organic food

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From **EC Reg. 834/2007**

Article 3
Objectives
(b) aim at producing products of **high quality**;

Organic production method as in line with the preference of certain consumers for products produced using **natural substances** and **processes**

Organic processed products should be produced by the use of processing methods which guarantee that the **organic integrity** and **vital qualities** of the product are **maintained through all stages of the production chain**

Specific principles applicable to processing of organic food
(c) the exclusion of substances and processing methods that might be misleading regarding **the true nature** of the product;
(d) **the processing of food with care**, preferably with the use of **biological, mechanical and physical methods**.

Prohibition on the use of GMOs and of ionizing radiation

Increasing demand for more processed organic food

Consumers' criteria related to quality for their choice of organic food

- **High sensory quality**
- **Freshness**
- **Naturalness**
- **Minimum use of additives**
- **Health**

Which criteria are important for an organic product to be successful on the food market? (*from QLIF project*)

- **Sensory quality**
- **Minimum use of additives and processing aids**
- **Freshness**
- **Authenticity**

Important but not the most important: health

Food processing serves multiple objectives ….

Safety

Preservation
- Stabilization
- Shelf-life

Ingredients
End products

FOOD PROCESSING

Convenience

Food availability

Quality

Nutrient availability

Variability of food supply

Health and wellness

Size reduction →
- milling
- cutting
- grinding
- homogeneization

Shaping

Transformation →
- fermentation
- enzymatic reaction
- chemical reaction

Stabilization →
- sterilization
- freezing
- drying

Mixing →
- kneading
- dissolving
- emulsifying
- foaming

Separation →
- sieving
- filtration
- centrifugation
- settling
- extraction
- crystallization
- distillation
- evaporation
- degassing
- absorption
- flocculation

Packaging (modified atmosphere, vacuum)

etc. ....

A process is an organized and logical sequence of unit operations

Applications of disciplines involved in food science and technology

Discipline	Examples of food science and technology applications
Biology, cell biology	Understanding of post-harvest plant physiology, food quality, plant disease control, and microbial physiology; food safety
Biotechnology	Rice with increased content of beta-carotene; enzymes for cheese-making, bread-making, and fruit juice manufacture
Chemistry	Food analysis, essential for implementing many of the applications listed here; improved food quality; extended shelf-life; development of functional foods
Computer science	Food manufacturing process control, data analysis
Genomics	Understanding of plant and animal characteristics, improved control of desirable attributes, rapid detection and identification of pathogens
Material science	Effective packaging; understanding of how materials properties of foods provide structure for texture, flavor, and nutrient release
Microbiology	Understanding of the nature of bacteria (beneficial, spoilage, and disease-causing microorganisms), parasites, fungi, and viruses, and developments and advances in their detection, identification, quantification, and control (for example, safe thermal processes for commercial sterilization); hygiene; food safety
Nutrition	Foods fortified with vitamins, and minerals for health maintenance; functional foods for addressing specific health needs of certain subpopulations; development of diets that match human nutrient requirements; enhanced health and wellness
Physics, engineering	Efficient food manufacturing processes to preserve food attributes and ensure food safety; pollution control; environmental protection; waste reduction efforts
Sensory science	Understanding the chemosenses (for example, taste, odor) to meet different flavor needs and preferences
Toxicology	Assessment of the safety of chemical and microbiological food components; food additives

From: Floros J.D. et al. 2010. Comprehensive Reviews in Food Science and Food Safety, 1-28

Effects of heat treatments

Positive

- Inactivation of food-borne pathogens
- Inactivation of natural toxins or other detrimental constituents
- Prolongation of shelf-life
- improved digestibility and bioavailability of nutrients
- Improved palatability, taste, texture and flavour
- Enhanced functional properties (including augmented antioxidants and other defense reactivity or increased antimicrobial effectiveness)

Negative

- Losses of certain nutrients
- Formation of toxic compounds (acrylamide, furan or acrolein)
- Formation of compounds with negative effects on flavour perception, texture or colour.

