UNIVERSITÀ DEGLI STUDI DI TERAMO

DEPARTMENT OF BIOSCIENCE AND TECHNOLOGY FOR FOOD, AGRICULTURE AND ENVIRONMENT

Master Degree in FOOD SCIENCE AND TECHNOLOGY (A.Y. 2025/2026)

Zootecnia di Precisione

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PROGRAM OF THE COURSE

1. General aspects of Livestock Production

Main production systems (intensive, extensive and organic systems). Main principles related to species, breed and genotype, genetic selection, feeding, reproduction, housing, animal welfare and production efficiency. Chemical and nutritional composition of animal products. Factors affecting quality of primary livestock products (species, breed, genotype, nutrition, farm management, health status, climate conditions).

2. Principles of Precision Livestock Farming (PLF)

Main purpose and technologies used.

3. PLF applications

Main applications in ruminants and monogastrics management, effects on primary production quality and animal welfare.

General aspects of Livestock Production

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Farming animals for food

- ✓ Ruminants: cattle, sheep, goat, buffalo
- ✓ Monogastric: pig, birds (chickens, laying hens)
- ✓ Fish
- ✓ Insects (insects as food, bees)

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Production systems

Intensive *vs* Extensive

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Intensive production systems

- ✓ **Indoor breeding – Animals live and are fed inside facilities dedicated to breeding**
- ✓ **Many of these systems are also essentially "landless"**
- ✓ **High genetic merit, high density, high cares, high technology, high energy.**

High production

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Extensive production systems

- ✓ Outdoors/free range
- ✓ Mainly self feeding
- ✓ Low genetic merit (the main intent is not to select the most suitable for production)
- ✓ Keep biodiversity
- ✓ Low density
- ✓ Low cares
- ✓ Low energy
- ✓ Low technology
- ✓ Low production

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Organic production

Animals must be born and raised on organic farms

- ✓ **Practices and housing**: number of livestock per unit of land must be limited; animals should have, whenever possible, access to open air or grazing areas.
- ✓ **Breeding**: natural methods must be used. Artificial insemination is however allowed; hormones are not permitted, unless as a form of veterinary therapeutic treatment.
- ✓ **Feed:** should primarily be obtained in the farm where the animals are kept or from farms in the same region; should be 100% organic feed; growth promoters and synthetic amino-acids are prohibited; suckling mammals must be fed with natural, preferably maternal milk.
- ✓ **Diseases and cares**: Farmers can prevent diseases by selecting the appropriate breed. When the animals are ill, chemically synthesized allopathic veterinary medicinal products including antibiotics may be used where necessary and under strict conditions. This is only allowed when the use of phytotherapeutic, homeopathic and other products is inappropriate.

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Genetic selection

- ✓ Generally used in intensive systems but also adopted for the selection of breeds capable of better adapting to free range conditions (outdoors).
- ✓ Is a technical to improve production and reproduction in livestock through the evaluation and subsequent choice (selection) of the reproducers.
- ✓ Variability in the population is necessary for selection it generates permanent increase of production
- ✓ Different parameters are selected
- ✓ Genomic selection is the new approach (combine analysis on DNA and phenotype information)

