Food processing principle

Dr. Szabó P. Balázs

TÁMOP-4.1.1.C-12/1/KONV-2012-0014
„Élelmiszerbiztonság és gasztronómia vonatkozású egyetemi együttműködés, DE-SZTE-EKF-NYME „ projekt segítségével jött létre

Food processing principle

Meat

Fish

Dairy

Bakery

Candy

Fats and Oils

Beverages

Fruits & Vegetables

- Roots
- Tubers
- Leaves
- Fruits
- Bulbs
- Stems
- Flowers
- Seeds

Vegetables – storage, canned, frozen, dried

Grain, Cereals

- Wheat
- Rice
- Barley
- Corn
- Buckwheat
- Oat
- Rye
- Ancient Grains (Amaranth, Quinoa, Kamut, millet, teff, triticale)

Conveyor

- Roller
- Chain

- Portable
- Vibrating
- Screw/Spiral
- Belt
- Overhead

Emulsion

- O/W (Oil in Water)
- W/O (Water in Oil)
- Emulsifiers – HLB level

Baking and roasting

- Direct heating ovens
- Indirect heating ovens
- Continuous and semi-continuous ovens

Liquids mixing

Meat

Meat is one of the best sources of protein (essential amino acids). The meat contains vitamins and minerals. The consumption of meat is increasing continuously. There are a lot of meat types, for example: chicken, pork, lamb, beef, etc. In the meat processing, we can find, muscle meat, animal fat, skin, blood. There are meat products (for example, fast-food products), which contain flavour, colour, taste, etc, so their products are different from fresh meat.

The beef is raised near corn, the poultry typically raised indoors and it can be raised in a variety of settings.

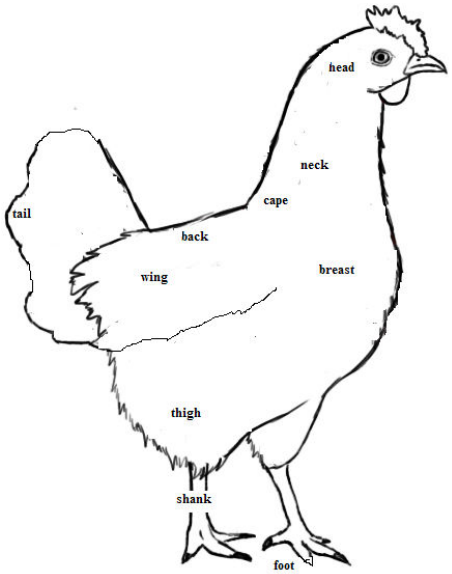

Figure 1. Parts of chicken

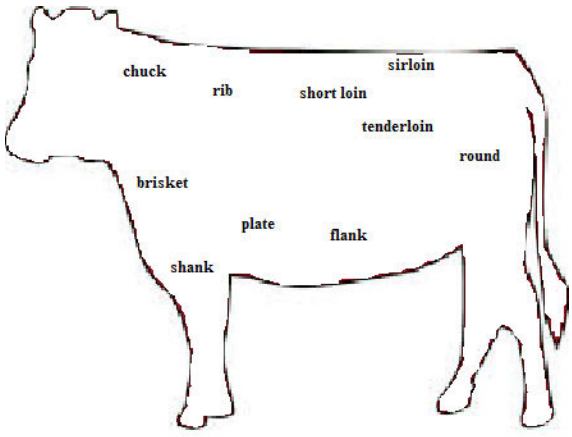

Figure 2. Parts of the cow

The products are salted, smoked and dried meat, patties, sausages, etc.

Animals are raised in locations with some regard to the climatic factors (temperature, humidity, etc.). The meat commodities need heating and cooling, and these processes are expensive (minimizing artificial conditions helps to minimize the cost of meat products).

The fermented meats are very famous, for example:

- German teewurst
- Hungarian salami
- Italian salami
- Summer sausage
- French saucisson

During the fermentation the microbial growth and development, there is biochemical changes (breakdown: carbohydrates, proteins, lipids) and physical changes (acid gelation of meat proteins). The main starters are starters as L. plantarum or P. acidilactici.

The temperature of fermentation can be high (30–35°C), intermediate (25–30°C) and milder temperatures (18–24°C).

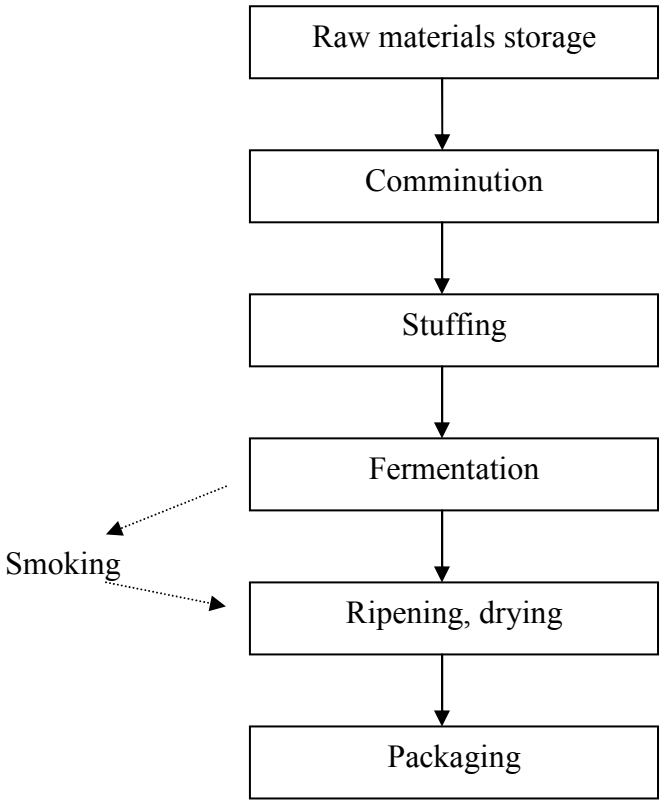

Figure 3. Flowsheet of processing of fermented sausages

Fish

There are about 26.000 various types of fish. More species than all other vertebrate groups combined. There are three groups: Bony fish, Cartilaginous fish, and Jawles fish. These classes have four characters, the first is the gills for gas exchange, and the others are the vertical tail fin, the streamlined body, and the lateral line system (no ears). The bony fish are the dominant fishes today. There are two distinct lineages: the ray finned (modern bony fish) and lobe finned (coelacanth, lungfish).

The other classification is the freshwater fish and the marine fish.

