Innovative Food Product Development Cycle: Frame for Stepping Up Research Excellence of FINS

European Commission

Food ingredients and additives

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Outline

- Introduction to encapsulation
- Active ingredients
- Carrier ingredients
- Labelling considerations
- Practical session

The science of ingredients

Definition of encapsulation

Encapsulation is a process to entrap active material within a carrier material (protective layer)

Technology has been in place for over 60 years

Used as a food ingredient, the process can

- ✓ *Make materials easier to handle (solid vs. liquid)*
- ✓ *Enhance nutritive value*
- ✓ *Enhance shelf-life i.e. protection against the environment*

Benefits of encapsulation in food

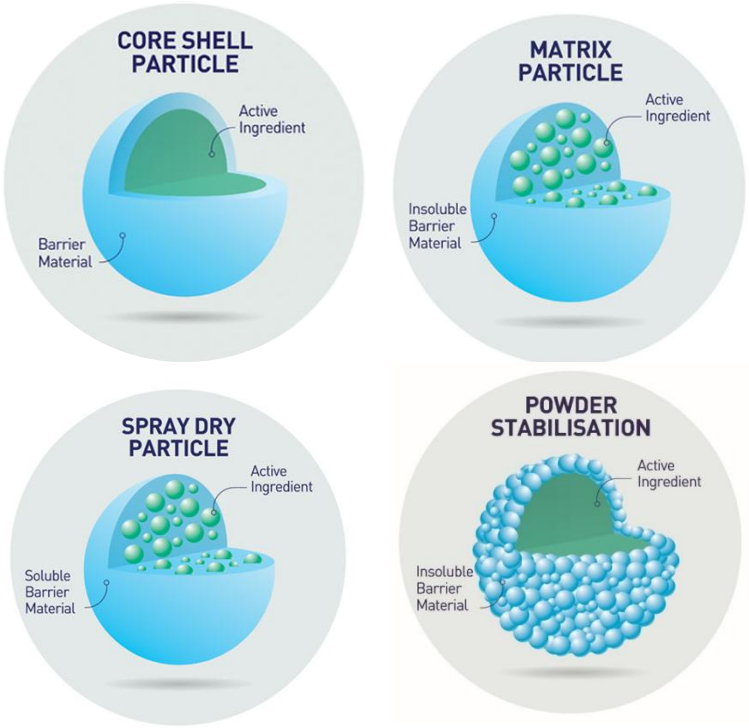
- Increase the vitality of ingredients (heat, oxygen, light….)
- Immobility and improved distribution of ingredients within food matrix
- Extended shelf-life (active ingredient will not deplete so quickly)
- Off-taste masking
- Controlled release
- Safety: improved stability of volatiles or flammable oils

Industry benefits

- Reduced complexity of production process (dry ingredients)
- Reduced cost (storage, labour, supply chain)
- Improved product quality = competitive advantage
- Extended shelf-life = improved processing and storage

Encapsulation

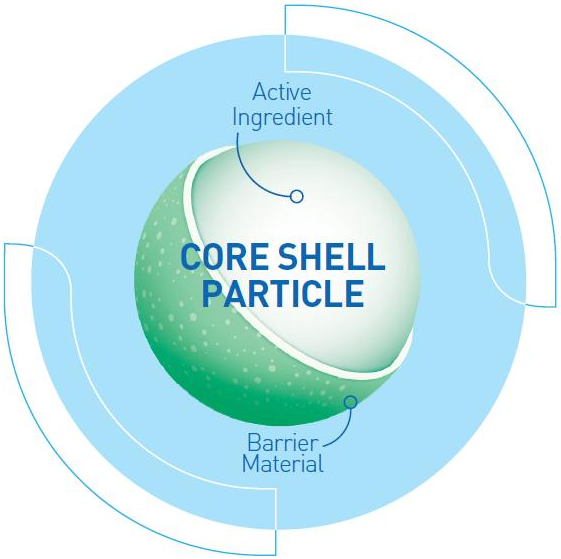
- A very specific science of two interaction ingredients



We must first understand food products and functional ingredients before encapsulating

1. Active Component- Food Ingredients

1. Techno-functional
   - Difference between an ingredient and an additive
   - Additive database
     - Categories
     - Labelling
     - Additives to be encapsulated
2. Flavour
   - Flavours
     - Flavour legislation
     - Encapsulated flavours
3. Nutritive



Techno-functional ingredient

Additive as defined by Regulation 1333/2008/EC:

A ‘food additive’ shall mean any substance not normally consumed as a food in itself and not normally used as a characteristic ingredient of food, whether or not it has nutritive value, the intentional addition of which to food for a technological purpose in the manufacture, processing, preparation, treatment, packaging, transport or storage of such food results, or may be reasonably expected to result, in it or its by-products becoming directly or indirectly a component of such foods

Food ingredient vs. additive

- An ingredient is a component of a food product which does not serve a technological function

- An additive is a component of a food product which serves a technological function in the food product as defined by functional categories in Regulation 1333/2008/EC

Categories of additives Regulation 1333/2008/EC

‘Functional class’ shall mean one of the categories set out in Annex I based on the technological function a food additive exerts in the foodstuff