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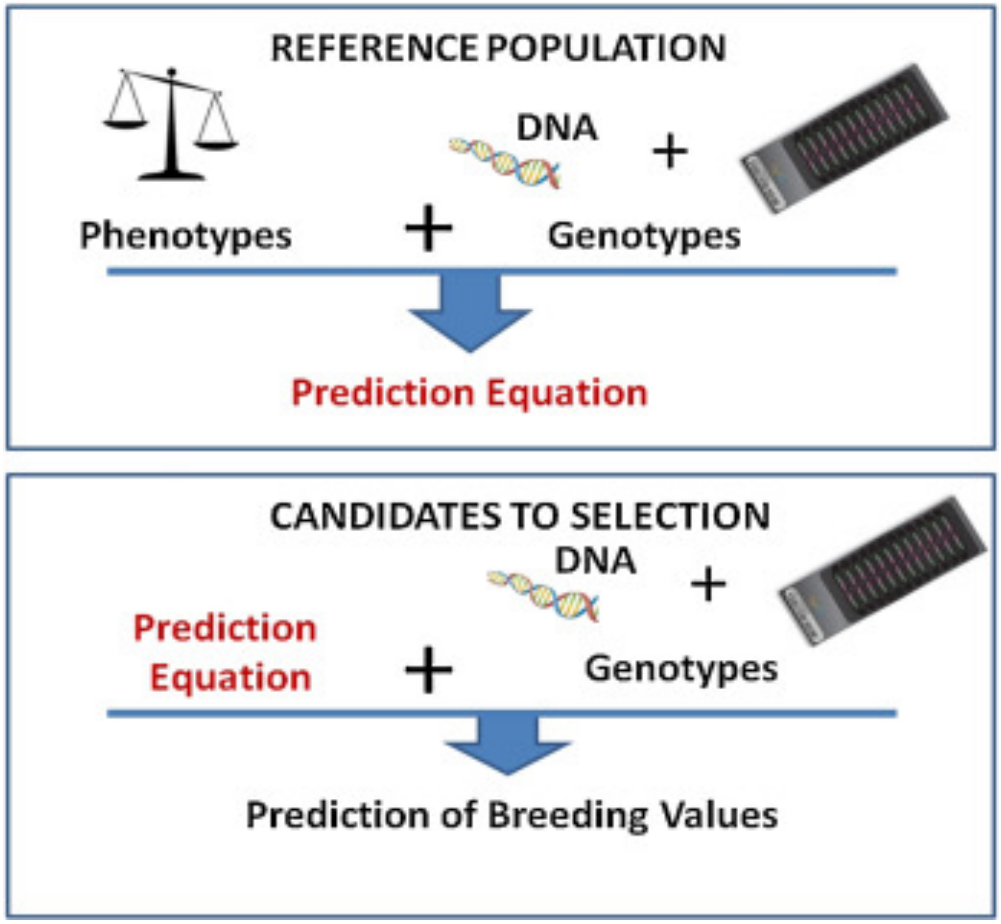
Genomic selection is the new approach

- ✓ Genomic selection is based on estimation of detailed associations between a very dense set of genetic markers (SNP) and phenotypes on a selected group of animals
- ✓ The resulting prediction equations are then applied to SNP genotypes of the rest of the population to estimate their genomic breeding, without the need of additional phenotypes.



Principles of genomic selection. Top: a prediction equation is obtained from a reference population with phenotypes and genotypes; bottom: this prediction equation is used on candidates with genotypic information only.

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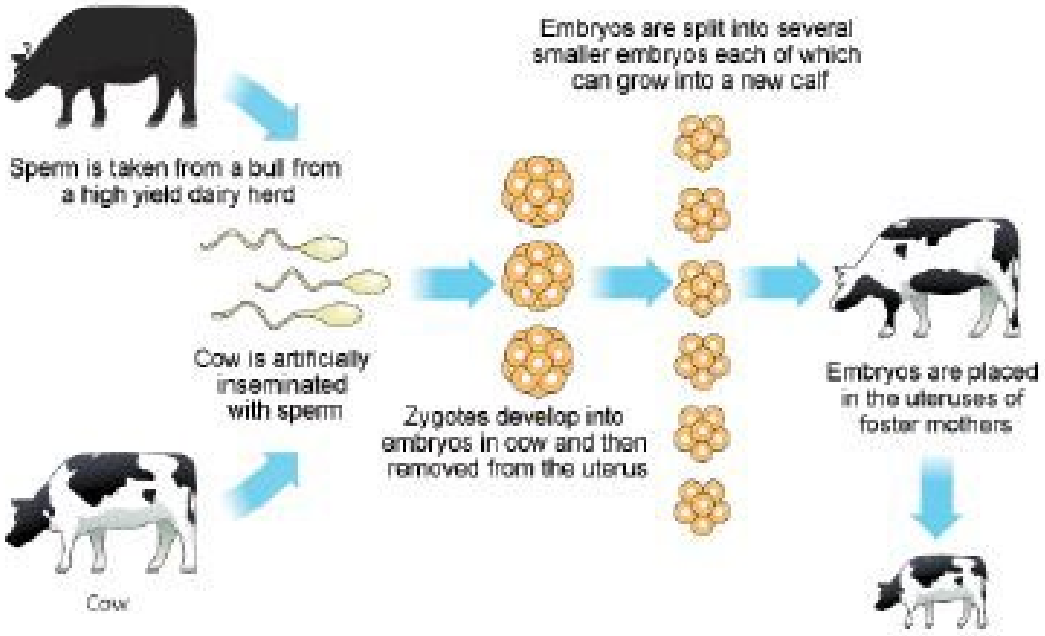
What does is selected?