The products are: cooked fish, cooled/frozen fish, cured fish products, dried fish, salted fish, smoked fish, fermented fish, fish paste (bagoong).

Dairy

The dairy products have high nutrient content. The most popular is the cow's milk, but we can find many different sources. The milk processing is different handling: fermentation, heating, cooling, removal of water, concentration, separation.

Table 1. Average composition (%) of milks of various mammals

Species	Water	Fat	Protein	Lactose	Ash
Cow	87.2	3.7	3.5	4.9	0.7
Sheep	80.71	7.9	5.23	4.81	0.9
Goat	87.00	4.25	3.52	4.27	0.86
Horse	89.04	1.59	2.69	6.14	0.51
Camel	87.61	5.38	2.98	3.26	0.7

The milk fat content is very important, because it determines the dairy using. The liquid milk need heat treatment (sterilization - the milk is sterilized at a temperature of 121°C maintained for 15-20 minutes; pasteurization - usually performed below 100°C) to destroy the bacteria. The milk homogenization helps that the shelf-life will be longer.

Milk pasteurization parameter:

- HTSH: 71.7° C for 15 seconds
- 88.3° C for 1 second
- 90° C for 0.5 second
- UHT: 135 to 140° C for a few seconds.

When we separation of milk components we give the cream, butter. The cultured, fermented products are the yoghurt, the different cheese (milk combined enzyme and lactic acid). Very popular dairy product is the ice cream, which contains milk, sugar, fat, and optional thickeners (e.g. pectin or gelatin), colouring, and flavouring. And it is a frozen.

The products are: milk, cheese, ice cream, butter, butter powder, cultured/fermented dairy products (yoghurt).

In the fermentation process we use of microorganisms to convert foods (raw commodities) into a more stable form.

The fermentation is influenced by:

- Type of organism
- Temperature
- pH
- Source of energy
- a_w
- Oxygen availability

The butter must contain more than 80 % of milk fat. It has some different types, for example sweet butter (this is the traditional butter, we use it everyday); cultured butter, which contains bacterial culture; flavoured butter with different spices and herbs; whipped butter is softer and easier to spread, because it contains innert gas (air). Margarine is a mixture of vegetable oils (hardened vegetable oil), animal fats (for example fish) and water/milk. The margarine has a similar appearance to butter, so it is used as a butter substitute (and the margarine is cheaper).

Evaporated milk is produced from whole milk, is made by removing ~ 60 % water from whole milk. After the evaporation, this milk is homogenized, and fortified with vitamin D and viamin A (it is optional). It has two types, which depends on the fat content, the fat free evaporated milk content (maximum 0.5 % fat), the sweetened condensed milk content (maximum 8 % fat) (it has been sugar added, which is sucrose). And we can talk about the mixing of the two types, this is the sweetened condensed fat free milk, it contains the same fat content like evaporated fat free milk and it contains sweetener.

The other dairy product is dry milk, which has longer shelf life and it doesn't need refrigerator. This is powder, made from dried milk solids and we can reconstitute it with water.

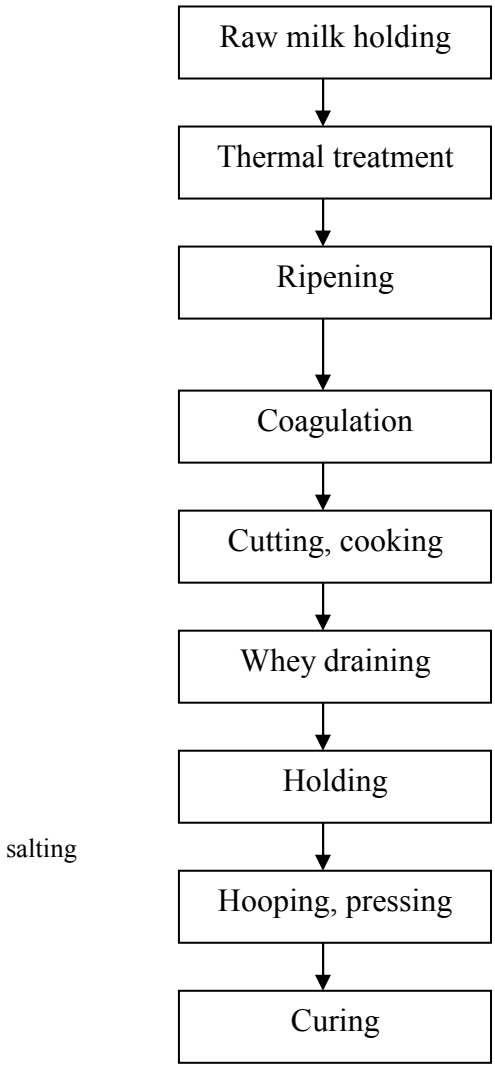

Figure 4. Flowchart of cheese making (general)

Bakery

The bakery products are the staple food. The different kind of bread, pastries, cake, cookies and crackers are the most famous products. The main product is the bread. Famous bread types are:

- Baguette (France)
- Balady (Egypt, Syria)
- Chapatti (India)
- Man-tu (China)
- Tannouri (Iran)

- Pan (Japan)
- White bread (Hungary)

Various types of breads:

- Multigrain
- High fibre
- Crackd wheat bread
- Sour dough bread
- Milk bread
- Composite flour bread
- High protein bread
- Wheat germ bread
- Low calorie bread
- Low salt bread
- Gluten free bread, etc.

The flour contain energy, protein, iron, vitamin (vitamin B), mineral and it has a long shelf-life. Many baked products contain fat, sugar, and sometimes fruit or nuts, etc also.

