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Leading Sensory Innovation

Microencapsulation and Controlled Release of Flavours

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Presentation Outline

- What is a flavour?
- Why, what and where of flavour delivery systems?
- Some principles
- Examples:
  - Barrier systems for dry environments
  - Barrier systems for water continuous environments
- Conclusions

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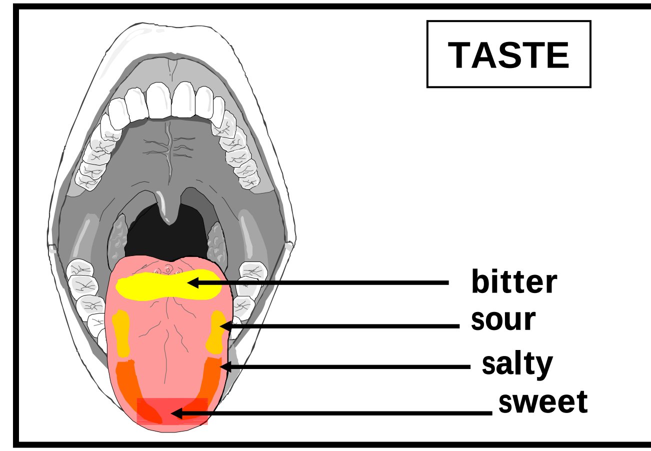
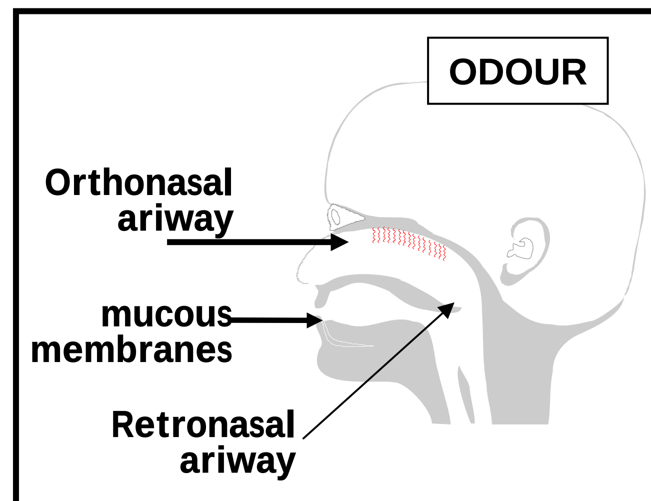
What is a flavour?

- Flavour is a mixture of taste and odour sensations.
- It deeply characterises our eating experience triggering physiological and psychological responses ultimately functioning as a quality control.
- Odour molecules must have a certain volatility to reach the nose epithelium.
- Typical odour molecules are aldehydes, esters, pyrazines, sulfides, furans, etc.
- Taste is generally associated with flavours in order to give the full sensorial experience during eating.





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Threshold value: the lowest perceptible concentration

1 gram ethanol	in	10 litre water
1 gram butyric acid	in	42,000 litre water
1 gram amyl acetate	in	200,000 litre water
1 gram methyl mercaptan	in	50,000,000 litre water
1 gram b-ionone	in	143,000,000 litre water
1 gram 2-isobutyl-3-methoxy pyrazin	in	500,000,000 litre water

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What makes flavour challenging to encapsulate?

- They are mainly available as liquids.
- They are usually a mixture of many components with different physico-chemical properties: They are usually relatively hydrophobic and relatively small and volatile.
- Sensory threshold may vary dramatically.
- They may be unstable in certain conditions or may interact with the food matrix.
- If used as such they generally have a single release kinetics.

The role of delivery systems for flavours

A delivery system consists in a chemical or physical or physico-chemical barrier between the active and the external environment. This barrier is designed to achieve:

- **Protection of the flavours from:** Oxidation, Water, Evaporation, Chemically interacting species, etc.

- **Allow processing of the flavours:** Turn liquids into powder, avoid dissolution of particles into matrix.

- **Controlled or triggered release:** Time intensity, Heat/Temperature, pH, Shear, Water/saliva.

- **Masking taste or very strong odour:** mask bitterness of sweeteners or reduce odour to improve factory conditions.