Heat treatment and tomato products

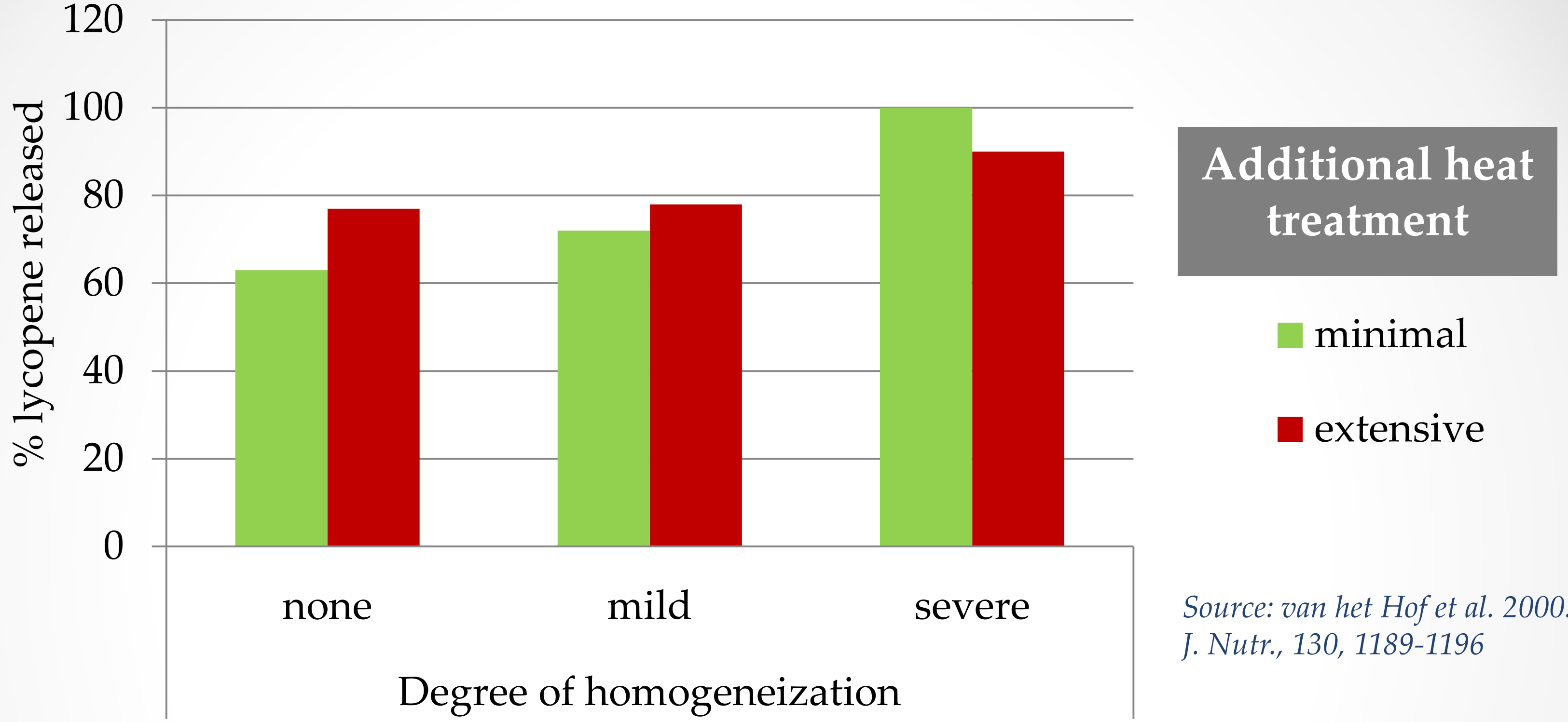
fresh

paste

°Brix	
6	25
trans-lycopene (mg/100 g f.w.)	
20.1	86.9 (+ 432%)
trans-lycopene (mg/100 g corrected to 25 °Brix)	
120.7	86.9 (- 28%)

Source: Takeoka et al., 2001. J. Agric. Food Chem., 49, 3713-3717

Breakdown of the matrix



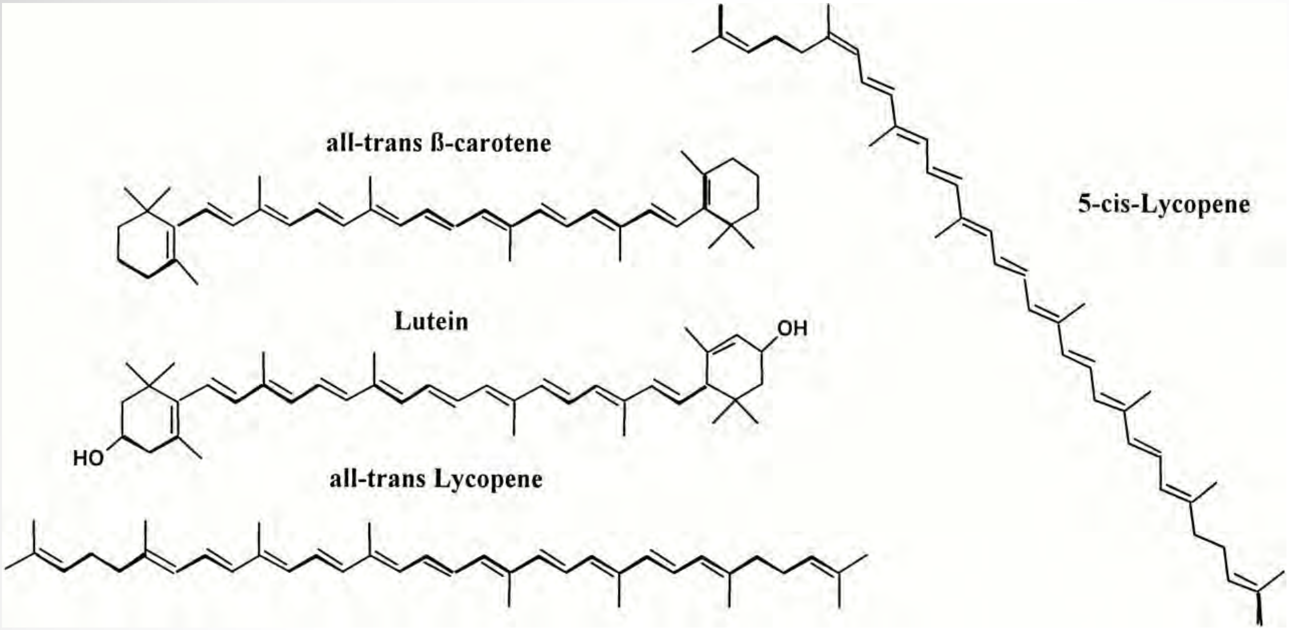
Source: van het Hof et al. 2000. J. Nutr., 130, 1189-1196