Table 1.1. Functional classes of food additives		
Acid	Emulsifier	Modified Starch
Acidity Regulator	Emulsifying salt	Sweetener
Anti-caking agent	Firming agent	Preservative
Anti-foaming agent	Flavour enhancer	Propellant
Antioxidants	Glazing agent	Raising agent
Bulking agent	Foaming agent	Sequestrant
Colour	Gelling agent	Stabiliser
	Humectant	Thickener

Labelling encapsulated ingredients

- Labelling legislation for additives
  - Additive functional class and specific name or E-number
- The following are not considered functional and as a result there is no requirement to label them as such*:
  - Carry-over additives
  - Processing aids
  - Substances used in the quantities strictly necessary as solvents for flavoring

  * Unless those components contain an allergen

  Encapsulated ingredients only name the active ingredient (and allergen if present)

Labelling

Ingredients in descending order

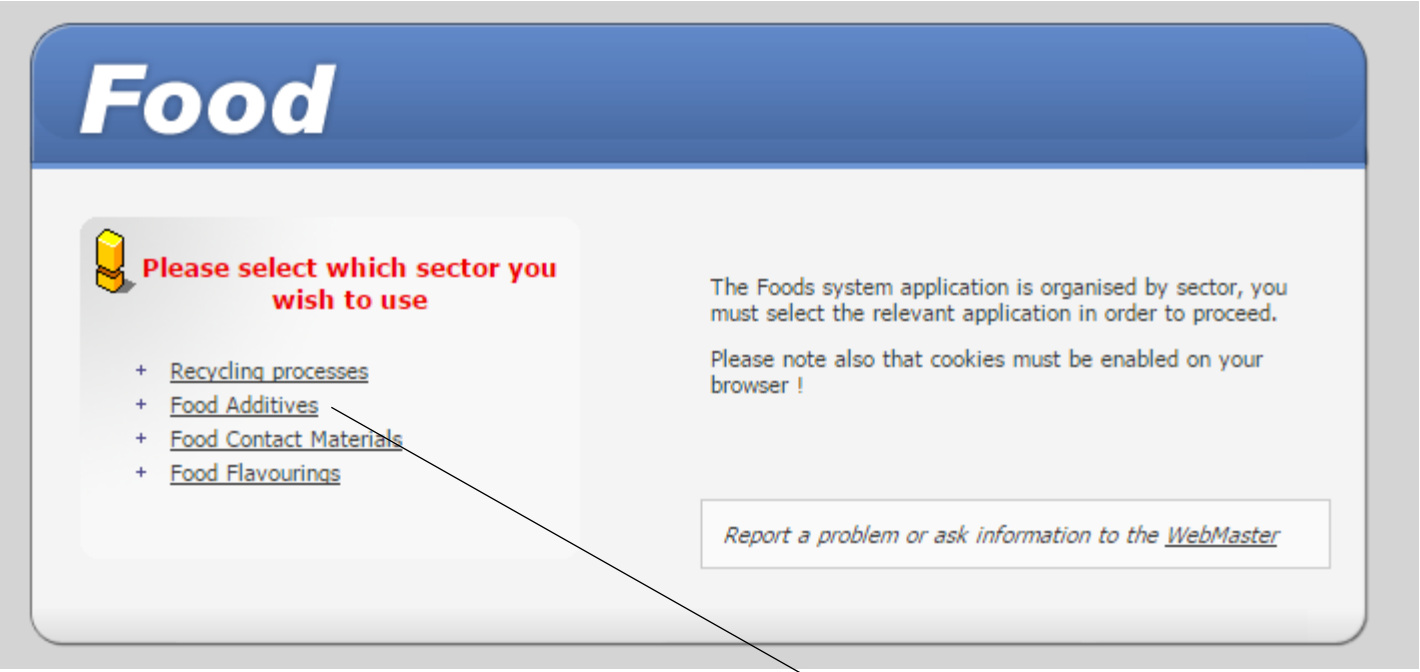
Active ingredients presented by class (name or E-Number)

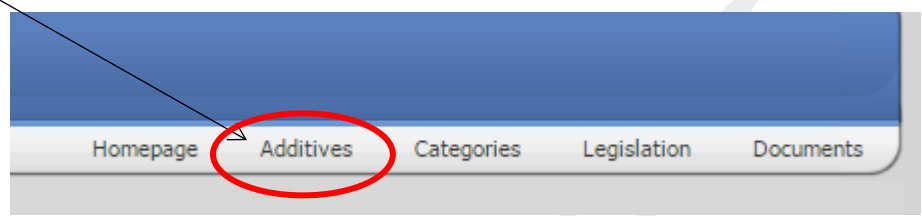
Example: Ice Cream

Partially Reconstituted Skimmed Milk Concentrate, Sugar, Whey Powder **(Milk),** Palm Stearin, Palm Oil, Dextrose, Palm Kernel Oil, Emulsifier (Mono- and Di-Glycerides of Fatty Acids), Flavouring, Stabilisers (Guar Gum, Sodium Alginate), Colours (Beetroot Red, Beta-Carotene)