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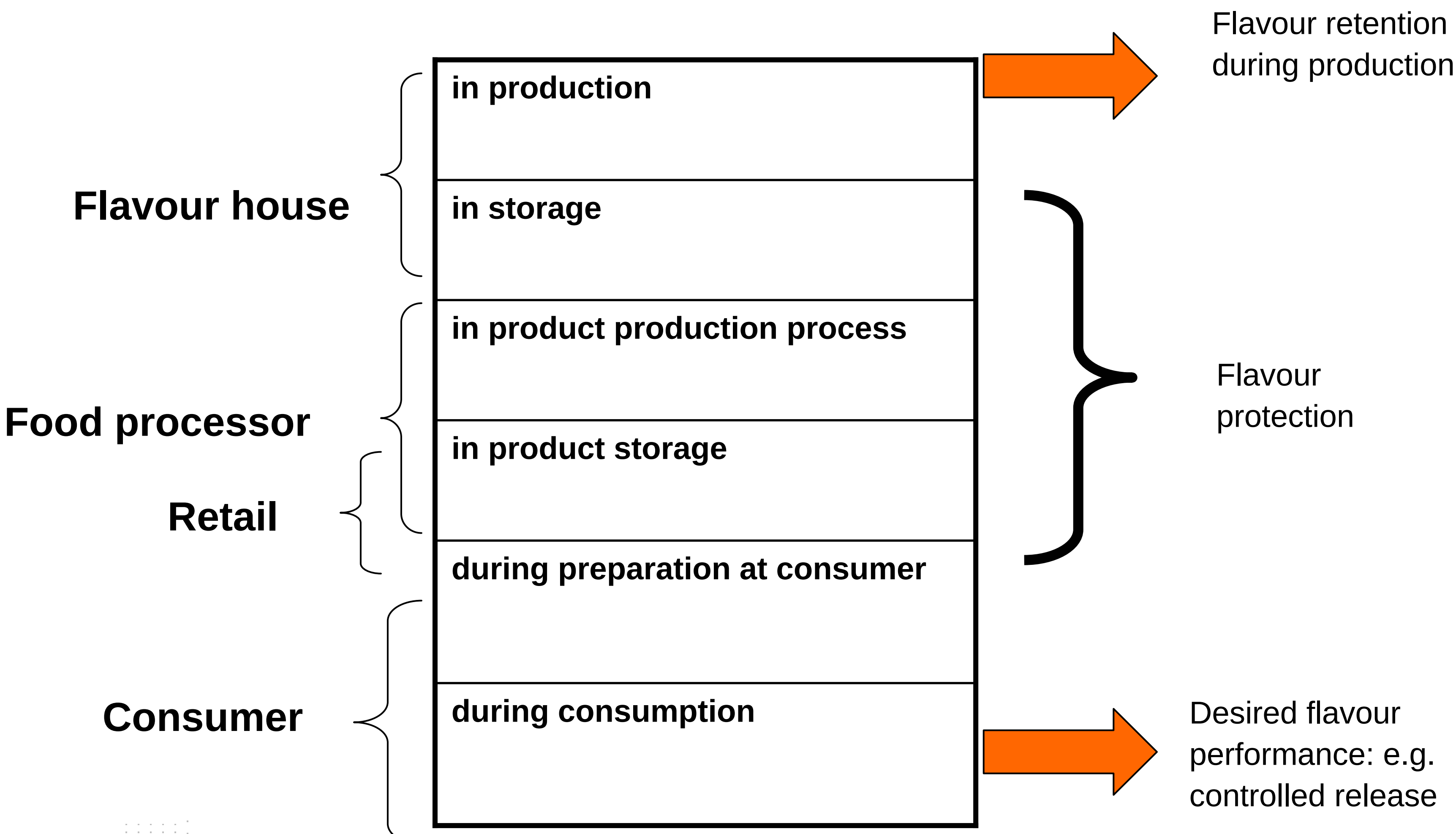
The Flavour Delivery System life cycle



Where are the used?
Applications and their evolution

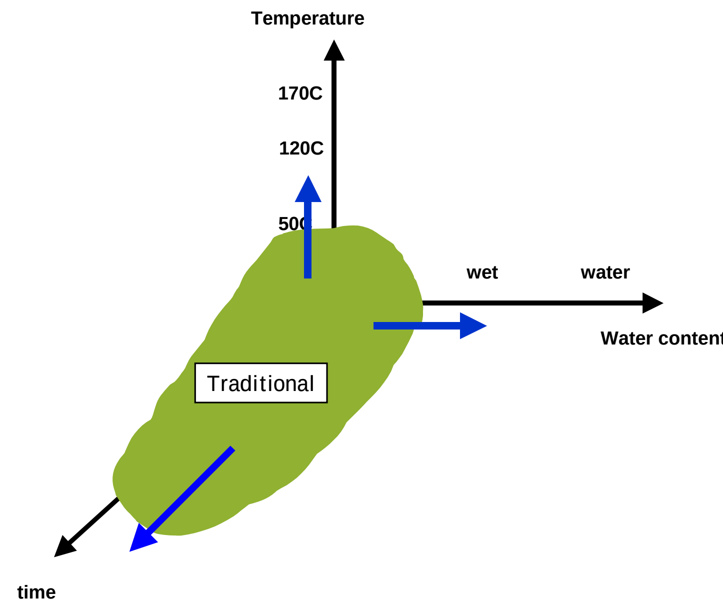
Flavour delivery systems evolved from dry powder applications where essential target was <u>encapsulation for protection</u> during the product shelf life for dry products into…

Where are the used?

Applications and their evolution

…more challenging conditions particularly focusing on:

- stabilisation in water continuous systems
- controlled release



Flavour Delivery System technologies

Some principles

There are three basic principles:

- Physico-chemical systems → e.g. emulsions

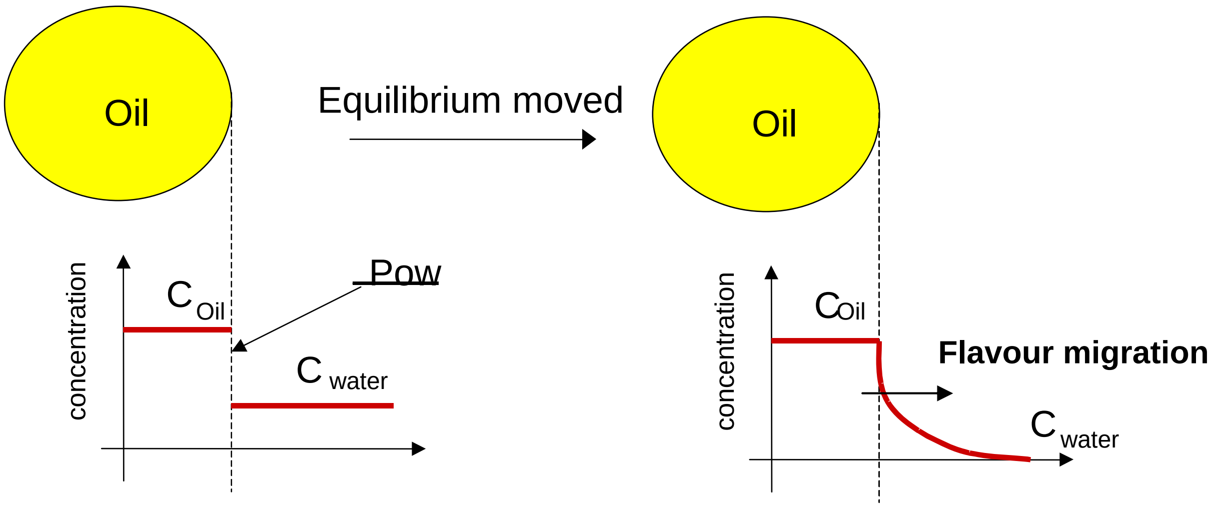
- Chemical routes → e.g. precursors

- Physical barriers → e.g. spray dry powders

Physico-chemical mechanism

In this case flavour species would be trapped by forces linked to chemical and physical interactions with the rest of the system.