- ✓ **Production traits**: Milk, protein and fat
- ✓ **Yield**: weight gain, feed conversion efficiency, quantity of the obtained product
- ✓ **Morphological traits**: udder (dairy ruminants), foot
- ✓ **Functional traits**: reproductive and longevity indices

The first two points are mainly related to intensive systems since particular attention is given to the animal ability to obtain high production yield in a short period of time.
The last two points can also be considered of interest for animals reared in extensive systems, as morphological and functional aspects are also taken into consideration which may justify a better adaptation of the animal in outdoor farming conditions.

Embryo transfer

Removal of embryos from high genetic merit cow (donor) and placement into a surrogate cow with low genetic merit or even in a different breed (recipient) for differentiation, growth and birth.



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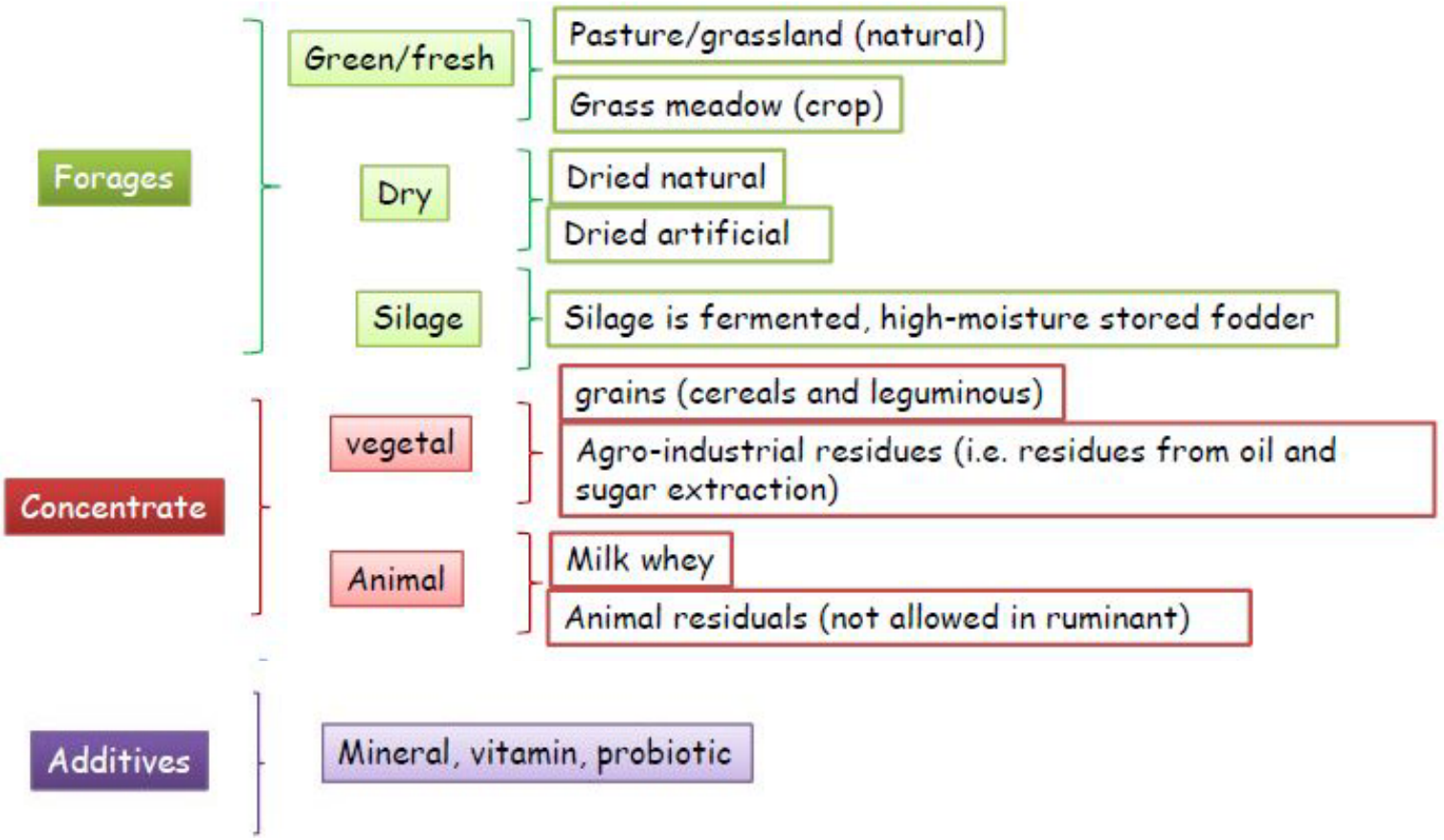
Laying Hens
Intensive vs Organic system