The proportion of lycopene release was significantly different

- *among all degrees of homogenization for the minimally additionally heated tomatoes*
- *between severely homogenized and not or midly homogenized for the extensively heated tomatoes*

Additional heat treatment significantly enhanced the release of lycopene only for not and mildly homogenized tomatoes

Lycopene isomerization



(Source: Boileau et al., 2002. Exp. Biol. Med., 227, 914-919).

Structures of common carotenoids found in human serum and tissues.

all-trans and 5-cis-lycopene are the two most common isomers found in human and animal tissues

Lycopene source	% trans	Reference
Fresh tomato	100	Shi J. Crit Rev Food Sci Nutr **40:**1–42, 2000
Fresh tomato	95.8	Nguyen and Schwartz. Proc Soc Exp Biol Med **218:**101–105, 1998
Fresh tomato, heated 200°C, 45 min	89.3	
Tomato paste	92.6	Schierle et al. Food Chem **59:**459–465, 1997
Tomato paste, heated 70°C, 3 hr	83.4	

Effect of homogenization of tomatoes on the response of lycopene in human trygliceride-rich lipoproteins after 1 d of consumption of tomato products

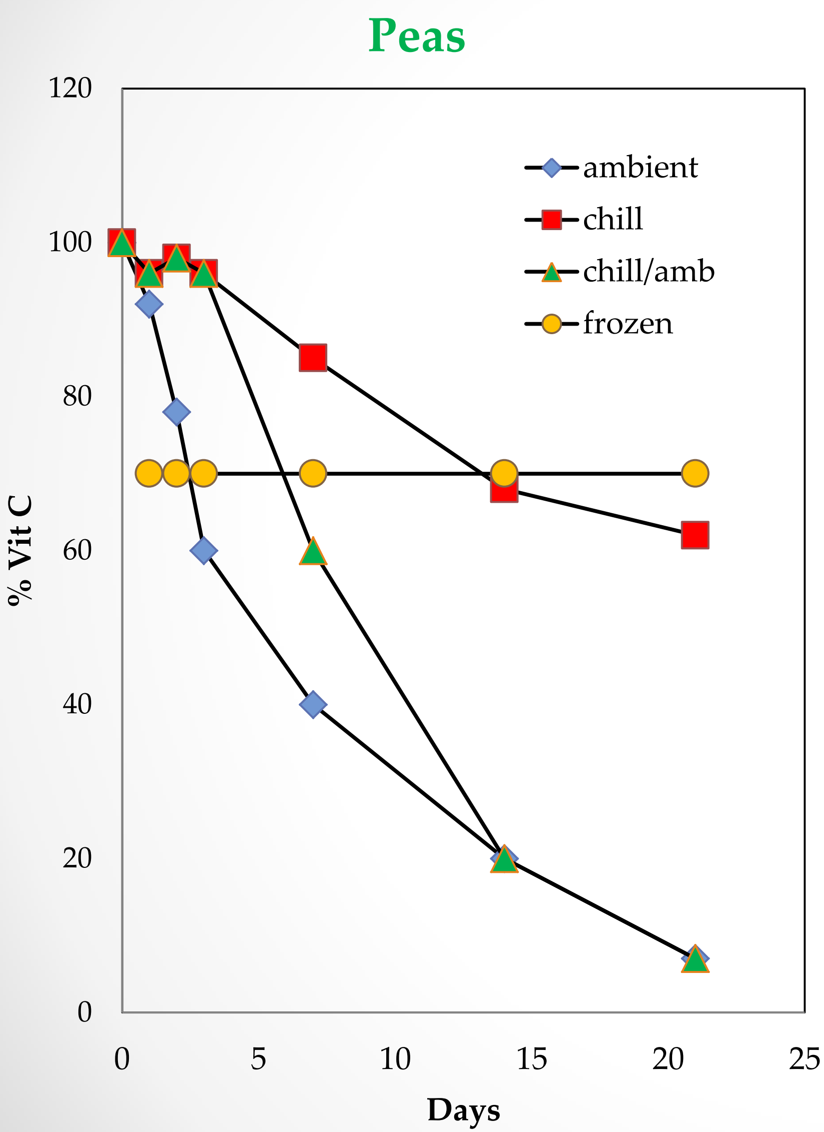
	Degree of homogenization		
	None	Mild	Severe
Postprandial TRL response			
Lycopene (nmol h/L)	54.9 ± 11.0 **a**	72.2 ± 11.0 **ab**	88.7 ± 11.0 **b**