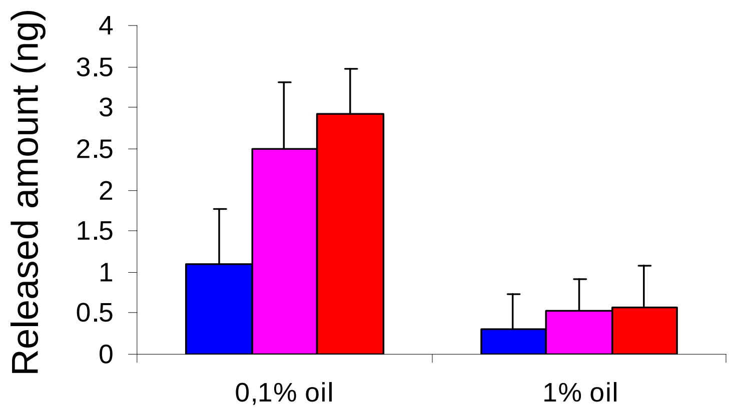
Trigger through dilution for partitioning molecules



Flavour Matrix Interaction

Effect of droplet size on in vivo release (geranyl acetate)

The release is affected by particle size, so different flavour perception associated due to release kinetics controlling flavour release!



mean droplet diameter (D(4,3)):

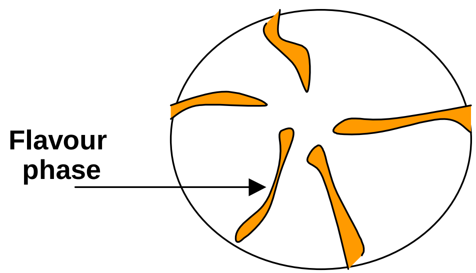
0.4 2.3 10 µm

Oil-water surface:

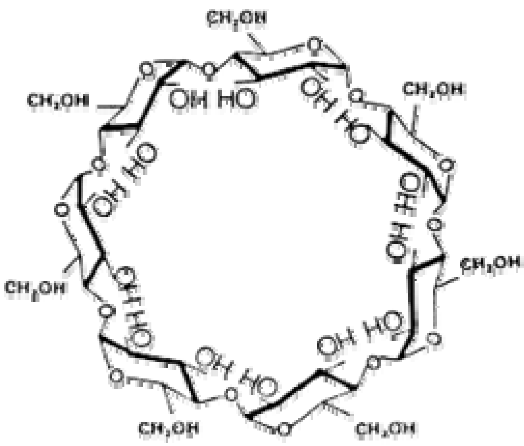
234.000 58.000 19.000 cm2/ml oil

MCT oil, effect on release.
Measured with MS-Nose.

Physico-chemical mechanism



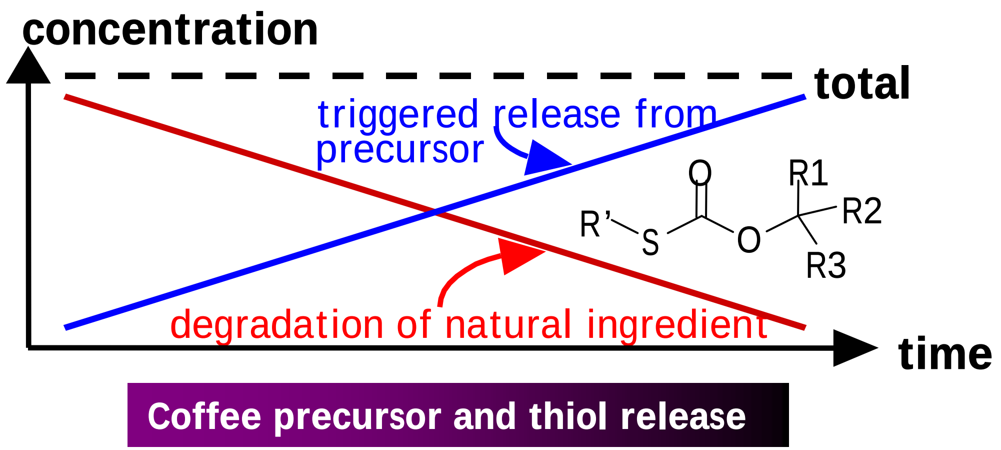
silica



cyclodextrins

Chemical systems

- Protect unstable molecules: e.g. thiols; unsaturated aldehydes/ketones.
- Develop Nature Identical precursors with appropriate (in)stability.
- Release triggers: e.g. pH; heat; light.
- Fine tune rate of release: e.g. sterilised vs instant products (coffee, soup).



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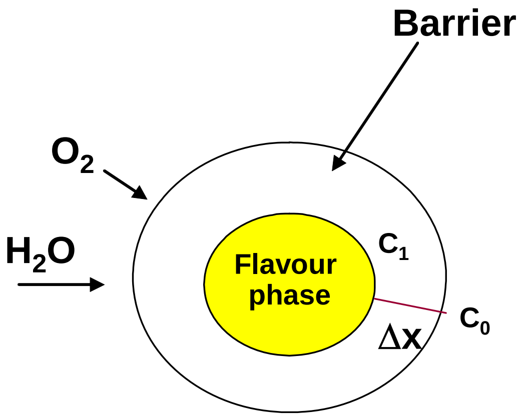
Physical barriers

Barrier properties are essential to control flavour permeability.