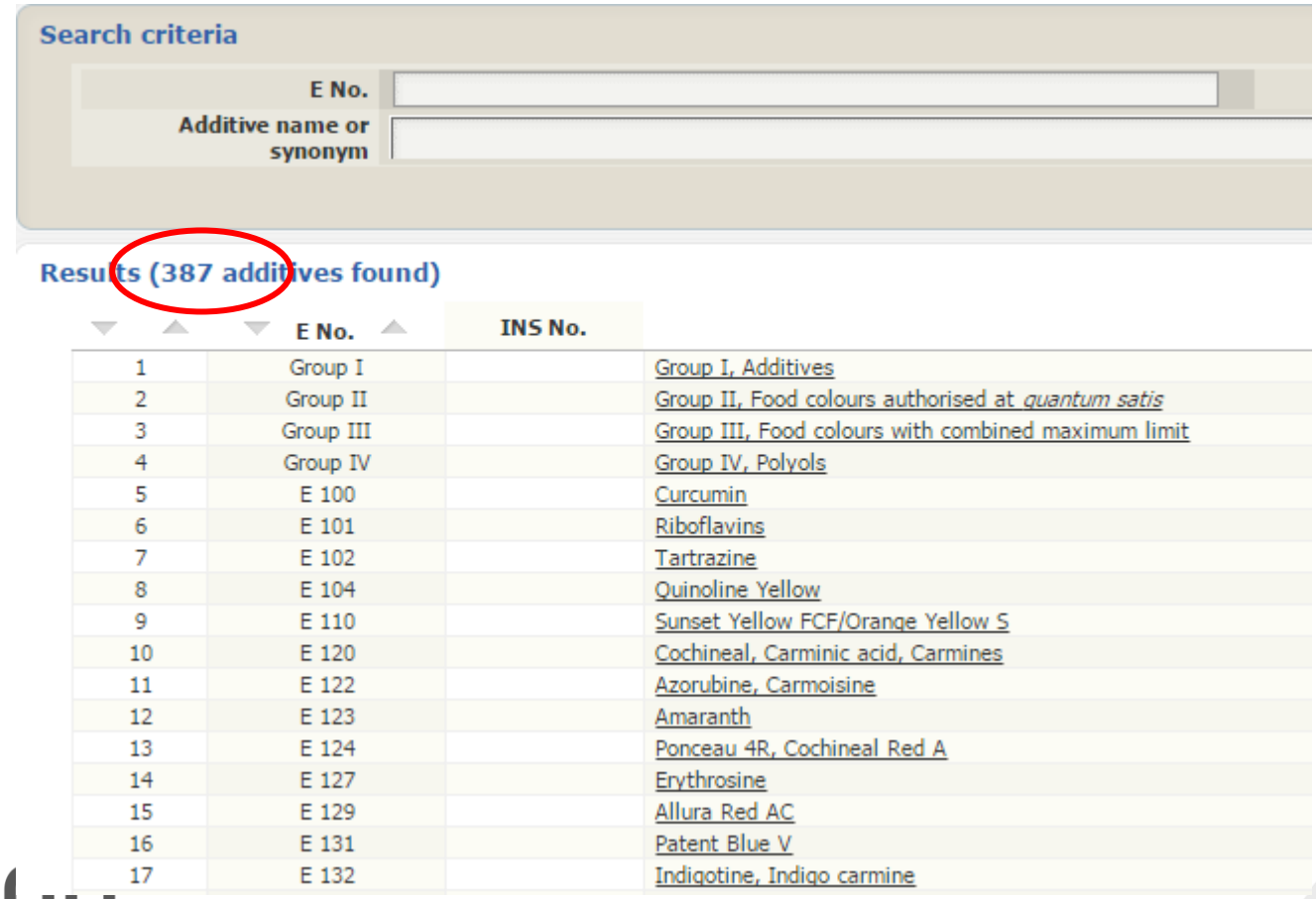
Additive database

https://webgate.ec.europa.eu/sanco_foods/main/index.cfm





Additive database



Search criteria

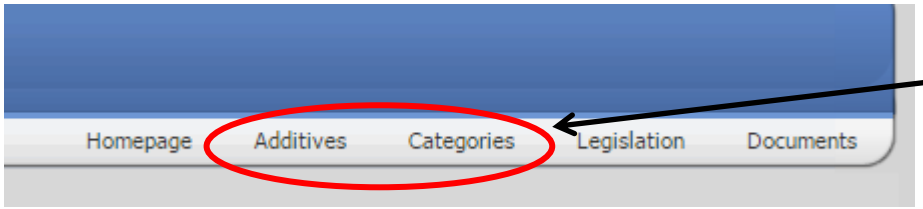
E No.

Additive name or synonym

Results (387 additives found)

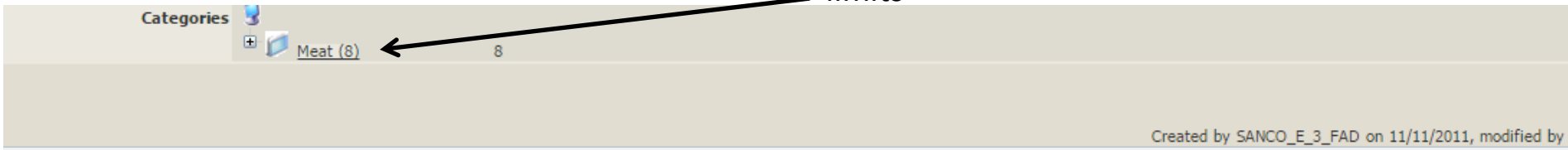
	E No.	INS No.	
1	Group I		Group I, Additives
2	Group II		Group II, Food colours authorised at *quantum satis*
3	Group III		Group III, Food colours with combined maximum limit
4	Group IV		Group IV, Polyols
5	E 100		Curcumin
6	E 101		Riboflavins
7	E 102		Tartrazine
8	E 104		Quinoline Yellow
9	E 110		Sunset Yellow FCF/Orange Yellow S
10	E 120		Cochineal, Carminic acid, Carmines
11	E 122		Azorubine, Carmoisine
12	E 123		Amaranth
13	E 124		Ponceau 4R, Cochineal Red A
14	E 127		Erythrosine
15	E 129		Allura Red AC
16	E 131		Patent Blue V
17	E 132		Indigotine, Indigo carmine

Use of additives



Categories (dairy, meat, confectionary….)