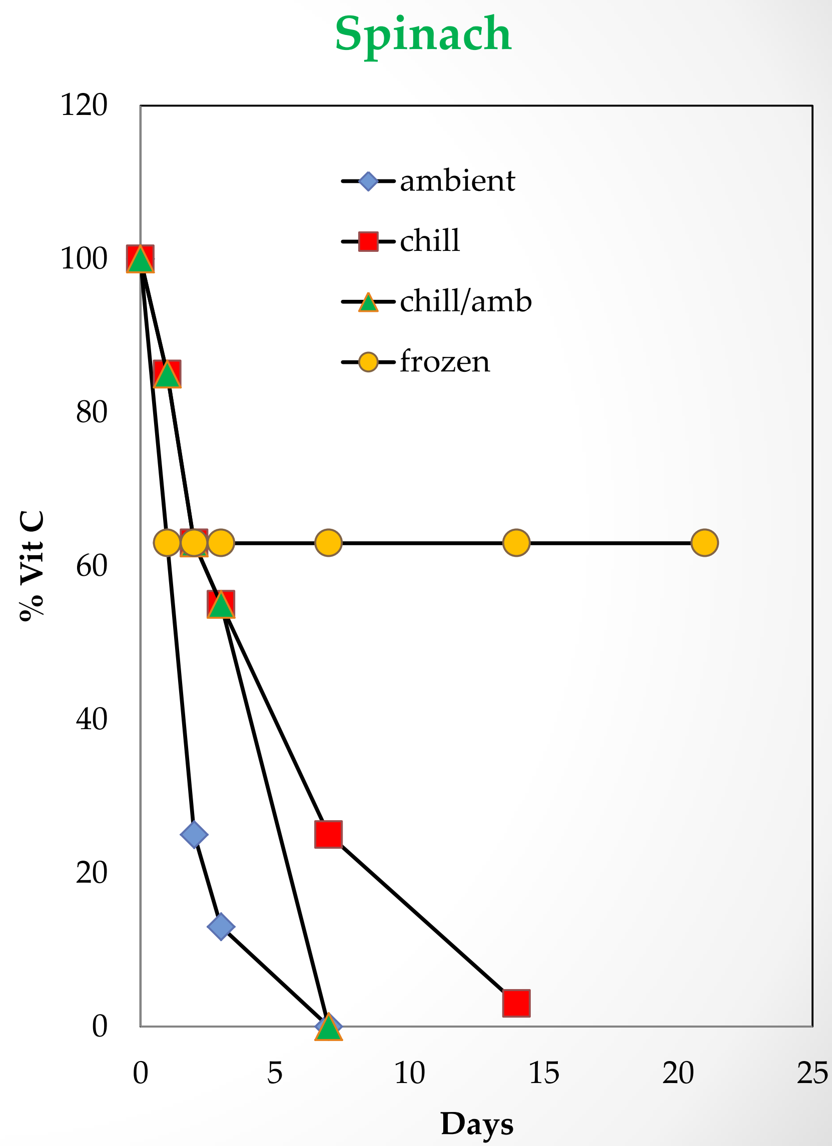
Effect of heat treatment of tomatoes on the response of lycopene in human trygliceride-rich lipoproteins after 1 d of consumption of tomato products

	Heat treatment	
	Minimal	Extensive
Postprandial TRL response		
Lycopene (nmol h/L)	59.0 ± 16.6 **a**	84.9 ± 16.6 **b**

The increase of lycopene concentration in human TRL after consumption of tomato product indicates an increase in lycopene bioavailabity related to the disruption of the matrix by homegenization and heat treatment and to the isomerization of lycopene from the configuration *all-trans* to *cis-isomers*