In this category most of the systems are present:

- Spray drying
- Fluidised bed processing (coating, agglomeration)
- Coacervation
- Spray chilling
- Extrusion
- Biological encapsulation



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Physical barriers

Applications based cases

Two cases will be reported involving design of physical barriers:

- **Barrier systems for dry environments**

Protection of flavour in dry applications in order to guarantee long shelf life stability

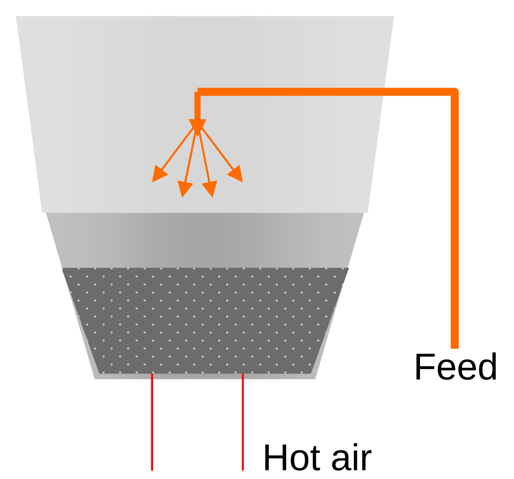
- **Barrier systems for water continuous environments**

Physical barriers designed to achieve controlled release once in contact with water

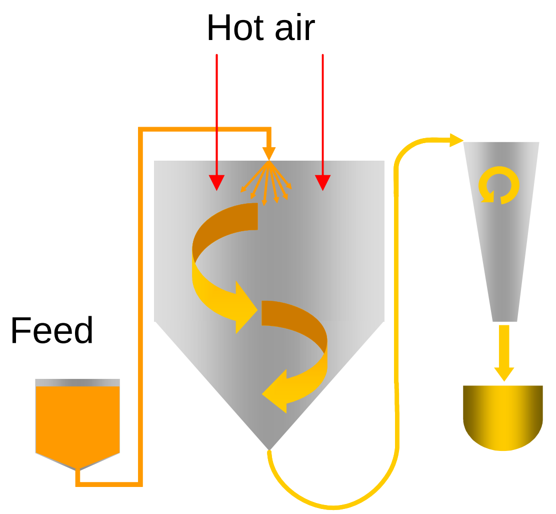
Barrier systems for dry environments

Challenges associated with drying processes

All drying processes are associated with exposure to heat due to the energy intensive process of drying water. Preserving flavour during the process is essential and barrier properties play an important role in combination with the same process design.



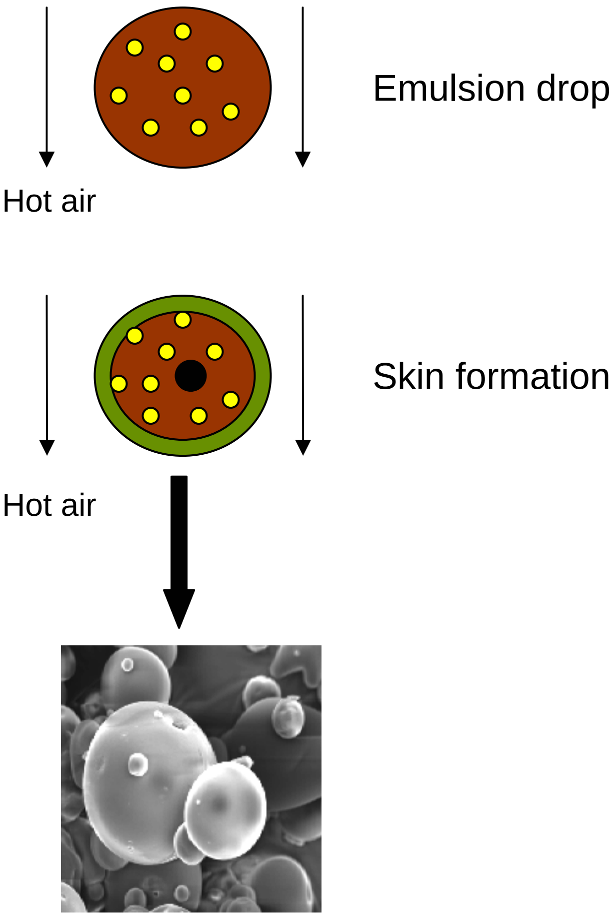
Fluidised bed processing



Spray drying

Example of spray drying

Drying kinetics and particle morphology



Various publications* refer to the theory of selective diffusion to explain the kinetics of volatile retention.

The presence of an equilibrium sink (emulsified lipid phase) also contributes to volatile retention.

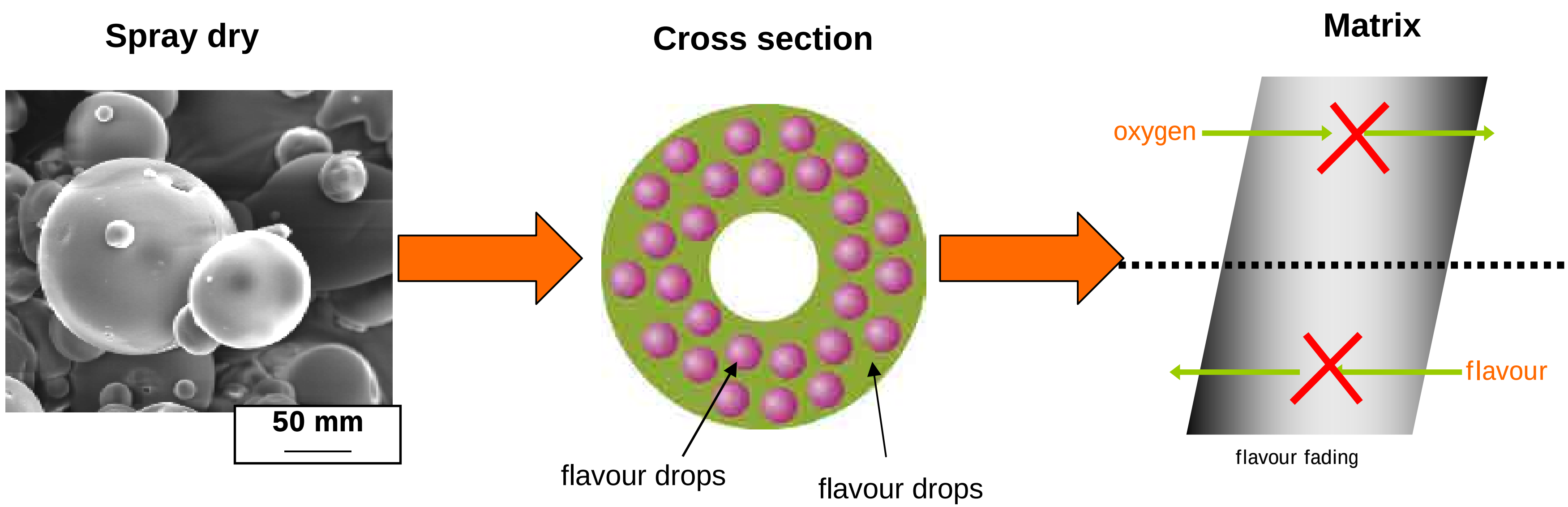
The drying kinetics principles are clearly applicable to all other drying processes.