Meat Category: permitted additives and maximum limits



litives linked to this subcategory

E No.	Additive name	Maximum limit, restrictions / exceptions
» Group I	Group I, Additives	except *foie gras, foie gras entier, blocs de foie gras, Libamáj, libamáj egészben, liban* ML = quantum satis; except E 425 ML = 10000 mg/kg; E 620 to E 625, ML = 10000 r or in combination, expressed as glutamic acid; E 626 to E 635, ML = 500 mg/kg indiv combination, expressed as guanylic acid.
» E 100	Curcumin	ML = 20 mg/kg , only sausages, patés and terrines
» E 120	Cochineal, Carminic acid, Carmines	ML = 100 mg/kg , only sausages, patés and terrines …
» E 129	Allura Red AC	ML = 25 mg/kg , only *luncheon meat*
» E 150a-d	Caramels	quantum satis only sausages, patés and terrines
» E 160a	Carotenes	ML = 20 mg/kg , only sausages, patés and terrines
» E 160c	Paprika extract, capsanthin, capsorubin	ML = 10 mg/kg , only sausages, patés and terrines

Understanding legislation- example of phosphates in meat

Phosphates serves many techno-functional properties in meat

- ✓ Bind to Ca^{2+} in the meat cell
- ✓ Dissociate acto-myosin complex (open cell)
- ✓ Alkaline leading to increase in pH and movement from IEP
- ✓ Increase protein solubilisation
- ✓ Greater intracellular immobilised water = ↑ WHC, ↑ Juiciness, ↑ Yield
- ✓ Chelating agents = ↓Oxidative Rancidity

Phosphates in meat

Name	E-Number	pH	P_2O_5 Content (%)
Sodium Tripolyphosphate	E451	9.9	57.2
Tetra Sodium Diphosphate	E450	10.5	53.5
Sodium Hexametaphosphate	E452	6.7	68.5
Sodium Acid Pyrophosphate	E450	4.2	63.5
Potassium Pyrophosphate	E450	10.4	43
Potassium Tripolyphosphate	E451	10.1	47.8

Maximum limit for category heat treated processed meats is:

Individual restriction(s)	ML = 5000 mg/kg , except *foie gras, foie gras entier, blocs de foie gras, Libamáj, libamáj egészben, libamáj tömbben*
Footnotes	1 The additives may be added individually or in combination
	4 The maximum level is expressed as P_2O_5

Important to check the small print on any additive before considering it for encapsulation in a food!

Emerging: encapsulated phosphates

Studies have shown

Phosphate encapsulated in vegetable oil

✓Reduces oxidation

✓Retains colour

when applied to chicken

Further studies are required on the benefits of encapsulating other additives.

B. Kılıç, A. Şimşek, J.R. Claus, E. Atılgan (2014)

Commercial example of an encapsulated additive

Sorbic acid encapsulated in palm oil

- Sorbic acid is a strong preservative for baked products
- Historically not used due to interference with yeast
- By encapsulating sorbic acid in palm oil (melting point (52-58°C), the yeast can function for leavening and volumes
- After the yeast has functioned, during cooking sorbic acid is released
- Case: Bakery in Africa increased shelf-life from 8 to 14 days
- Declaration: Preservative (Sorbic acid or E200)

Flavours

- Flavours are very volatile compounds
- Very prone to evaporation and oxidation
- Over-time, there is a loss in perceived aroma/flavour
- For this reason, encapsulation has been widely applied in the food industry

Flavours legislation

- Specific legislation: Regulation (EC) No 1334/2008
- EU legislation defines different types of flavourings, such as:
  - flavouring substances
  - flavouring preparations
  - thermal process flavourings
  - smoke flavourings
  - flavour precursors
  - other flavouring

Encapsulated flavours

- Prolonged sweetness from chewing gum
- Artificial sweetness e.g. aspartame in gum acacia