Vit C retention in fresh, chilled and frozen vegetables





From: Favell D.J. 1998. Food Chemistry, 62, 59-64

Losses of ascorbic acid (% d.w.) due to canning and freezing processes

	Canning	Blanching + freezing
Carrots	90	0-35
Green beans	63	28
Spinach	62	61

Losses of ascorbic acid (% w.w.) due to storage of fresh, frozen and canned vegetables

	Fresh			Frozen		Canned	
	Days	°C	Loss (%)	Months	Loss (%)	Months	Loss (%)
Carrots	84	4	5-10	12	0-50	12	NS
Green beans	16	4	90	6	4	6	8
Spinach	21	4	75	6	26	6	NS

From: Rickman J.C. et al. 2007. J. Sci. Food Agric., 87, 1185-1196

USDA nutrient data for ascorbic acid (g/kg w.w.) in selected vegetables

	Fresh		%	Frozen		%	Canned	
	Uncooked	Cooked		Uncooked	Cooked		Drained solids	Liquid + solids
Green beans	0.163	0.097	**-40**	0.129	0.041	**-68**	0.048	0.034
Peas	0.400	0.142	**-65**	0.180	0.099	**-45**	0.096	0.098
Spinach	0.281	0.098	**-65**	0.243	0.022	**-90**	0.143	0.135

- Fresh is often best for optimal vit C content, as long as the fresh product undergoes minimal storage at refrigerated temperature
- Canning process causes significant initial loss of ascorbic acid; further losses due to storage and cooking are minimal
- Blanching and freezing process is not as destructive to ascorbic acid, but continued storage and subsequent cooking result in significant degradation of the vitamin

From: Rickman J.C. et al. 2007. J. Sci. Food Agric., 87, 1185-1196

Fresh products category

Their shelf life is shorter than that of the raw materials from which they are obtained. **Convenience**

Short shelf-life

Their preservation is based on:

- **the high quality of raw materials, both microbiological, sensory, nutritional;**
- **the presence of hurdles to the growth of the microorganisms**

Refrigeration

Hurdle technology concept

Minimally processed foods. Possible definitions

From: "Minimal processing technology in food industry. (Ohlsson T and Bengtsson N. eds.). Woodhead Publishing Limited, Cambridge, UK, 2002

The least possible treatment to achieve a purpose

Minimal processes are those which minimally influnce the quality characteristics of a food whilst, at the same time, giving the food sufficient shelf-life during storage and distribution

Techniques that preserve food but also retain to a greater extent their nutritional quality and sensory characteristics by reducing the reliance on heat as the main preservative action

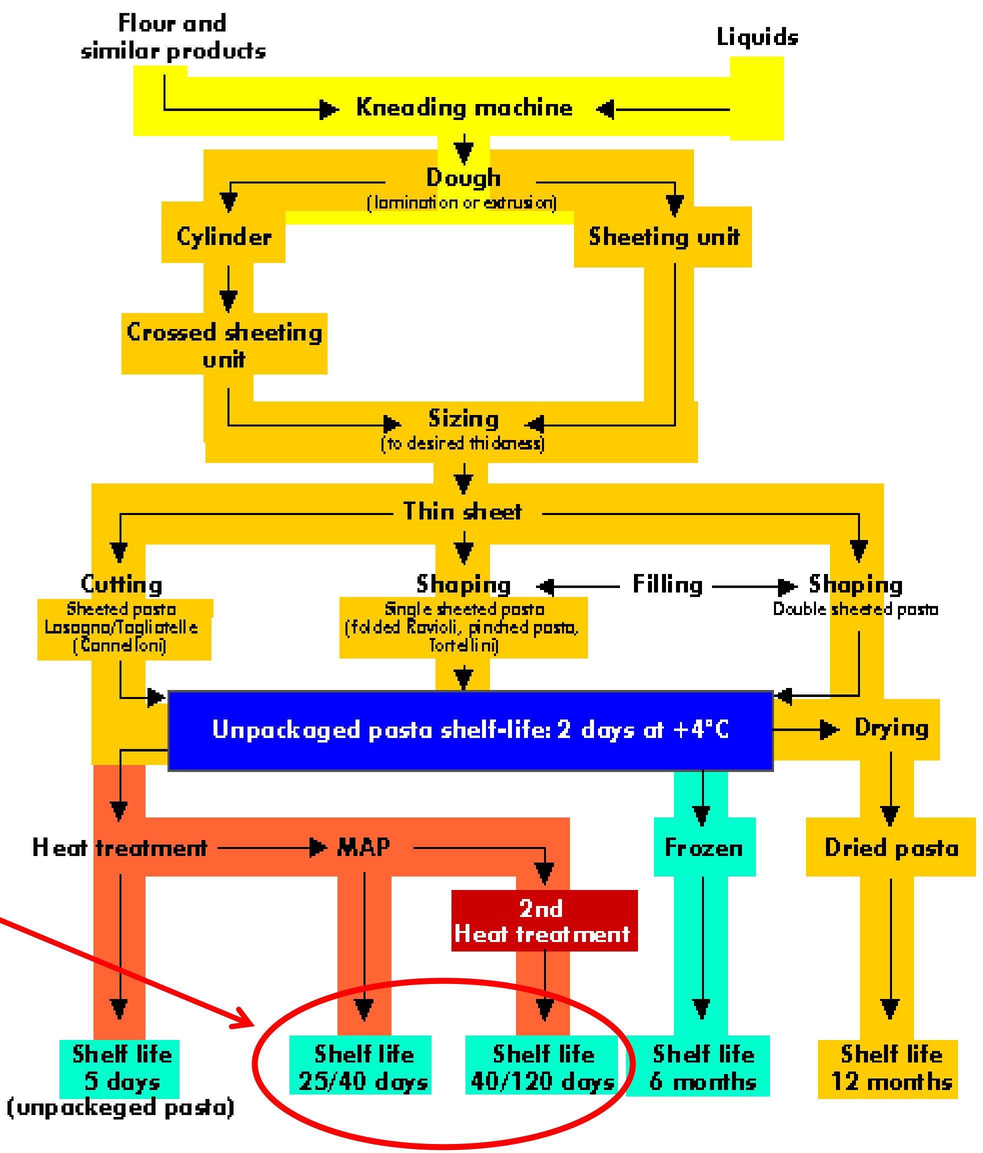
Minimal processing describes those technologies to process food in a manner to guarantee the food safety and preservation, as well as to maintain as much as possible the fresh like characteristics