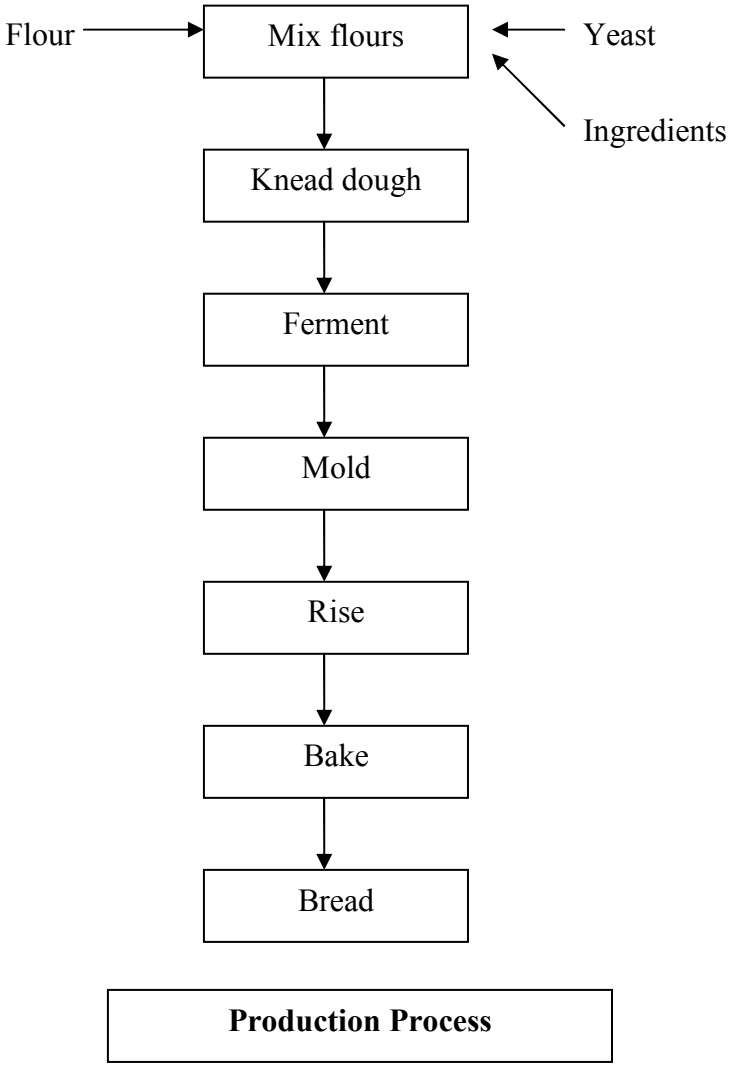

Figure 5. Flowsheet of baking technology

Candy

The candies are popular products. The main ingredient is the sugar. The different boiling temperature, the other ingredients and the shaping results the wide variety of these products (toffee, fondant, fudge, caramel, etc.).
The added ingredients will be: liquid milk, fats, different colours, flavours.
Types of sweets:

- Fondants and creams
- Gelatin sweets (gum, jellies, marshmallow, pastille)
- Toffee and caramels
- Hard-boiled sweets (moisture content is less than 2 %)

Fats and Oils

The fats and oils are made from animal or vegetable source. There are good fats, which are the monounsaturated fat (seeds, nuts, olive oil) and polyunsaturated (fish oils). There are bad fats, the saturated fats (butter, creams, cake, biscuits) and the trans fat (fried food, snacks).
The soybean is one of the vegetable shortening. Before oil extraction, soybeans must be preparation (clean, dry). After it the production processes are the following:

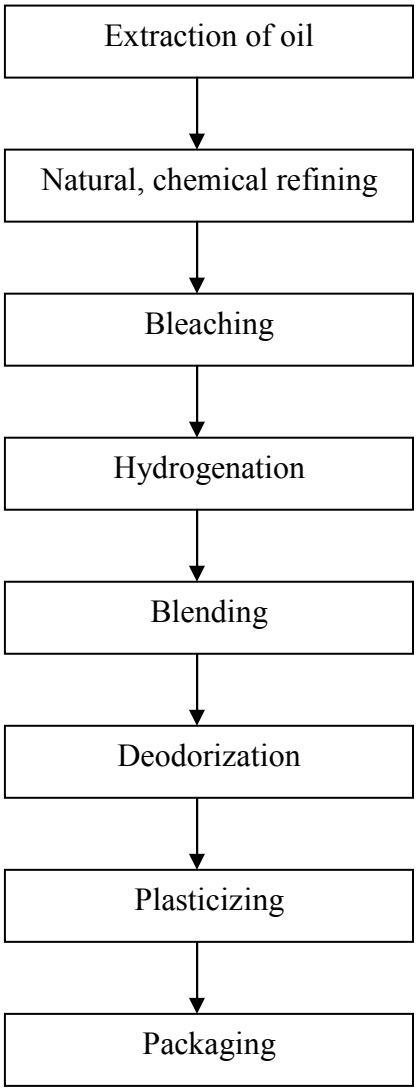

Figure 6. Soybeans process flow

The extraction is the first step in fat production and this step is difference between animal (similar for all animal sources) and plant (numerous different ways) fats is encountered. The aim is the highest yield of fat.

Extraction of plant fats:

- Pressing (batch process or continuous process)
- Solvent extraction (hexane)

After the extraction the steps are the following: degumming (the removal of phospholipids); neutralization (caustic or alkali refining); bleaching; deodorization. There are optional processing steps, for example dewaxing (waxes are esters of long-chain free fatty acids and monohydroxyl alcohols), hydrogenation, interesterification, winterizing (the fat is divided into fractions), plasticizing.

Beverages

The beverages include leaves, stems, sap, fruits, tubers, and seeds (grains).

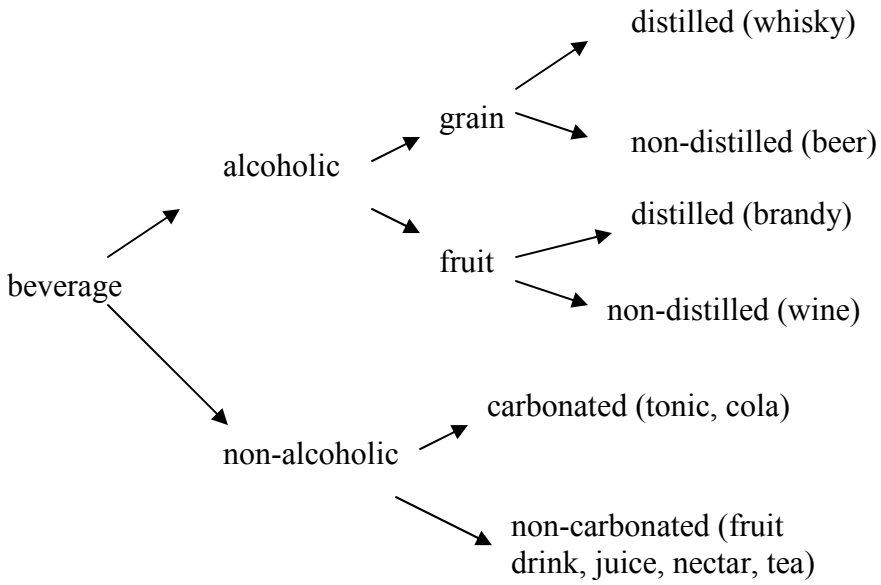

Figure 7. Beverage main groups

The two groups are the non alcoholic (tea, coffe and soft drinks) and the alcoholic. Both groups contain a huge deal of water. The fruit drinks contain sugar, fruit juice, flavouring and colouring. Some drinks contain vitamins and minerals. Non alcoholic carbonated beverage production begins with careful measurement of the formula quantities of each component (treated water; sweetener - fructose syrup or sucrose, medium invert; concentrate – colour, flavour, juice, salt, preservatives; liquid or dry acidulates)) into the syrup blending tank.