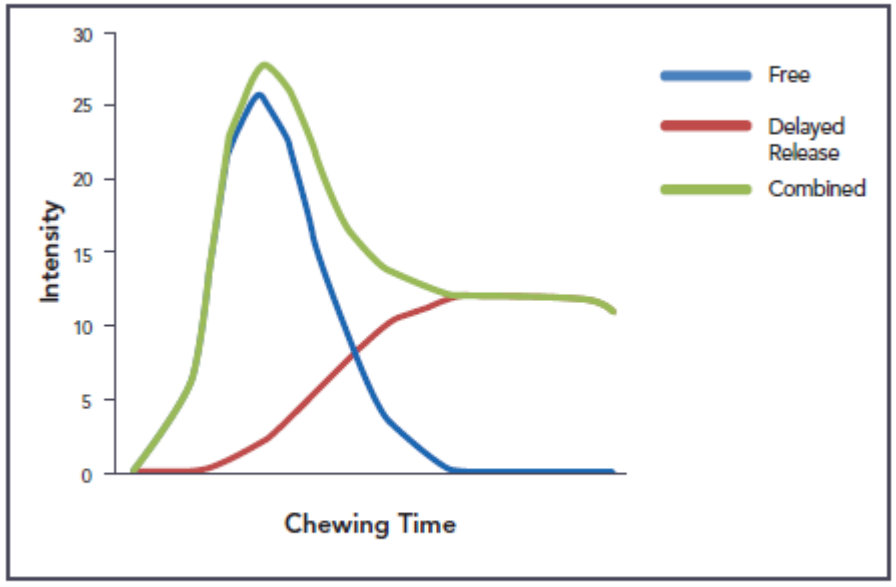


Fig. 1 Demonstrates the benefit of combined release sweeteners

Flavour masking

Used widely in sports nutrition

- Mask bitter tones of protein, such as soya, pea and whey
- Mask bitter tastes and odors from supplements such as vitamins, minerals and caffeine

Flavour masking & time-release

- Sports drink
  - Caffeine encapsulated in cellulose
  - When a 16 fl.oz. bottle is consumed, Zum Energy Drink releases 60mg of caffeine immediately and then gradually releases 140mg over an extended period.
  - Time released in small intestine
- Instant Soup
  - Flavors encapsulated in starch
  - Starch releases flavor when hot water added

Encapsulation for nutrition

- Nutrition
  - Encapsulation of sensitive fatty acids
  - EPA stabilised for use in powder drinks/formulas
  - Arachidonic acid (ARA) and docosahexaenoic acid (DHA) in hypoallergenic infant formulae which enables eye and brain developments
  - Probiotic encapsulation for delivery to the gut
  - Bioactive peptide delivery

2. Carrier material

- Should be *food grade* and able to *form a barrier* for the active agent and its surroundings

- Important to choose a carrier material which does not contain an allergen for declaration

- Depending on the application, either hydrophilic or hydrophobic coating

Carrier material for encapsulation

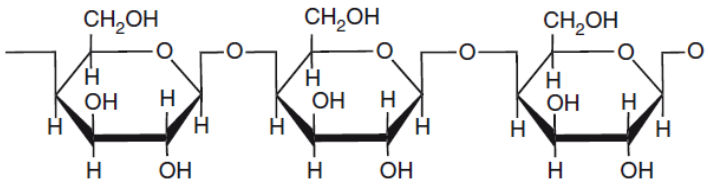
Origin	Carbohydrate	Protein	Lipid
Plant	Starch	Gluten (corn)	Fatty acid/alcohols
	Cellulose	Isolates (pea, soy)	Glycerides
	Plant exudates		Waxes
	Plant extracts		Phospholipids
	Polysaccharide		
Marine	Carrageenan		
	Alginate		
Microbial/animal	Xanthan	Casein	Fatty acids/alcohols
	Gellan	Whey	Glycerides
	Dextran	Gelatin	Waxes
	Chitosan		Phospholipids (shellac)

Carbohydrate

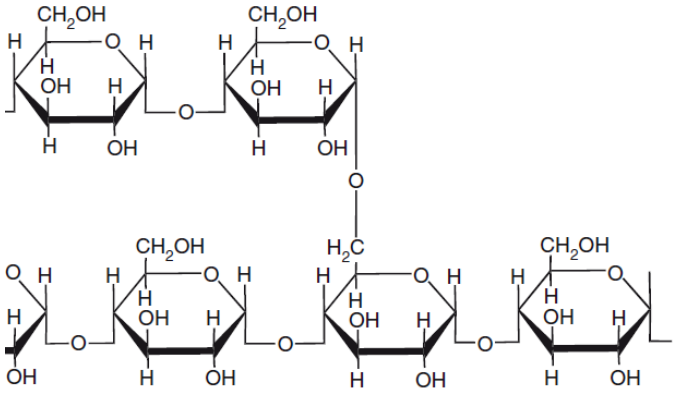
- Starch
- Maltodextrin
- Corn Syrup Solids
- Dextran
- Modified Starch
- Sucrose
- Cylodextrin

Starch

- Comprised of amylose and amylopectin
- Amylose
  - 20–30%
  - Linear α(1 -> 4)- linked D-glucose units
  - Higher amylose = reduced gel strength
- Amylopectin
  - 70–80%
  - Side chains of about 30 D-glucose units bonded with α-(1->6) linkages approx. every 20-30 glucose units
- Varies with the source of the starch



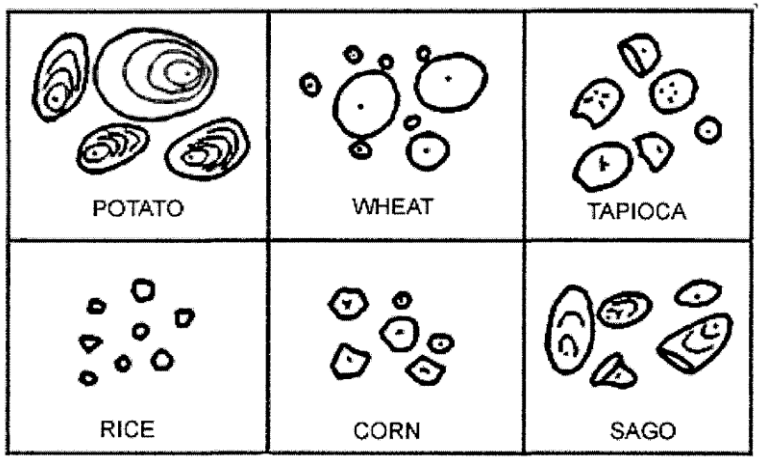
Amylose



Amylopectin

Starch cont.