	Intensive (battery cage)	Intensive onshore	organic Free range
Laying age	20	20	20
End of cycle (weeks)	72	72	72
Lay length (weeks)	52	52	52
Mortality (%)	5	8	10
Eggs per cycle	280	286	267
Eggs declassed (%)	6	9	10
Feed consumed head/day (g)	115	120	130

(adapted from Pignattelli P. 2001)

Feeds for Livestock



Forages

The forages used in livestock feed contain various components useful for the metabolic health of the animals.

The main components are: fibers (cellulose which represents an important source of carbohydrates), proteins, vitamins (both fat-soluble and water-soluble), microelements (especially divalent ions such as manganese and magnesium), and bioactive compounds (mainly phenolic compounds with antioxidant action).

Concentrate

They include those based on starch (cereal), fat (protected fat), protein (soy meal), rich in fiber (soy hull), rich in fiber and fat (Cotton seeds).
In addition they are commercial concentrate that can be a mix of them above.
Concentrate may be: raw, meal, pelleted, flaked, etc

Starch: It represents cereal and corn, it accounts 80% and 20% of diet for monogastric (pig and broiler) and dairy cattle, respectively. It is high energetic and digestible

Lipid: High energy but it can not be used up 5%. It can be oil (soy oil, palm oil), seeds (soy, cotton), and protected fat (absorbed intestine).

Protein: high protein content, the soy is the main used. It can be as seed and as meal after oil extraction. Its quality depends from protein content, ratio of the protein rumen degradable and rumen by-pass, and essential amino acid concentration.

Additives

Additives or supplements are substance that not have a nutritive value but their use may improve feed security, feed efficiency, feed acceptance, health and metabolism.

Stability and security of feed: mold inhibitor used to contrast mold development in feed, or they may be substances that have antioxidant (oxidation fat) action such as vitamin C and E.

Buffers: are salt used to balance pH of rumen, for example they may buffer acidosis at the beginning of lactation when cows are feed with high concentrate diet.

Flavors: are additives used to increase palatability and feed intake

Additives

Probiotics: are "live micro-organisms which, when administered in adequate amounts, confer a health benefit on the host". (World Health Organization, 2001). The main are: *Lactobacillus acidophilus, Lactobacillus casei, Lactococcus lactis, Enterococcus faecium, Bifidobacterium bifidum, Bifidobacteriumt hermophilum*, and *Saccharomyces cerevisiae*.

They maintain proper composition of intestinal microflora, have a positive effect on immune system increasing the IgA release or macrophage activity.