The liquid sugars have three main types: liquid sucrose, medium invert sugar, and high fructose syrups. Granulated sugar is normally received in bulk form or in bags.

In these products we can find sweeteners. The two major categories of sweetener types are nutritive and high potency (aspartame, acesulfame potassium, etc.).

Different types of drink:

- Juices (pure fruit juice with nothing added)
- Nectars (~30 per cent fruit solids)
- Squashes (contain at least 25 per cent fruit pulp and sugar syrup), the crystal-clear squashes are the cordials.
- Syrups (concentrated juices with a high sugar content)

The main alcoholic drinks are the wine and the beer. The beer is made from different cereal, the wine is made from fruit (especially grapes). These products need fermentation by yeast (Saccharomyces cerevisiae). The yeast breaks down the sugars to carbon dioxide and ethanol. The good temperature range is between 20 to 40ºC, above 40ºC yeast cells are started to get killed. The simplified fermentation reaction equation for the 6-carbon sugar, glucose, is:

$$C_6H_{12}O_6 \longrightarrow 2\ CH_3CH_2OH + 2\ CO_2$$

The processing of the beer is the following: selection of barley (or other grains), malt barley (steeping, germination, kilning), mash, lautering, boiling and hops addition, cooling and hot break separation, fermentation (yeast pitching), settling and aging, carbonation and packaging.

Beer pasteurization is used of heat before or after bottling and sometimes cold pasteurization (sterile filtering: better flavor than heat pasteurization not to be confused with irradiation).

Processing methods are: Pulping/juice extraction, fermentation.

In carbonated products there is CO_2. CO_2 is a colorless gas, with a slightly pungent odor at high concentrations.

Fruits & Vegetables

The fruits and vegetables are the source of lot of products: fried products; dried fruits and vegetables; juices, squashes and cordials; sauces; wines; chutneys; jams, jellies and marmalades; pickles and salted vegetables; pastes and purees; bottled fruits; crystallized fruits, fruit leathers and fruit cheese.

The vegetables are the following:

- Bulbs: garlic, onion
- Flowers: broccoli, cauliflower
- Fruits: cucumber, tomato
- Fungi: shiitake, enoki
- Leaves: cabbage, spinach
- Roots: carrot, radish
- Seeds: bean, sweet corn
- Stems: asparagus
- Tubers: potato, yam

Fleshy Fruits

Fruits by definition are the “mature seed-bearing structure of a flowering plant”. These fruits are sweet and fleshy, examples of which include plum, apple and orange. Citrus fruits contain vitamin C or ascorbic acid, which promotes wound healing and healthy blood vessels, joints, gums and connective tissue. Vitamin C is a water-soluble nutrient and vitamin essential for life and for maintaining optimal health. Deep orange fruits contain Vitamin A (retinol). It is needed for a healthy immune system, vision growth and reproduction. But too much vitamin A can be harmful or fatal, resulting in what is known as hypervitaminosis A.

Fruits are divided into groups according to their physical characteristics.

- Berries: small juice fruits with thin skins (blackberries, cranberries, blueberries, strawberries, grapes, boysenberries, etc.)
- Drupes: outer skin covering, soft fleshy fruit with a single hard stone (pit) (cherries, peaches, apricots, plums, prunes, nectarines)
- Pomes: central, seed containing core surrounded by a thick layer of flesh (apple, pears, quince, loquat)
- Citrus fruit: thick outer rind, thin membrane separates the flesh into segments (oranges, grapefruit, limes, lemons, ugli, tangerines, kumquats, tangelos)
- Melons: large juicy fruits with thick skins and many seeds (cantaloupe, casaba, honeydew, crenshaw, persian, watermelon)
- Tropical fruit: grown in warm climates and are somewhat exotic (bananas, avocado, figs, kiwifruit, mangos, pineapples, coconut, etc.)

The fruits must be maturity (reached it full size) and ripeness (top eating quality, color, and fragrance, press lightly to see if it gives slightly).

These products contain vitamin A (broccoli, spinach), which promotes normal growth of bones and teeth and helps maintain healthy skin tissue and night vision. Vitamin C (tomato, broccoli, etc.) helps body form, repair itself and fight infections. The B vitamins (beans, peas) prevents beriberi and helps body use carbohydrates and break down proteins. The functions of minerals are the following: to maintain good health, to build bones, soft tissue, and other compounds.

Vegetables require different climates:

- Cool climate veggies: cabbage, broccoli, potatoes, cauliflower
- Warm climate veggies: beans, tomatoes, sweet corn

The main roots are the following:

- Cassava (Manihot esculenta Crantz),
- Yam (Dioscorea spp.),
- Sweet potato (Ipomoea batatas L.),
- Potato (Solanum spp.).

The roots are a good source of carbohydtares, protein, mineral and vitamins. They grow deep into the soil, and their qualities are firm, unwrinkled, unblemished, and have good colour. The tubers are grown all over the world. The potato is originated from South America, it is a very wild range root. The potatoes are cultivated at least 4000 years ago. Potatoes are an important source of protein (~2 %), iron, riboflavin (B2 vitamin) and ascorbic acid (20-25 mg/100g). But the potato contains solanin (glycoalkaloids), when in the periderm green colour develops. Sweet potatoes are native to northwestern South America. The carrot contains carotene (this is the orange pigment that the body converts to vitamin A). The tubers are rich in nutrients.

The Brussels sprouts (Brussels sprouts are similar to cabbage), cabbage, lettuce, spinach are in the leaves group. They are called cole crops. They are green, and we can eat them raw or cooked.

Fruit and vegetables are technically the fruit of the plant. They are: tomatoes (it is a New World crop, native to the west coast of South America and first domesticated in Mexico), cucumbers, eggplant, okra, peppers, pumpkins, and squash. They have smooth, unblemished skin.