* e.g. *W. H. Rulkens and H. A. C. Thijssen, J. Food Technol. 7, 95–105 (1972).

Barrier systems for dry environments

The challenge: prevention of off-flavour formation in shelf life

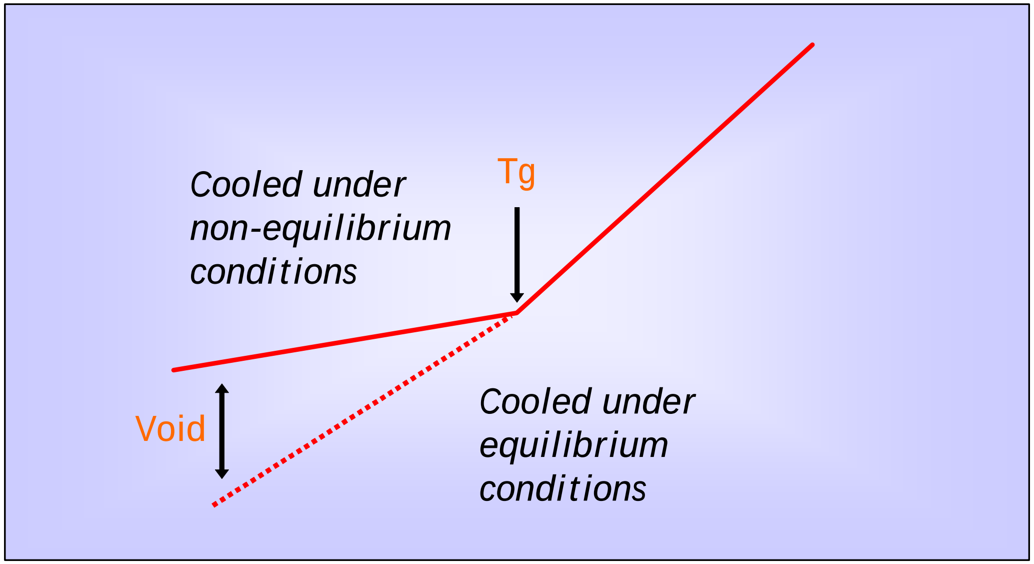
Matrix design plays a fundamental role in the flavour stability during storage in typical drying processes.



Flavour stability in dry applications

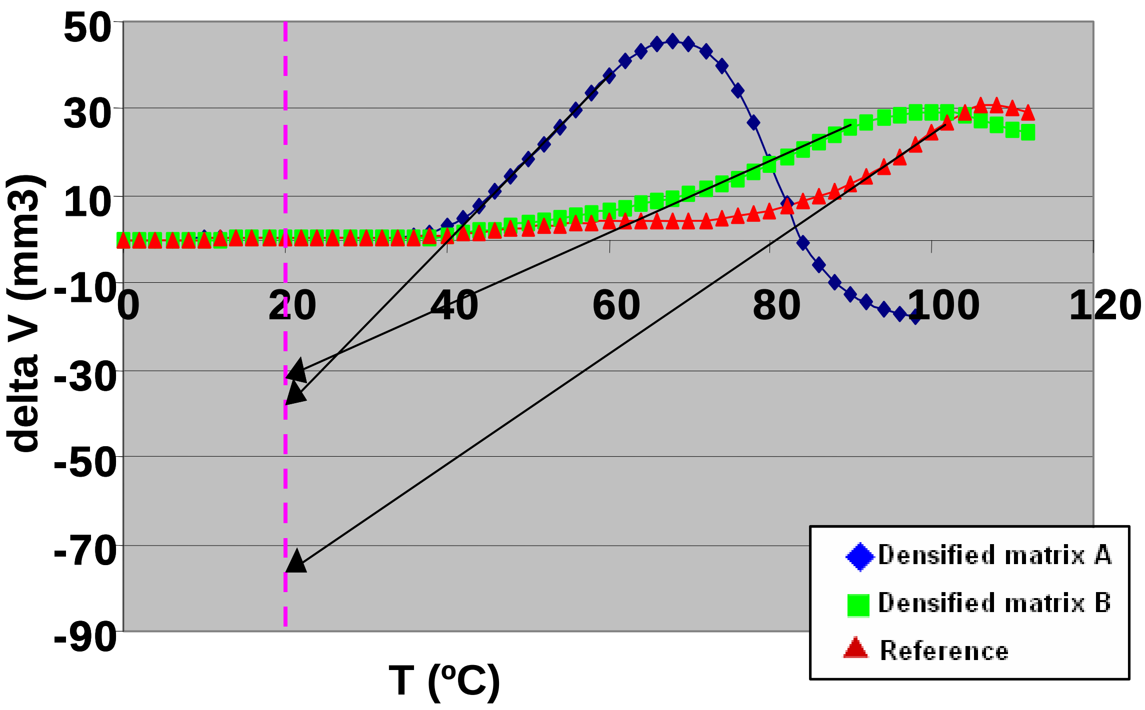
The impact of drying

Non-equilibrium drying conditions may lead to formation of free volume which is affecting the permeability of the matrix particularly to oxygen, for many flavours the main cause of degradation phenomena.