High level of convenience. Synonym of minimally processed are ready-to-use, ready-to-eat, pre-cut, fresh-cut, lightly processed, etc.

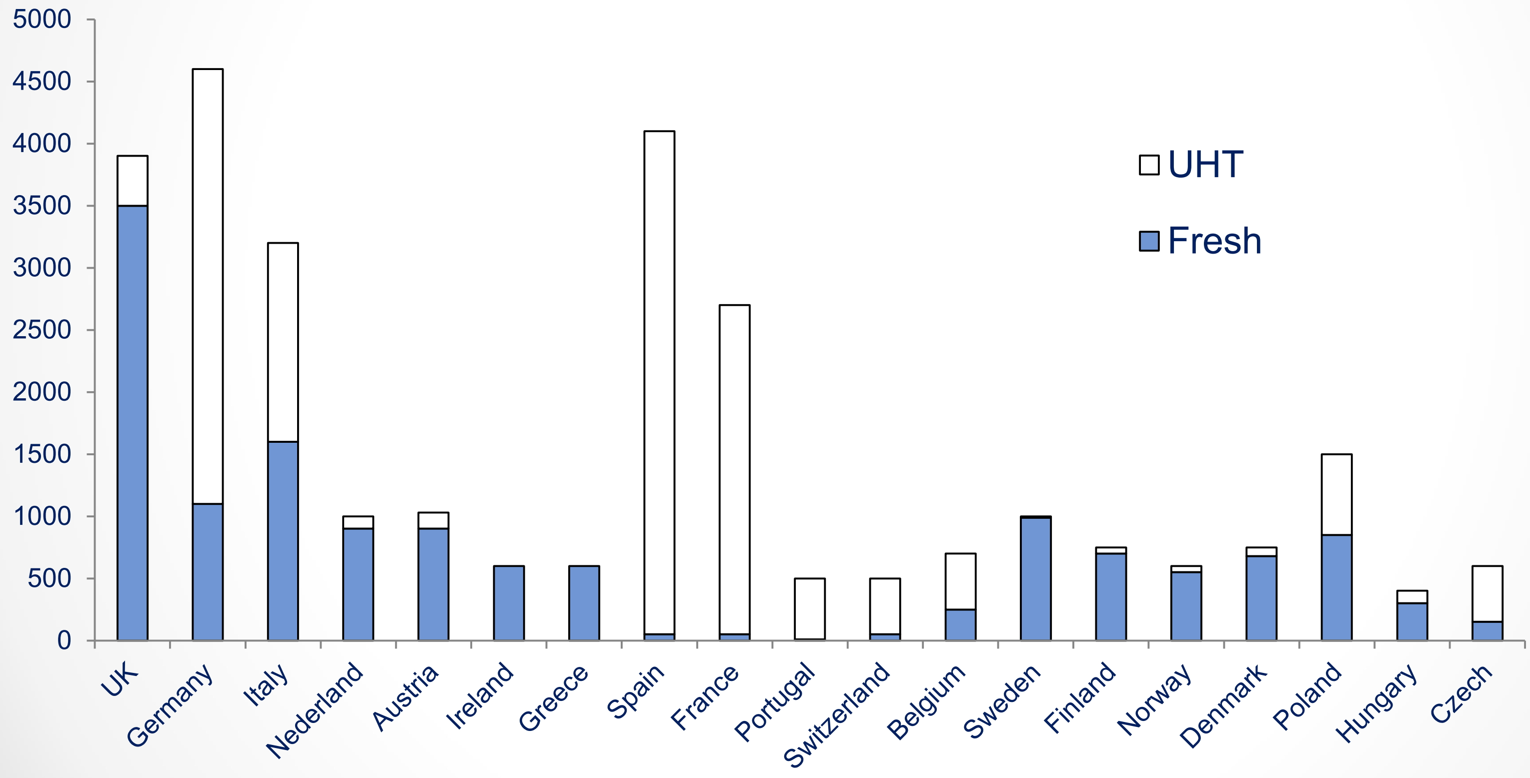
Developments in thermal technologies have been considered minimal where they have minimized quality loss in food compared to the conventional thermal techniques