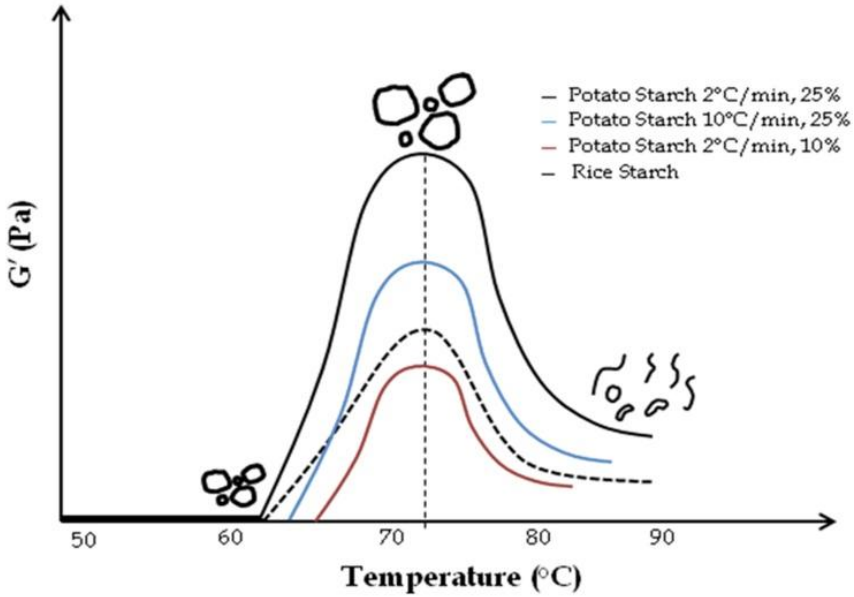
- Normally white, odourless and tasteless
- Insoluble in cold water and ethanol
- Swelling behaviour dependent on
  - Shape (spherical or lentil)
  - Grain size (5-900 µm)



Starch	Granule Size (µm)	Shape	Gelatinization (°C)
Potato	15-100	Oval	56-66
Wheat	2-35	Flat & elliptic	52-63
Rice	3-8	Polygonal	61-77.5
Corn	5-25	Polygonal	62-75

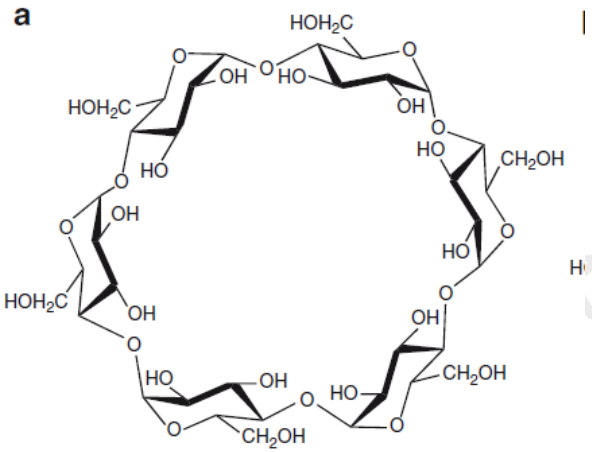
Starch for encapsulation

- Suited to products where active material release is required upon heating or by enzymes (amylase in saliva)
- Depending on the process, modified starched may be useful
- Modified starches
  - have cross-linkage to replace hydrogen bonds
  - Higher shear and heat stability
  - Increased shelf-life
  - Tolerance to temperature fluctuations
  - Hydrolysis by acids or enzymes (chemical) or by temperature/pressure (physical)
- Suited to flavours and aromas



Cyclodextrin

- Commonly used modified starch for encapsulation
- Dextrin refers to product obtained by hydrolysis of starch
- Cyclodextrin = enzymatic hydrolysis
- Six to eight glucose monomer
- Cavity of 0.7-0.8 nm
- Used for food, pharmaceutical, drug delivery…
- Lipid soluble vitamins & hormones
- Soluble in 25 °C water (degree of solubility depends on no. of glucose molecules)
- Not absorbed in digestive tract
- Metabolised by gut micro-flora



Cyclodextrin	Glucose number	Solubility (g/100ml)
α	6	1.85
β	7	14.5
ϒ	8	23.2

Proteins

- Gluten
- Casein
- Gelatine
- Albumin
- Haemoglobin
- Peptides

Casein

- Originates from bovine milk (3-3.6% protein)
- Casein and whey are the two major proteins
- Caseins vary in net charge, hydrophilicity and metal binding
- Extremely heat stable
- Acid caseins are soluble at pH <3.5 and >5.5
- Rennet caseins soluble at pH >9
- Good fat emulsifiers
- For example, encapsulated fat soluble Vitamin D for fortified milk
- Allergenic- suited to dairy products