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Additives

Organic Acids: are naturally present in plants, in animal tissues, and are also produced in the gut starting from the fermentation of carbohydrates. Short chain organic acids have antimicrobial capacity such as formic acid, acetic, propionic, butyric, lactic, sorbic, fumaric, tartaric, citric and benzoic acid. Their mechanism of action includes lowering the pH of the stomach, increase the proteolytic action and the digestibility of foods, increased pancreatic secretion, control the bacterial population by promoting the growth of useful bacteria and decreasing pathogen bacteria

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Additives

Phytotherapics: are natural secondary compounds of plants and their use in livestock is increasing. It is reported a positive effects on the production and animal health. Studies have shown that the use of these extracts in the diet of livestock species induces improvements in production performance, feed conversion, antioxidant capacity of plasma, rumen activity and intestinal enzyme activity.

Very important in the organic farming systems!

Reproduction

- ✓ **High technology**: oestrus synchronization (in order to synchronize lactation), instrumental insemination (artificial insemination), sexed semen (when necessary), embryo transfer (optional)
- ✓ **Management of reproduction**: Ovulation may be synchronized with hormonal treatments. Artificial insemination is done in correspondence of the ovulation induced, when females are ready to be fertilized.

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Animal Production

Not only food…

Food

- ✓ Milk
- ✓ Meat
- ✓ Eggs
- ✓ Fish
- ✓ Honey
- ✓ Insects
- ✓ Derivates

Not Food

- ✓ Wool
- ✓ Leather
- ✓ Fertilizers, energetic biomass
- ✓ Sport performance
- ✓ Entertainment
- ✓ Therapeutic tool

Total Quality:

Intrinsic parameters of quality

Extrinsic parameters of quality

Intrinsic quality:

- Health and hygiene
- Chemical bromatological
- Nutritional
- Organoleptic
- Technological

Extrinsic quality:

- Animal welfare
- Environmental sustainability

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Intrinsic quality of animal products

✓Hygienical sanitary	1) Microbial count 2) Residues
✓Chemical	1) Water 2) pH 3) Protein 4) Fat
✓Organoleptic	1) Taste 2) Odour 3) Colour 4) Flavour
✓Nutritional	1) Protein fractions 2) fatty acids 3) Cholesterol 4) Minerals 5) Trace elements 6) Vitamins
✓Technology	1) Processing 2) Yield

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Extrinsic quality of animal products

In the last years the concept of quality was also directed to:

- ✓ Animal welfare
- ✓ Environmental sustainability
- ✓ Social aspect

Quality of livestock products

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Factors affecting quality of primary livestock products

- ✓ Hygiene
- ✓ Species, breed, genotype
- ✓ Animal nutrition
- ✓ Farm management
- ✓ Health status
- ✓ Climate conditions

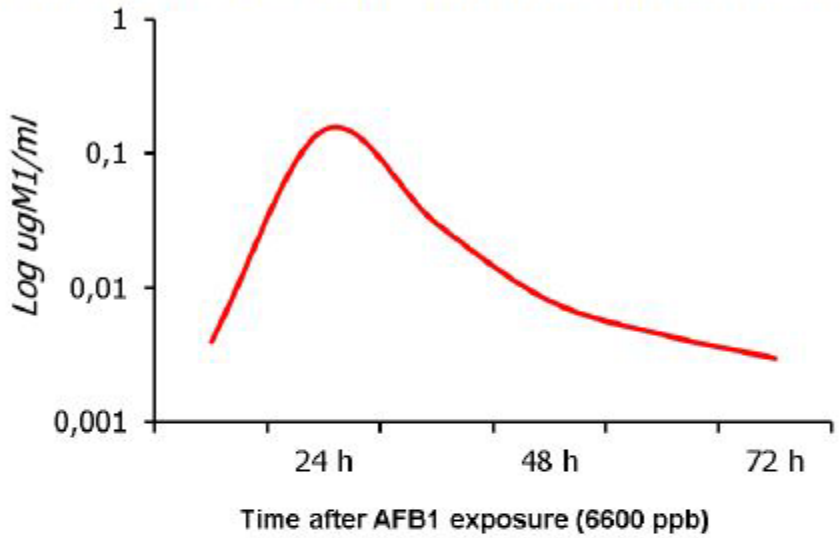
Hazard factors related to food consumption