Nowadays, for the consumers «fresh pasta» is …….

FRESH PASTA DIFFERENT PRODUCTION TECHNOLOGIES AND SHELF LIFE



The European milk market is split between pasteurized and aseptic



Source: Elopak Market Units, Euromonitor. 2003

ESL milk is a product that has been treated in a manner to reduce the microbial count beyond normal pasteurization, packaged under extremely hygienic conditions, and which has a defined prolonged shelf life under refrigerated conditions.

Current methods for ESL:

- **Microfiltration**
- **Direct heat treatment (injection or infusion)**
- **Indirect heat treatment**

Process technology: effect on spore reduction, heat damage indicators, and rough estimate of shelf life

Process	Log reduction aerobic psychrotrophic spores	Expected shelf life Max 6*C storage (days)	Lactulose (mg/kg)	β-lactoglobulin (mg/L)
Raw milk			0	3,500
Pasteurization	0	10-12	10	3,100
Direct heating	8	180	25	1,600
Indirect heating	40	180	32	1,000
Microfiltration	2-3	30	17	2,500

Source: Rysstad and Kolstad, 2006. Internation Journal of Dairy Technology, 56, 85-96

CLA content is higher in organic milk than in conventional. Several studies on the effect of heating milk and processing have shown no changes in CLA content. (Butler G. et al., 2011. NJAS – Wageningen Journal of Life Sciences, 58, 97-102).

Lactulose content in Italian UHT milk

UHT milk Commercial products	Lactulose (mg/kg)	
	mean	SD
A	102.2	5.8
B	134.9	2.7
C	475.4	8.1
D	193.3	4.6
E	859.1	4.3
F	200.5	1.7
G	354.3	3.2
J	905.6	12.8
H	771.7	7.1
K	626.1	6.0

Range min -max: 102.2 – 905.6 (mg/kg)

It means that different procedure have been applied to have the same product from a product sector point of view

Several (more or less careful) technological solutions can be adopted to achieve the same objective

Source: Manzi and Pizzoferrato. Food and Bioprocess Technology, 2013, 6: 851-857

Novel technologies

Thermal

Ohmic heating

Internal generation of heat due to the electrical resistance of foof componenents to the passage of an electric current

Non-thermal

High pressure

Pressure 100 – 1000 MPa
Pascal principle
Le Chatelier principle
Protein denaturation

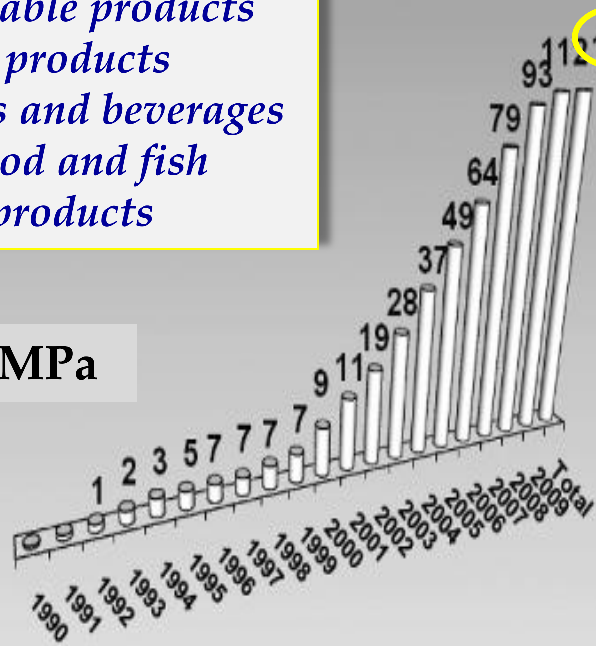
Pulsed electric field

High intensity electric field (> 0.5 kV/cm) in form of very short pulses (μs to ms)
Membrane permeabilization (electroporation)