The bulb vegetables are the following:

- Garlic,
- Onions,
- Chives,
- Leeks,
- Shallots,
- Scallions

These vegetables have a modified leaves under the ground. The bulbs are the underground stem base surrounded by fleshy leaves. The optimal temperature is between 13 ^{o}C and 29 ^{o}C and they like the good fertile soil (soil pH between 6.2 and 6.8). The main species is the garlic. They are used for seasoning and flavoring (strong taste, odor). Onion is really a biennial or perennial. This bulb vegetable grows in one year and it send up a flower stalk next year.

The main steams are the following: celery: vegetable with edible petioles; asparagus: vegetable with edible shoots; swiss chard: white beet; rhubarb: stem-vegetable with edible petioles. They are picked when they are young and tender.

The flowers are the following: artichokes, broccoli (broccolis head is immature flower buds), and cauliflower (cauliflower is a mass of stem tips, harvested before the flowers develop). These vegetables grow quickly in cool weather.

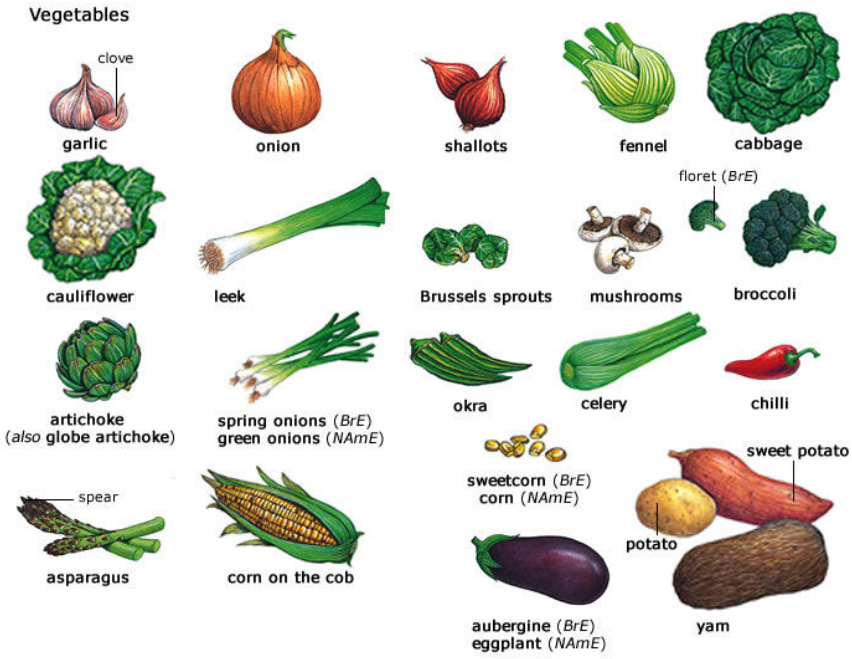

Figure 8. Vegetables (http://www.healthtipsever.com/topic/vegetables/)

The seeds category consists of vegetables with edible seeds (peas, beans). The seeds are firm, well-shaped, and without blemishes.

Vegetables – storage, canning, freezing, dry

The vegetables are consumed shortly after harvest or processed by canning, freezing or drying for future consumption

The vegetables storage is the processing after the harvest. The aim is to keep physical and the microbiologocal behaviour. We can store in a fridge or at room temperature.

The frying and the drying are traditional processing/method. In the drying method, the aim is to reduce the moisture content of the product. The drying methods benefit, is a long shelf life.

If we drying foods we reduce the amount of free water and we will prevent chemical and microbial spoilage. This is the oldest form of food preservation and the most widely used preservative method. The advantages of dried food are the less costly to produce and less costly to store and transport.

Types of drying:

- Sun drying (it is a slow process and high nutrient loss)
- Hot air drying
- Drum drying
- Spray drying (ow nutrient loss and good control)
- Puff drying (heating system, extruders)
- Freeze drying (best nutrient quality and best product quality, good control but most expensive)
- Hot oil
- Chemical drying (for example: sugar, salt)
- Smoking

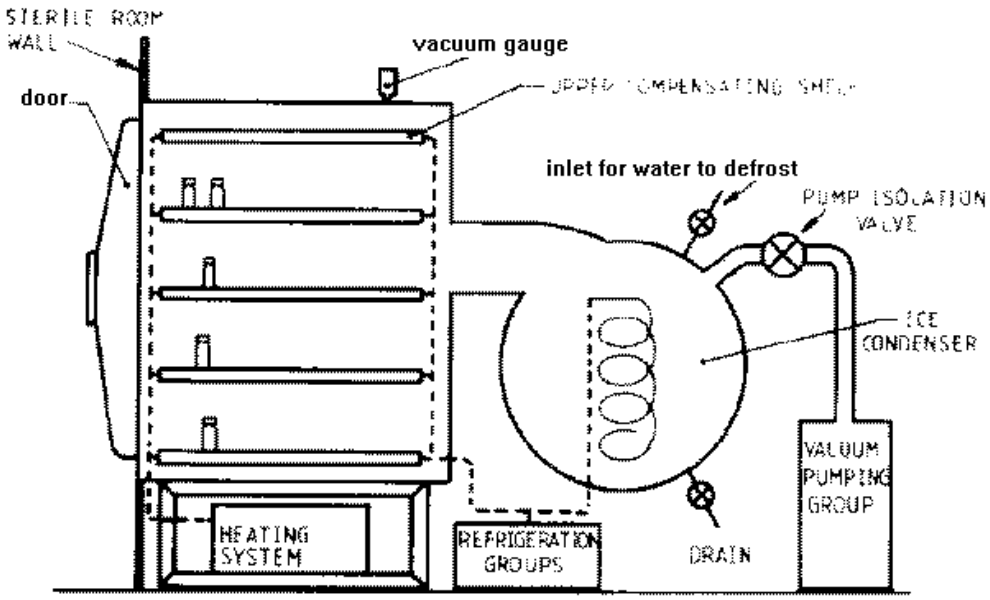

Figure 9. Freeze dryer (http://www.rpi.edu/dept/chem.-eng/Biotech-Environ/DOWNSTREAM/fig7.htm)

The frozen benefits are the following: available out of season, partially prepared, no need to thaw before cooking and retain the appearance and flavor fresh-picked veggies.

The theory of canning is: use of heat and absence of oxygen to prevent the quality of foods. The quality of the proteins, fats, carbohydrates, vitamins must be saved.

The canning methods are the following:

- Aseptic
- Agitation
- Microwave
- Pressure

The advantages of canned: precooked and convenient; the disadvantages of canned: higher in sodium and possibly mushy texture.