- ✓ **Biological origin:** bacteria and bacterial toxins, viruses, mold and mycotoxin, prions, protozoa, insects, etc.
- ✓ **Chemical origin:** environmental contaminants (dioxins heavy metals, etc.), drug residues and hormones, pesticide residues, fertilizers.
- ✓ **Physical origin:** radionuclide

AFLATOXIN M_1

- Produced by the metabolism of animals exposed to contaminated food of AFB1
- Oxidation of AFB1 catalyzed by hepatic monooxygenase system and excretion in milk

KINETIC OF AFM1 EXCRETION



Ruth *et all.*,1968

The rate of excretion of aflatoxin M1 with respect to aflatoxin B1 assumed (CARRY-OVER) can vary between 0.2% and 5.0%

Average Carry-over about 3%

AFM_1

MILK

Raw milk to be eligible for human consumption must come :

"from officially tuberculosis-and brucellosis free herd and from animals that do not show any symptoms of infectious diseases communicable to humans through milk, from animals that denoting a general good health and they not highlighting symptoms of disease that might result in contamination of milk ..."

(Reg. CE 853/2004)

"... which have not been administered unauthorized substances or products, or for which, in case of administration of authorized products or substances, the withdrawal periods prescribed for these products or substances have been observed."

(Reg. CE 853/2004)

Antibiotics

Cow's milk, at the time of collection from farm must comply with the following parameters

Parameters	Raw milk for human consumption	Raw milk high quality
Fat	Not given	> 3,5 %
Protein	> 2.8 %	> 32 g/litro
Total bacterial count CFU/ml	< 100.000*	< 100.000*
Somatic cells (n./ml)	< 400.000**	< 300.000**

* Geometric average calculated over 2 months with at least 2 controls for month.
** Geometric average calculated over 3 months with at least 1 control for month.

Requirements for raw milk from other species than bovine

- total bacterial count at 30°C: < 1.500.000* (ml)
- somatic cells: not established

* Geometric average calculated over 2 months with at least 2 controls for month.

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Additional information about milk composition and quality

MILK FAT

- ✓Composed for glycerides at 98%
- ✓40-45 % is synthesized by mammary gland
- ✓Starting from: ac. acetic e ac. butiric
- ✓Of the fatty acids that compose the triglycerides only from C4 to C14 and the C16 they are synthesized from the udder, while from C18 and above are of blood origin

Feeding factors that may modify fatty acids (CLA) in milk

Factors	Effetc on CLA
Lipids	
unsaturated vs saturated	↑ with UFA
Type of vegetable oil	↑ with oil ↑ C18:2
palm oil	It is dose dependent
fat of animal origin	low effect ($p<0.05$)
corn oil	low effect ($p<0.05$)
soy	↑ if heat treated
Modulators of biohydrogenation	
forage/concentrate ratio	↑ with high rate
feeding restriction	↑
fish oil	↑ ↑ compared to veg. oil
tampons	low effect ($p<0.05$)
Type of forage	
pasture vs. conservated forages	↑ with pasture
age of forage	↑ with juvenile forages

Bauman et al., 2001

Proteins in feed vs proteins in milk

Low proteins or higher content of non degradable protein

↓

↓ % Milk proteins

Excess of proteins (above requirements)

↓

1. None effects of protein content
2. ↓ Casein
3. ↑ Urea (r = 0.98)
4. If raw protein > 17%:
   - ↑ health risk
   - Reduced fertility
   - mastitis