Gelatine

- Heterogeneous mixture of single or multi-stranded polypeptides (300-4000 amino acids)
- Derived from animal skin, bones and connective tissue
- Melt when heated and solidify when cooled
- Soluble in most solvents
- Amphiphilic so great emulsifying properties
- Mammalian gelatin an be manufactured to have ‘melt in mouth’ properties (35-40°C)- flavour release
- Cold fish gelatin can gelate as low as 5°C which can have applications for ingredient encapsulation in refrigerated products

Gum

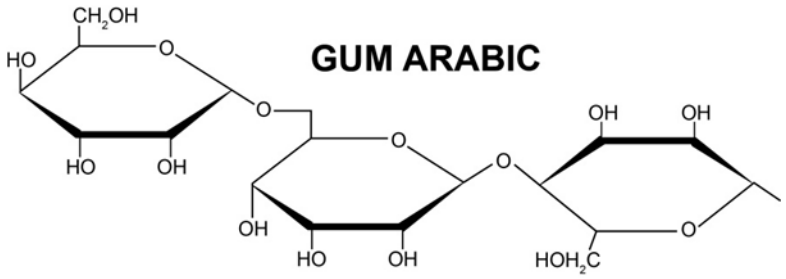
- Mostly water soluble
- Viscous colloidal solution
- Gel network under temperature
- Emulsion stabiliser, crystal formation protector

Gum	Properties	Use
Acacia	High solubility, emulsifier, low viscosity	Flavours
Karaya	High solubility, colloidal stabiliser	Sauce & Ice cream
Carrageenan	Gelling agent, viscosity control, stabiliser	Meat or juice stock encapsulation

Gum Acacia (also gum arabic)

- Originates from tree *Acacia senegal* grown in Africa
- Complex mixture of arabinogalactan oligosaccharides, polysaccharides and glycoproteins
- Branched neutral or slight acidic substance
- Natural substance so prone to variability (source climate, season, age of tress, rainfall, exudation)
- Odourless, tasteless and colourless

Gum Acacia cont.



- Highly soluble in hot and cold water (up to 50% wt.)
- Colloidal stabiliser and emulsifier
- Effect on viscosity varies with type
- The hydrophobic polypeptides anchor polysaccharides to active surface
- Hydrophilic carbohydrate chains prevent aggregation by forming thick charged later
- This unique property means it is greatly suited to encapsulating oil droplets, flavours and prebiotics

Lipid

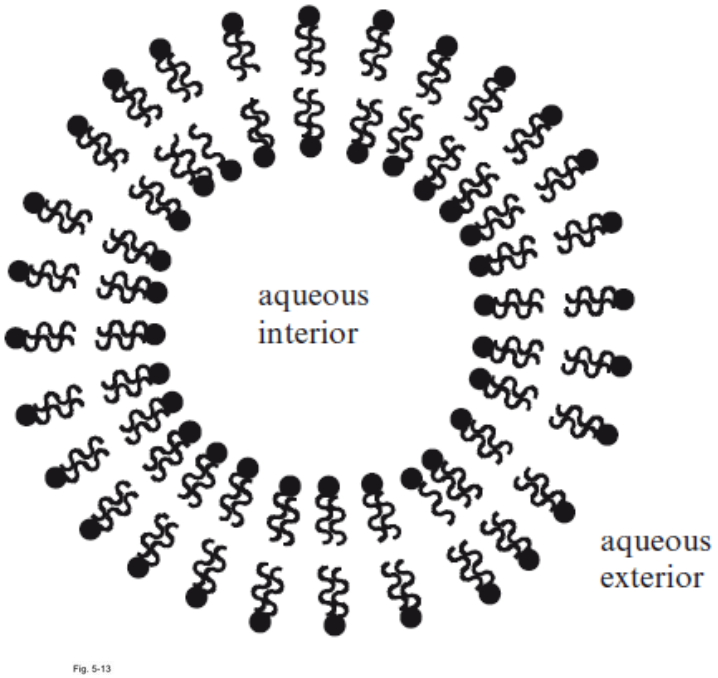
- Phospholipids
- Glycerides
- Wax
- Paraffin
- Beeswax
- Tristearic acid
- Oils
- Fats
- Hardened oils

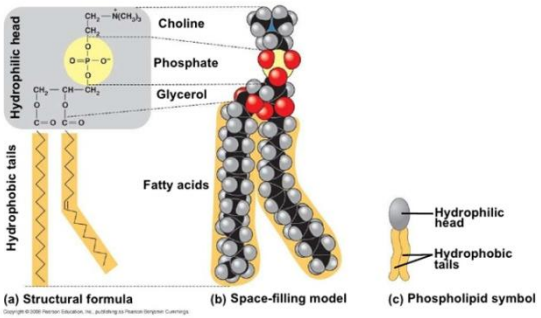
Phospholipids

- Commercially isolated from egg, soybean oil or buttermilk (lecithin)
- Two long chain fatty acids, third hydroxyl group of glycerol is modified with phosphoric
- Hydrophilic head, hydrophobic tail
- Excellent emulsifier due to amphiphilic character
- When mixed with water, they self-assemble into bilayers
- With energy, this can form a liposome with an aqueous centre