Another preservation technology is the freezing. The base of the freezing is: the lower temperature will reduce the spoilage. And the other is that the water is unavailable for microorganisms and chemical reactions. The freezing temperature is under 0 ^{o}C, here change in water from liquid to solid. This method causes long shelf life of foods, and better nutritional and organoleptic parameter than other processed foods (the disadvantage is the high energy demand).

Types of freezing:

- Air freezing (slow method, cheap)
- Direct contact (fast method, expensive)
- Indirect contact (between the air freezing and direct contact)

The benefits of frozen: partially prepared, no need to thaw before cooking, no sodium added, and available “out of season”.

Grain, Cereals

The grains are the staple food all over the world. The cereals are all the members of the grass family. The main cereals are: rice, wheat, maize and sorghum. They are grown for their seeds (grains) which are high in carbohydrates and protein. The water content of the grains is low. Grain (its flour, and flakes) is the base of the following products: dough, batters, pasta (extrusion), bread, cake, biscuits, snack food (frying), tortilla, etc.

The grain is the base of pet food and animal feed too.

The grains have beneficial effects. The whole grain reduces the cardio vascular disease and the risk of gastrointestinal cancer. The grains decrease the risk of diverticulitis and the risk of type 2 diabetes.

The staples foods are the cereals. Their gains contain protein, carbohydrates, low water content (good storage characteristic), vitamins and minerals. The main cereals of the world

are the wheat (this was one of the first domesticated crops) and the rice for a human nutrition. They are easy to store and transport.

Wheat Cultivated species:

- Common wheat or Bread wheat (T. aestivum); the most widely cultivated wheat.
- Durum (T. durum); the second most widely cultivated wheat.
- Einkorn (T. monococcum); wild and cultivated variant.
- Emmer (T. dicoccum).
- Spelt (T. spelta).

The wheat is the base of the flour. Flour can be bleached or unbleached. The wheat flour contains gluten (insoluble protein) which gives the structure of the bakery products. The types of the flour are the following: 100% whole wheat (whole grain); white flour (made by sifting out the bran and germ); bread flour – high protein/gluten (hard wheat); all purpose flour; cake flour – low protein/protein (soft wheat); self raising flour – raising agent/salt added. The optimum growing temperature is about 25°C (minimum 3°C, maximum 32°C).

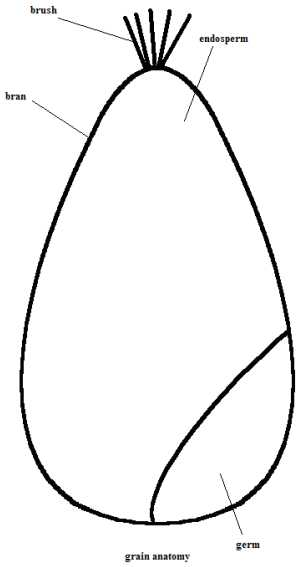

Figure 10. Parts of wheat

Rice (Oryza sativa) is the staple food on the third of the world's population. It has two types: brown rice (is hulled but it has a bran) and polished rice (white rice, lost most of the nutrients). The products are the following from the rice:

- Brown Rice
- Enriched white rice – long grain
- Short grain or arborio rice (risotto)
- Fragrant rice – basmati, jasmine

- Wild rice – actually a native grass
- Ground rice
- Rice flour

Figure 11. White rice (www.khawajagroup.com.pk)

The rice production is limited to where there are proper climatic conditions.

Barley is the oldest cultivated grain, which has low fiber content, low gluten content, so it is not good for baking products, but it is very good in soup and stew.

Corn is another staple food. It is the base of a lot of products: sweetcorn, dried corn, hominy or grits, polenta, cornstarch, cornmeal, tortillas, corn syrup, corn oil, popcorn and breakfast cereals. The corn needs warmer climates. Corn is a primary feed for example pork.

The oat became very important in the last twenty years. It is used in many forms: cereals, oatmeal, oatbran, granola bars, muesli, cookies, and multigrain bread.

The rye has low gluten content, but in spite of it, it is good to make rye bread, pumpernickel, sour dough bread and crispbread (in Eastern Europe and Scandinavia).

Figure 12. Rye (http://www.dreamstime.com/stock-images-rye-grains-image8507824)

Ancient Grains (amaranth – complete protein; quinoa - used in salad, multi grain bars, the other name is the supergrain; kamut; millet - cooked and eaten like rice; teff – love grass; triticale - cross between wheat and rye)
Cereal is grown all over the world, but the climatic factors once dictated where certain foods were grown. The modern technology is allowing producers to raise cereals in controlled conditions.

The oil crops (soybeans, sunflowers, coconut, peppermint, etc.) are invisible food products and there are sugar crops (sugar beets and sugar cane).

Food industry
Operations within the food industry:

- Harvesting: taking a product from a plant where it is grown or produced (important: timely and careful manner; correct stage of maturity).
- Preparation, processing, handling: These steps involved in turning raw agricultural products into an attractive and consumable food.
- Storage: climate conditions.
- Transport: transportation of fresh and processed food products.

The process of food is very important, it is: extend shelf life, ensure safety, maintain the sensory and nutritive properties and make more convenient.

Conveyor

In the food industry: production, processing, storage, preparation and distribution. Among these steps, there is transport process (for example: conveyors).
Conveyors types:

- Roller
- Chain
- Portable
- Vibrating
- Screw/Spiral
- Belt

- Overhead

The material of the roller conveyors are steel, (plastic or stainles steel). The types of the roller conveyors are gravity, belt-, chain driven or line shaft driven. The roller conveyor is cheap and it can move heavy objects.

The chain conveyor is very good to transport heavy materials. The configuration of these conveyors are single or double chain stand. Motor drives the chain conveyor technology.

The portable conveyor is useful for small applications and it is easy to store.

The vibrating conveyor is very good transport system in the food industry. This conveyor is good for sorting, classifying, screening and orienting parts. The incline can be between 5^{o} and 45^{o}.

The spiral conveyor is useful for accumulation, drying, and moving things vertically (if we haven't got big space).

Figure 13. Spiral conveyor (http://www.conveyor-manufacturers.co.uk/UK/spiral-conveyors.html)

Belt conveyor: the material on the belt forward. The belt conveyor has two or more pulleys and the belt rotates about them. The pulley is powered, the name of it is drive pulley (the other pulley is unpowered pulley – idler pulley). So the belt is looped around the rollers. The driven rollers are powered by an electrical motor. This process is used in bulk (cereals, salt, etc.) material handling. The belt conveyor is good to transport different size materials in the same time. The belt has minimum two layers (carcass – cotton, polyester; and cover – rubber,

silicon, etc.), the materials are PVC and rubber. There is a sandwich belt system, when two belts are face to face.
The overhead conveyor moves things vertically.