High Pressure Processing (HPP) and High Pressure Thermal Sterilization (HPTS)

32% vegetable products
24% meat products
21% juices and beverages
17% seafood and fish
6% other products

100 – 800 MPa



Number of commercial high-pressure equipment units around the world (2009)

Juices, jams, jellies, yogurts, ready-to-eat meat, oysters

- **Inactivation of vegetative organisms and spoilage enzymes at low or moderate temperature**
- **Opportunities for increased shelf life and preservative-free stabilization**
- **Modification of physical and functional properties of some food (gelation of protein)**
- **Improvement of protein digestibility**
- **Tenderization of meat products**
- **Fresh-like qualities retained**

For the inactivation of microbial spores a combination of high pressure and elevated temperatures, HPTS, is necessary.
Synergistic inactivation at potentially lower temperatures or shorter processing times: improving quality while reducing energy consumption

Advantages

- Energy efficient
- Very rapid treatment (OH, PEF)
- Little effect on colour, flavour, nutrients
- Reduction unwanted thermal effects

Disadvantages

* Unless in combination with heat

	Ohmic heating	HPP	PEF
Uniformity of treatment	No	No	No
Limited throughput	No	Yes	No
High cost equipment	---	Yes	Yes
Labor	No	Yes	---
Spore inactivation	Yes	No *	No *
Enzyme inactivation	Yes	Reversibility of inactivation, activation of latent forms *	Many are not affected *
Knowledge	Yes	To be developed	To be developed
Type of product	No limit	No limit	Liquid, semi-fluid
N. applications in food industry	Scarce	126 plants worldwide (2009)	Still scarce
Refrigeration	No	Yes *	Yes *

Nanotechnology

Involves the manufacture, processing and application of materials that have one or more dimensions of the order of 100 nm or less

From the convergence of nanotechnology with other technologies → innovations → production, processing, storage, transportation, traceability, safety and security of food (e.g., nano-biosensors, electronic tongue, etc.)

Nanostructured food ingredients and delivery systems for nutrients and supplements

Food packaging

Objectives of the incorporation of nanoparticles in food packaging materials

- to improve packaging properties (flexibility, gas barrier properties, temperature stability)
- produce active packaging (nanoparticles with antimicrobial or oxygen scavenging properties)
- produce intelligent food packaging (incorporating nanosensors to monitor and report the condition of food)
- produce biodegradable polymer-nanomaterial composites

The knowledge about this technology is still very scarce

Potential migration of nanoparticles into food and drinks from food packaging

Migration data are not currently available.
A number of such food packaging materials containing already available and in commercial use in some countries.

Indirect sources of food contamination with nanoparticles:

- **nano-sized pesticides and veterinary medicines**
- **contact of food with nanoparticulate-based coatings**
- **as the environmental behavior, distribution and fate of nanoparticles is currently not fully understood, it is difficult to assess whether nanoparticles in the environment will bioaccumulate/bioconcentrate in the food chain**

- ***Few studies have been carried out into the toxicology of nanomaterials***
- ***The potential effects of nanoparticles through the gastrointestinal route are largely unknown.***
- ***A growing body of scientific evidence indicates that free nanoparticles can cross cellular barriers and that exposure to some forms can lead to increased production of oxyradicals and, consequently, oxidative damage to the cell.***

Use of nanoparticles to deliver ingredients and supplements in food

Functional foods can be divided into three categories according to the nature of the functional ingredients:

a) natural food containing high levels of the functional ingredient or with high functionality;
b) food to which functional ingredients were added or removed;
c) food in which the nature of functional ingredients has been changed.

Consumers buy organic food because they associate them to naturalness; in contrast, the decision to buy functional food is related to rationality and consumer associate functional food with a more technological approach (Kahl et al., 2012)

This should be even more valid for food enriched by nanotechnology

Some considerations

- A possible definition for careful processing could be «the one which allows to achieve a preset objective while reducing at minimum the (undesirable) side effects»
- Careful processing is not an absolut concept and its assessment needs a comparison between different solutions to achieve a specific objective for a specific product based on the assessment of different parameters
- Sensory characteristics and freshness, in particular, are the most important indicators. The parameters have to be individuated for the different products
- Like for the environmental impact assessment (LCA method), also for the assessment of the impact of a technology on quality the entire life cycle of a product should be considered, including also its preparation for consumption (CE Reg. 834/2007 recommendation for quality maintenance)

•The "minimal process" seems to be suitable for the organic sector, but it appears as a part of the more comprehensive concept of careful processing
•Many novel technologies seems to be suitable for the organic sector and consider a "minimal processes" but further research is needed
•There is a need of research for packaging material (biodegradable, recyclable, etc.)
• Traditional and innovative. Structural problems of the organic SMEs; different ideological visions of the organic production

Thanks for your attention!