Densified matrix

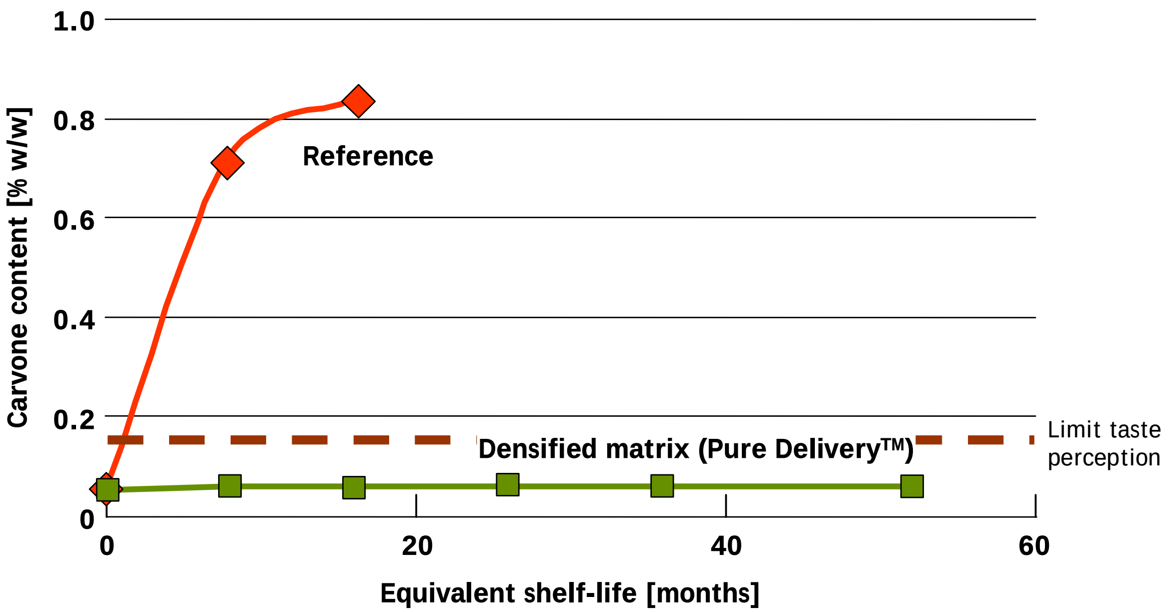
Addition of fillers to the matrix design increases carrier density.



TMA data on unflavoured carrier material

Impact of denser barriers on shelf life performance

Densification prevents off-flavour formation up to 6 years without anti-oxidants.



*Patented technology. Tested at 40°C and low RH for production scale batches. Every 10°C increase in temperature results in a reaction rate acceleration by a factor of approx. 2.5 (20°C:6.25)

Physical barriers
Applications based cases

Two cases will be reported involving design of physical barriers:

- **Barrier systems for dry environments**

Protection of flavour in dry applications in order to guarantee long shelf life stability

- **Barrier systems for water continuous environments**

Physical barriers designed to achieve controlled release once in contact with water

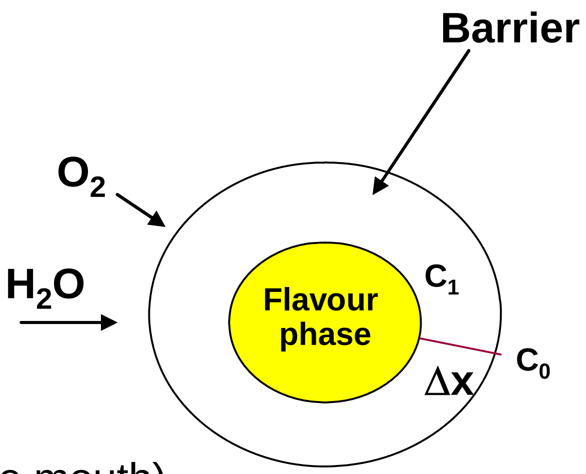
Barrier systems for water continuous environments

- In many food applications the high amount of water and the high temperatures involved may dramatically influence the flavour.

- Water resistant barriers are therefore used generally providing controlled release in application.

- Examples of applications are:

  - Soups
  - Baked goods
  - Ready meals
  - Ice creams
  - Chewing gums (controlled release in the mouth)



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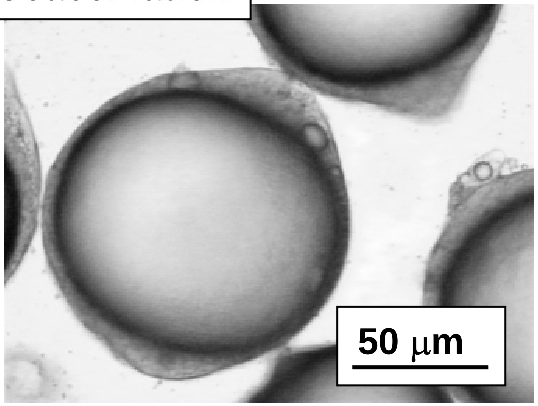
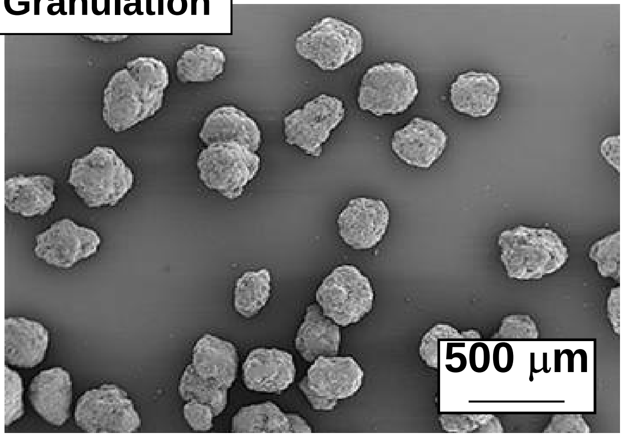
Examples of processes and related morphologies