Emulsion

Oil and water do not mix, do not stay mixed. There are two types of emulsion: oil in water - oil droplets dispersed in water (f.e. milk) and water in oil - water drop lets dispersed in oil (f.e. margarine, butter). Oils are non-polar and are effected more by Van der Walls forces.

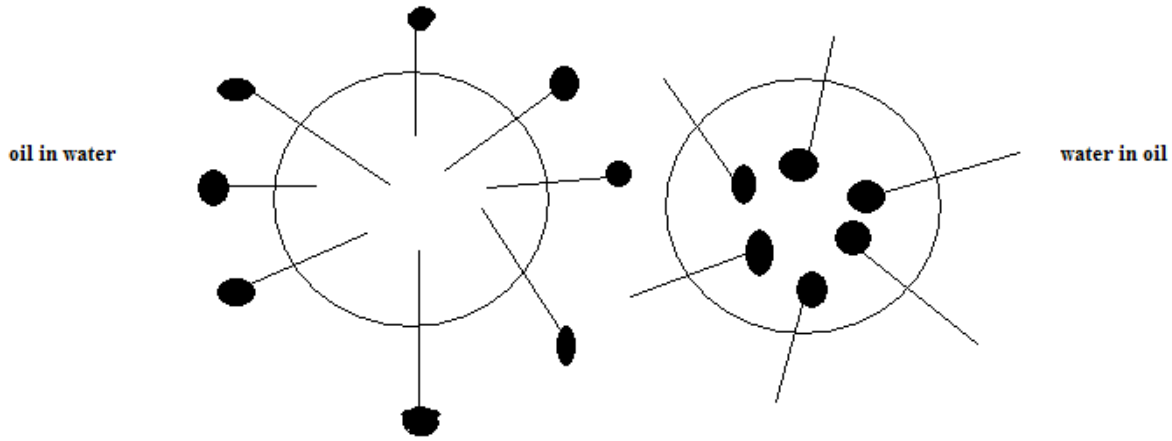

Figure 14. Oil in water, water in oil emulsion

Oil in water: the internal phase is the oil; the external phase is the water. Water in oil: the internal phase is the water; the external phase is the oil. (There are multiple emulsions: Oil in Water in Oil - O/W/O; Water in Oil in Water - W/O/W; multiple emulsions are used for drug delivery).
The solution will be to add energy to the system (agitation, heat) or it needs something to stabilize (surfactants or emulsifiers).
The emulsifiers destroy the physical barriers (reduce the interfacial surface tension). They have lipophilic tails (align with oil) and hydrophilic heads (align with water).

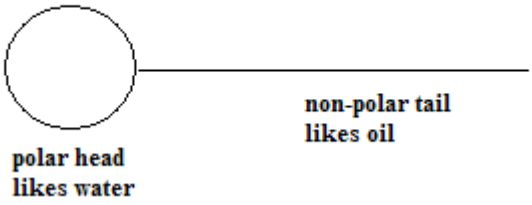

Figure 15. Emulsifier

Emulsifier is a substance that facilitates the dispersion of one phase into another. These materials are used everywhere, for example: food industries, industrial – home care etc. Emulsifiers contain both a hydrophilic (water-loving, polar) head group and a hydrophobic (oil-loving, nonpolar) tail. The emulsifiers surround the oil with the nonpolar tail and extend into the oil. The emulsifiers are anionic and cationic (and there are non ionic emulsifiers).

Table 2. There are four emulsion types, which depend on the particle size:

Type	Particle Size
Macroemulsion	>1000 nm
Microemulsion	10 – 300 nm
Micelles	5 – 10 nm
Solutions	<5 nm

The important parameter of the emulsifiers are the hydrophilic and lipophilic balance, this the HLB balance. HLB is a concept for choosing emulsifiers. The HLB scale ranges from 0 to 20. The emulsifier, which has HLB values under 10 (for example: glycerol monostearate), is good in w/o emulsion. The emulsifier, which has HLB values above 10 (for example: sodium stearoyl lactylate) is good in o/w emulsion.

Low HLB emulsifiers are soluble in oil while high HLB emulsifiers are soluble in water.

Table 3. The HLB level

Solubility	HLB Range
No dispersability in water	1-4
Poor Dispersion in water	3-6
Milky appearance	6-8
Stable milky appearance	8-10
Translucent to clear dispersion	10-13
Clear solution	13+

The food emulsions are difficult, they need water solube to oil solube emulsifiers. In the mayonnaise (about 80% oil and 20% vinegar, egg, mustar, salt), the ice cream, the salad dressing, chocolate, etc the main emulsifier is the lecithin (from soybean oil). The other commercial emulsifiers are the egg yolk, fatty acid esters, sodium stearoyl lactylate, and mono- and diglycerides.

Table 4. HLB values of some food emulsifiers

EMULSIFIER	HLB VALUE
Oleic acid	1.0
Sorbitan trioleate	1.8
Glycerol dioleate	1.8
Glycerol monostearate	3.8
Glycerol monolaurate	5.2
Sorbitan monopalmitate	6.7
Soy lecithin	8.0
Diacetylated tartaric acid esters of monoglycerides	8.0
Sodium Stearoyl lactylate	8.3
Sorbitan monolaurate)	8.6
Polyoxyethylene (20) sorbitan monostearate	14.9
Sucrose monolaurate	15.0
Polyoxyethylene (20) sorbitan monooleate	15.0
Polyoxyethylene (20) sorbitan monopalmitate	15.6

Baking and roasting

The baking and the roasting use heated air. The heat is transferred into the products, the moisture is transferred from the products, so there will be heat and mass transfer. During these methods we can talk about convection, radiation and conduction.

The typical baking products are the flour based products, the typical roasting products for example the nuts, the meat. These methods reduce the micro-organisms's life. These methods change the properties of the products. The texture - moisture content, the protein and the carbohiydrates - is changing. The physical state of proteins and fats is altered, and starch is gelatinised and hydrolysed to dextrins and then reduce sugar. The aroma, the taste - Maillard browning reactions between sugar and amino acids; caramelisation of sugar; aromatic chemicals produced during the process - is changing. The vitamins are destroyed during these processes.