Feeding and Meat quality

In relation to breeds

composition of meat

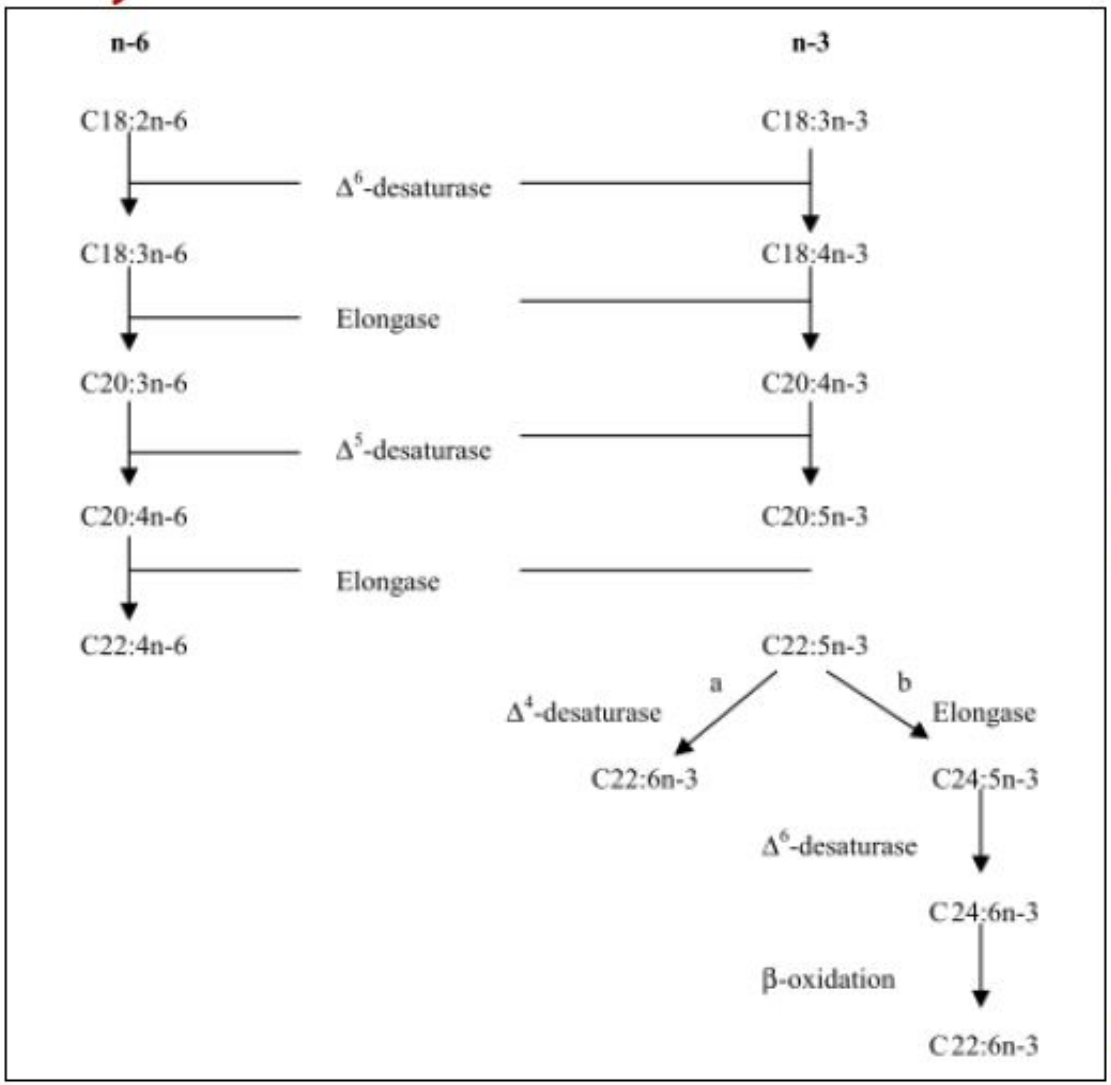
	carcass Kg	meat %	Bone %	Fat %
Chianina	457.85	64.71	23.83	11.45
Maremmana	317.42	63.91	22.51	13.59
Frisona	294.28	63.66	22.02	13.31
Charolaise	307.52	67.32	21.63	11.04

Chemical and nutritional parameters of meat

- Moisture
- Protein
- Lipids
- Saturated and unsaturated fatty acids
- Cholesterol
- Micro e macro elements
- Vitamins
- Bioactive compounds (Q10 Coenzim, anserine, carnosine)

Protein and amino acid content are little influenced by feeding, while it is well documented that diet may affect fat content and fatty acid composition

CONVERSION OF C18:2n6 (Linoleic) and C18:3n3 (Linolenic)TO THEIR LONGER CHAIN FATTY ACID



EPA

DHA