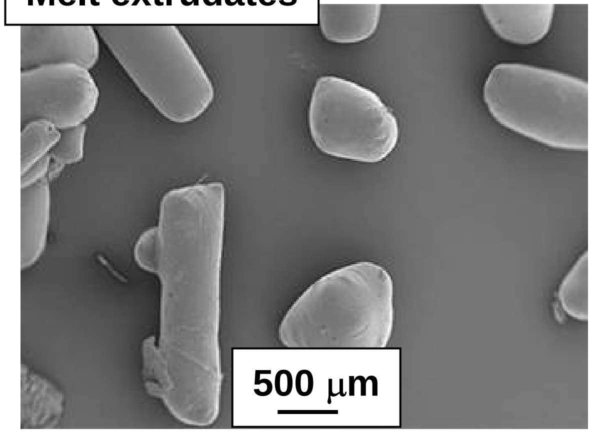
Coacervation



Granulation

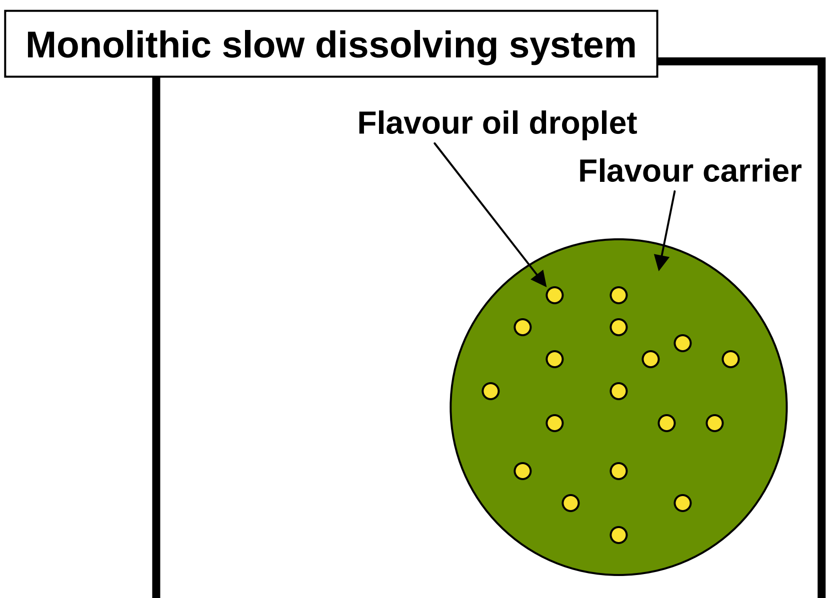


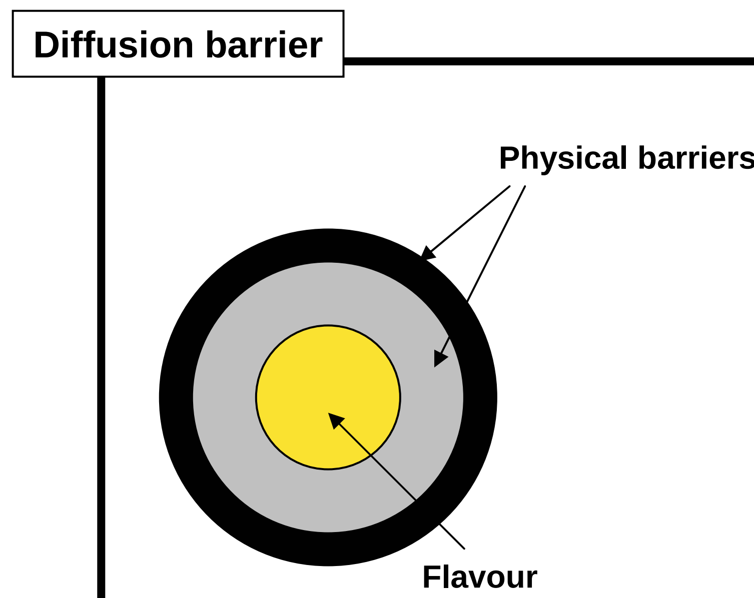
Melt extrudates



Schematic principle of flavour release

Two basic encapsulation system morphologies can be used: a monolithic system which slowly releases by matrix erosion and a single or multilayer structure generally designed to reduce water and flavour permeability.





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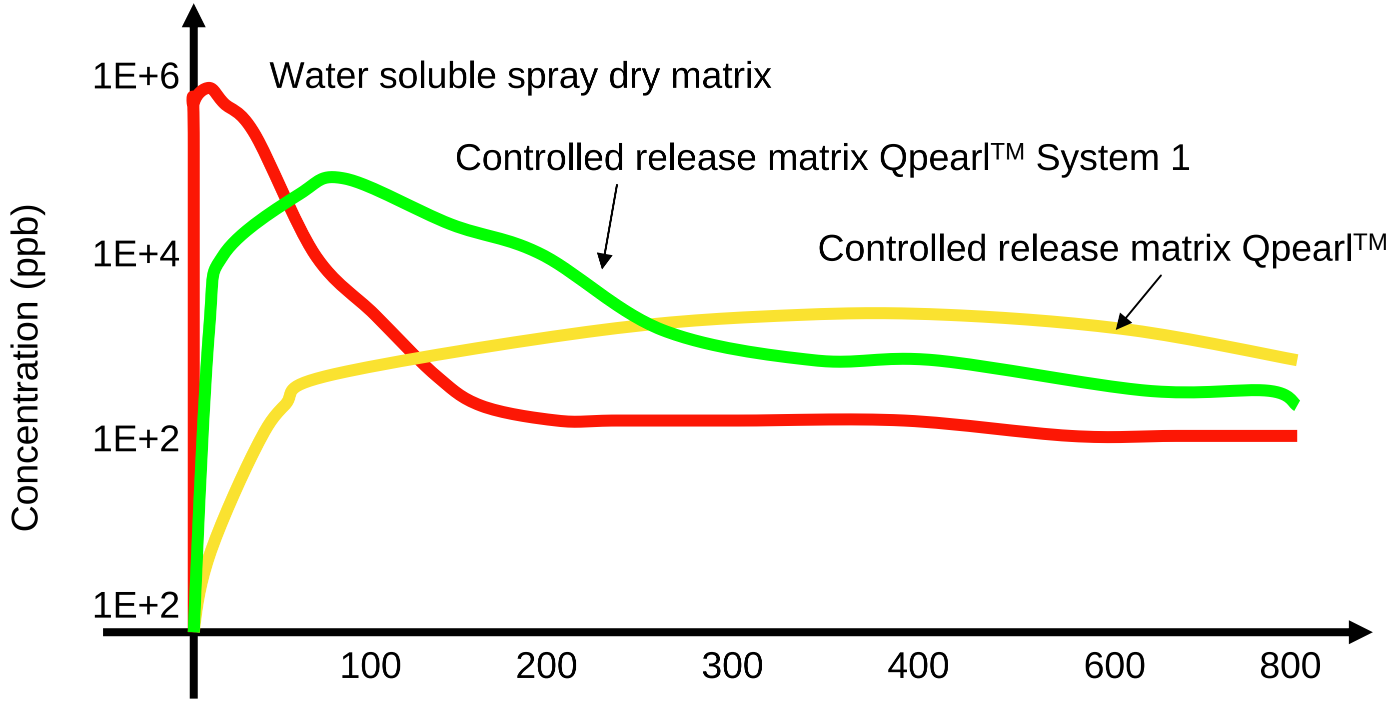
Application of flavour controlled release in soups