Changes during the baking (for example bread baking):

Physical

- Oven-spring
- Crust formation

Chemical

- Yeast activity (inactivated at 55°C)
- Starch gelatinisation (60ºC)
- Gluten coagulation
- Enzyme activity
- Browning reaction (The browning reaction starts at around 160°C.)

In meat the fats melt, the oil is dispersed, the protein loses the water holding capacity, the collagen is solubilised. In meat there are nutrient losses (reduce the size of the meat).

The equipment of the baking is the oven. These ovens have a modern technology, we can operate the duration, the temperature, the humidity, cooling time, air speed and the sequence.

The types of the oven:

- Direct heating oven (microwave oven, dielectric oven) – short baking time, good efficiency,
- Indirect heating oven

The other classification are:

- Continuous oven

- Semi-continuous oven (the oven must be stopped to remove the food)

Continuous and semi-continuous ovens: tray oven, reel oven, tunnel oven, etc.

Figure 16. Tunnel oven (http://apple722722.en.ec21.com/Tunnel_Oven_Baking_Oven_Bakery--3046298_4255665.html)

In the oven natural gas is commonly used (sometimes propane, butane, fuel oil or solid fuels are also found).

Liquids mixing

The liquids can be high-viscosity liquids (pasta) and low viscosity liquids. The machine for mixing liquids is the propeller stirrer (propeller mixer). The propeller mixer is probably the most common and the most satisfactory. The final mass of the mixed fluids is:

$m = m1 + m2 + ... + mn$

where

m = final mass (kg, lb)

m1..n = mass of substances

Power consumption is important. Liquid flow is defined by a series of dimensionless numbers: Reynolds-, Power-, Froude number.

Reynolds classified the flow type according to the motion of the fluid. The laminar flow, when every fluid molecule followed a straight path (parallel to the boundaries of the tube), when every fluid molecule followed wavy but parallel path, it is the transitional flow. The third is the turbulent flow, when every fluid molecule followed very complex path.

The Froude number is the classification of flows according to their water surface behaviour.

The liquid food is non-Newtonian material. They are pseudoplastic (sauces), dilatant (chocolate) and viscoelastic (dough).

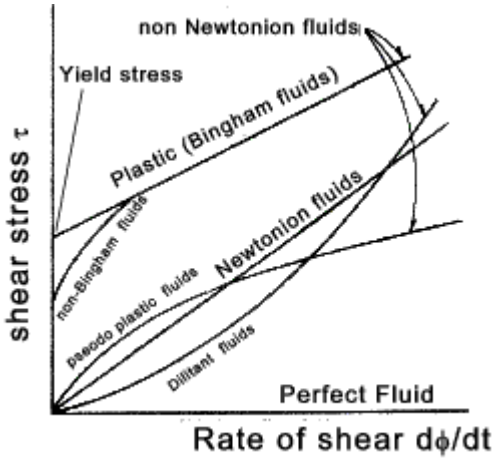

Figure 17. Examples of non-Newtonian fluids
(http://www.roymech.co.uk/Related/Fluids/Fluids_Characteristics.html)

Pseudoplastic sauces form a zone of thinned material around a small agitator as mixing proceeds, and the bulk of the sauces don't move. Dilatant chocolate should be mixed with great care. Viscoelastic bread dough require a folding and stretching action to shear the material.

Mixers have four types:

- dry powders or particulate solids,
- low- or medium-viscosity liquids,
- high-viscosity liquids and pastes,
- dispersion of powders in liquids.

Type of mixers: paddle agitators, impeller agitators, multiplepaddle (gate) agitators, counter-rotating agitators, anchor and gate agitator, screw conveyor mixers (continuous), planetary mixers, Z-blade (or sigma-blade) mixer.

Figure 18. Screw conveyor mixers with single screw (http://www.kwsmfg.com/)

Tools type:

- hook (bread dough, croissants, pizza)
- beater (cake, pancake, etc.)
- whisk (eggs, butter cream)

References

1. BENDER, A. E. 1978. Food Processing and Nutrition. Academic Press, London.
2. MATZ, S. A. 1972. Bakery Technology and Engineering. AVI, Westport, Connecticut.
3. MIZUKOSHI, M. 1990. Baking mechanism in cake production. In: K. Larssen and S. E. Friberg (eds) Food Emulsions, 2nd edn. Marcel Dekker, New York, pp. 479–504.
4. ATWELL WA. 2001. An overview of wheat development, cultivation and production. Cereal Foods World 46:59–62.
5. FOSTER T, editor. 2003. Beverage Quality and Safety. Institute of Food Technologists and CRC Press.
6. JACOBS MB. 1951. Chemistry and Technology of Food and Food Products, 2nd edition. Interscience Publishers, New York
7. RAY B. 2001. Fundamental Food Microbiology, 2nd edition. CRC Press.
8. LEWIS MJ, TW YOUNG. 1995. Brewing. Chapman and Hall, New York.
9. BEAN MM, CS SETSER. 1992. Chapter 3. Polysaccharides, sugars, and sweeteners. In: JA Bowers, editor. Food Theory and Applications, 69–198. Macmillan Publishing Co., New York.
10. CALDWELL EF, RB FAST. 1990. Chapter 1. The cereal grains. In: RB Fast, CF Caldwell, editors. Breakfast Cereals and How They Are Made, 1–34. American Association of Cereal Chemists, Inc., St. Paul, MN.
11. POTTER N, J HOTCHKISS. 1995. Chapter 17. Cereal grains, legumes and oilseeds. In: N Potter, J Hotchkiss, editors. Food Science, 5th edition, 381–408. Chapman Hall, New York.
12. WILSTER GH. 1980. Practical Cheese Making.Corvallis: Oregon State University Press.
13. CHANDRAN R. 1998. Dairy Based Ingredients. EagenPress, Eagen, Minn.
14. FELLOWS PJ. 2000. Food Processing Technology Principles and Practice, 2nd edition. CRC Press, New York.
15. BOWERS J. 1992. Food Theory and Applications. Macmillan Publishing Company, New York.
16. WAN PJ. 1991. Introduction to Fats and Oils Technology. AOCS, Champaign, Ill.
17. CARLSON KF. 1991. Fats and oils processing. INFORM 2(12)

18. DEMEYER D. 1992. Meat fermentation as an integrated process. In: FJM Smulders, F Toldrá, J Flores, M Prieto, New Technologies for Meat and Meat Products, 21–36. Nijmegen, The Netherlands: Audet.
19. ROCA M, K INCZE. 1990. Fermented sausages. Food Reviews Int. 6.