Phospholipid uses and structure

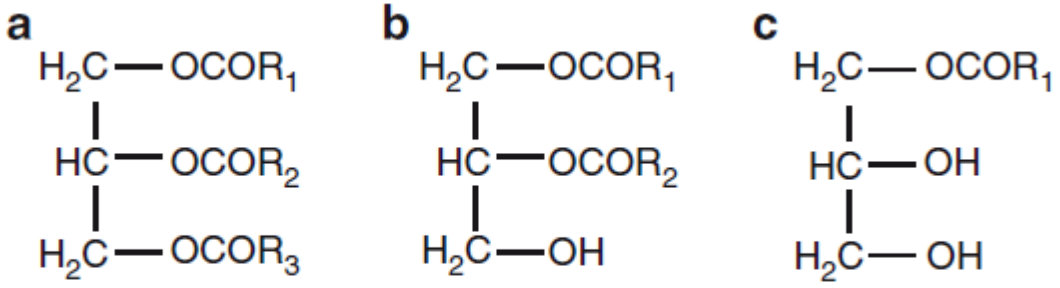
- Used to encapsulate rennet enzymes for less losses during cheese manufacture
- Aqueous centre also environment for flavour masking or nutrient delivery
- Permeability can be modified during manufacture so it can be created to have high pH stability and various permeation across a temperature range
- For this reason ideal for nutrient delivery in the gastrointestinal tract.
- Widely used in food and pharmaceutical industry





Glycerides

- Most natural fats contain high level of glycerides (animal and plant)
- Tri-, di-, mono- glycerides depending on number of glycerol molecules on the fatty acid chain
- Melting points depend on chemical nature (increased with number of carbons in hydrocarbon chain)
- Mainly used for drug delivery in lipid matrices



Glycerides. (a) triglyceride, (b) diglyceride, (c) monoglyceride

Consideration when choosing carrier material

- What are the characteristics of the active?
- What are the processing conditions during food manufacture?
- What are the storage conditions?
- What triggers or mechanisms for release are in place?
- Are there legal issues (e.g. food grade allergen free?)

Allergens

- An allergen is a type of antigen that produces an immune response to fight off a perceived threat that would otherwise be harmless to the body
- Such reactions are called allergies
- The EU recognizes 14 allergens and these must be declared on food packaging

Allergens in EU

1. **Cereals containing gluten**, namely: wheat, rye, barley, oats
2. **Crustaceans**
3. **Eggs**
4. **Fish**
5. **Peanuts**
6. **Soybeans**
7. **Milk**
8. **Nuts**, namely: almonds, hazelnuts, walnuts, cashews, pecan nuts, Brazil nuts, pistachio nuts, macadamia
9. **Celery**
10. **Mustard**
11. **Sesame seeds**
12. **Sulphur dioxide and sulphites**
13. **Lupin**
14. **Molluscs**

Labelling of allergens

- List established since 2003
- Regulation (EU) No. 1169/2011 in effect since December 2014
- No longer permitted to state ‘may contain…..’
- Allergens must be emphasised the ingredient list
- Ingredients: Flour (**wheat**), sugar, **Eggs, Milk**, cocoa powder
- As per previous slides, only active material needs to be declared for encapsulated ingredients unless the carrier material contains an allergen

What We Know

- Many ‘active’ ingredients can be encapsulated
  - Techno-functional
  - Flavour
  - Nutrition
- The choice of carrier material depends on many process factors and targeted delivery
- Encapsulation has many advantages (protection and delivery)
- Controlled release can be generated
- The carrier material does not need to be declared but any associated allergens do

Practical session

- You have been asked to develop an instant soup (just add hot water)
- Must release flavour/aroma when water is added
- Must gradually release flavour over temperature
- The colour must be protected from oxidation
- What is the ingredient declaration

What is the ingredient declaration?

Ingredient	Percantage	Functional Class	E-Number	Allergen
Potatoes	2			
Onions	1.2			
Wheat Flour	27.3			Gluten
Salt	9.3			
Sugar	8			
Beef powder	1			
Maize Starch	35			
Caramel (encapsulated in lecithin which could have egg traces)	1.5	Colour	E150	Egg
Palm Fat	4			
Ascorbic acid	0.6	Antioxidant	E304	
Peas	1.4			
Carrots	1.3			
Green beans	1.8			
Paprika	0.4			
Yeast Extract	2.5			
Tomato Powder	1.5			
Flavouring (encapsulated in starch)	0.8			
Rosemary Extract	0.4	Antioxidant	E392	
	100			

Answer

Starch, Wheat Flour (**Gluten**), Salt, Sugar, Palm Fat, Yeast Extract, Potatoes, Green Beans, Colour (Caramel) (**Egg**), Peas, Carrots, Onions, Tomato Powder, Beef powder, Flavouring, Antioxidant (Ascorbic Acid, Rosemary Extract), Paprika

Or

Starch, Wheat Flour (**Gluten**), Salt, Sugar, Palm Fat, Yeast Extract, Potatoes, Green Beans, Colour (E150a) (**Egg**), Peas, Carrots, Onions, Tomato Powder, Beef powder, Flavouring, Antioxidant (E301, E392), Paprika

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FOOD stars
Innovative Food Product Development Cycle: Frame for Stepping Up Research Excellence of FINS

European Commission

NAPOMENA:

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