Flavour components monitored in the application headspace

Example of aroma release in a model simmered soup system based on water and flavour. Flavour ingredients are volatile and soon lost in the headspace as for spray drying unless delayed release matrices are used.

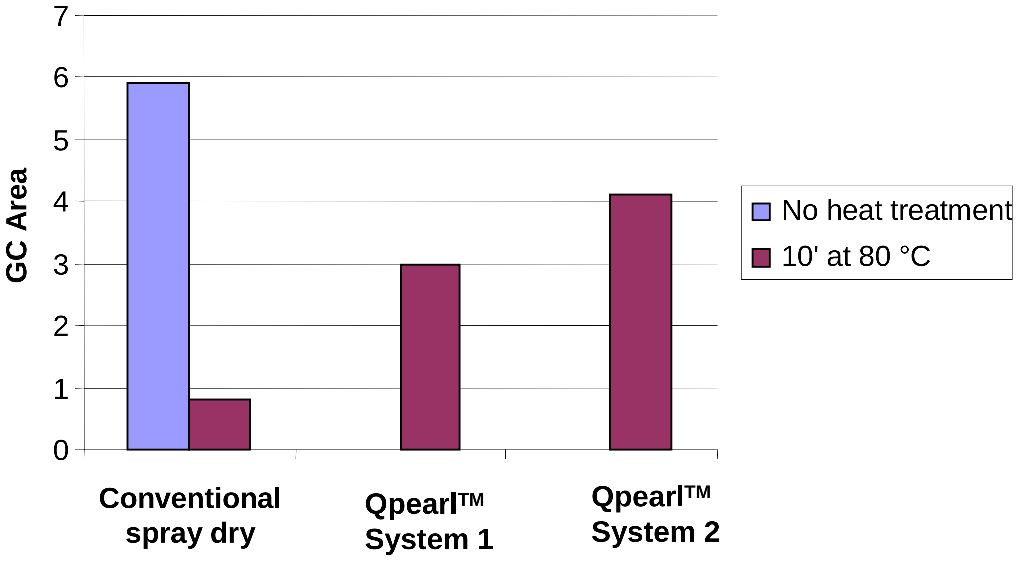


Givaudan patented technology.
Data obtained with PTR-MS.

Application of flavour controlled release in soups

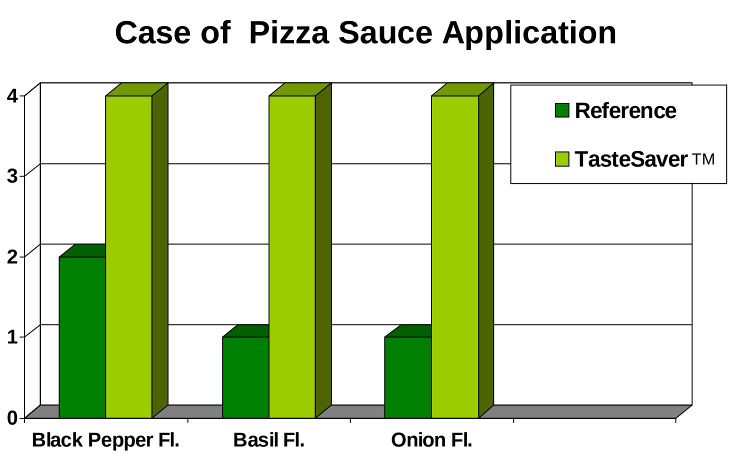
Flavour component monitored in the application liquid phase

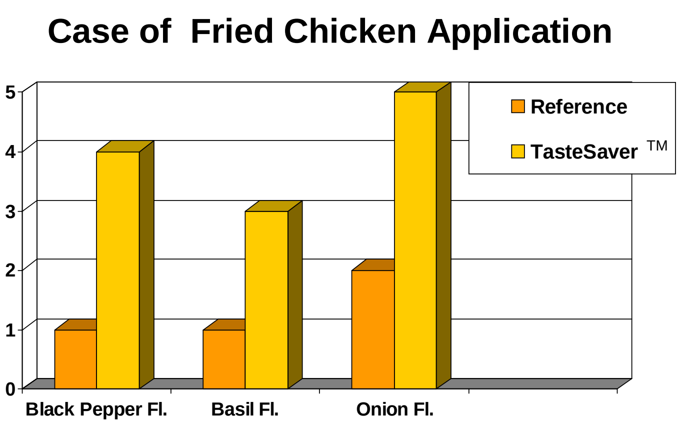
Analysis of the water phase shows that the delayed release has helped increasing the level of flavour in the model soup contributing to an enhanced consumer's experience.



Stabilisation of flavours undergoing thermal treatment – baking and frying

In the case of pizza and fried chicken the delivery system needs to minimise flavour release during respectively the sauce and batter preparation, and protect flavour during respectively baking and frying. The end result is enhanced flavour impact as shown by the graphs below for different flavour profiles.





Givaudan patented technology

Conclusions

- Encapsulation and controlled release have been successfully applied in the flavour industry delivering opportunities for product differentiation.
- There are various technologies available in the industry but not a unique solution.
- The challenge of combining the understanding of material properties and manufacturing processes in order to meet performance requirements in the end product is key to successful new product development in this field.

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