UNIVERSITÀ DEGLI STUDI DI TERAMO

UNITE

DEPARTMENT OF BIOSCIENCE AND TECHNOLOGY FOR FOOD AND AGRICULTURE

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

Sustainable Livestock Production

UNIT 2

Quality of livestock products

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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

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

A. Nardone XXXIX Brazilian Soc. Animal S.M. Recife 2002

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

Factors affecting quality of primary livestock products

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

Health and Hygiene quality

The health quality of a food is given by the compliance with minimum hygiene requirements defined by law.

- ✓ Presence of microorganisms and their metabolic products (also toxins!)
- ✓ Presence of chemical compounds

Regulation on the hygiene of foodstuffs
CE 852 2004

Health and Hygiene quality

Regulation on the hygiene of foodstuffs CE 852/2004

‘food hygiene’ specifically means the measures and conditions necessary to control hazards and to ensure fitness for human consumption

Health and Hygiene quality

The European Food Safety Authority (EFSA) is responsible for the of European Union in evaluating risks associated to food and feed safety

In close collaboration with national authorities EFSA provides independent scientific advice and clear communication on existing and emerging risks

EFSA
http://www.efsa.europa.eu/en/aboutefsa.htm

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

Food poisoning

Food poisoning are pathological manifestations which occur following the consumption of food containing bacterial toxins

In this condition, the intoxication does not require the presence of the microorganism but is essential the presence of its toxin produced by microorganisms that have multiplied on food before consumption

…an example is represented by **botulinum toxin**

Origin of microorganisms in foods

Microorganisms are directly responsible for contamination

Initially, the raw foods can be contaminated with microorganisms from air, water, soil, surface of plants and animals (primary contamination).

During processing, food can be re-contaminated by microorganisms resulting from storage environments, processing surfaces, processing tools, and from the personnel engaged in productive activities.

Finally, the food may be subject to contamination and/or changes in the microbial content in the later stages of the storage, transport, distribution and consumption.

<u>Technological process to which food is subjected may also determine variations in the microflora naturally present or added (such as probiotics)</u>

Origin of microorganisms in foods

- WATER AND SOIL: plant and animal foods with which these products come into contact during their production and farming.
- AIR AND DUST: especially spore-forming, micrococci and mold spores.
- SURFACES OF PLANTS AND ANIMALS: are rich in microorganisms that originate from water, soil and faeces.
- GASTROINTESTINAL TRACT: is an important source of contamination, especially of pathogenic bacteria such as Salmonella and other Enterobacteriaceae.

Origin of microorganisms in foods

To ensure the hygienic/sanitary quality of food, a key role is played by operators (manufacturer, distributor or seller)

Reg. EC 852/2004 - *Food safety must be guaranteed throughout the food chain, starting with primary production and again. Furthermore, to ensure the safety of food is necessary to consider all aspects of the food production chain, starting with primary production up to the sale or provision of food to the consumer and including each element that has a potential impact on food safety*.

For this purpose, a tool to guarantee the people's health adoptable by all food business operators is represented by

HACCP (Hazard Analysis Critical Control Points)

Hazard Analysis Critical Control Points

The HACCP is a tool of hygienic self control, which aims to analyze the risks and critical points of the various production stages for each food.

The specific hazards for hygiene and health are then identified and evaluated and then established measures to prevent such risks

Reported cases, Italy 2009

http://www.oie.int/wahis_2/public/wahid.php/Countryinformation/Zoonoses
http://www.oie.int/

Disease	Cases	Rate per 100,000 popul.
• Salmonellosis	4156	7.1528
• Campylobact.	531	0.9139
• Listeriosis	88	0.1515
• E. coli O157	51	0.0878
• Brucellosis	23	0.0396
• West Nile Fev.	18 (4 morti)	0.031
• Bov. Tub.	5	0.0086
• Trichinellosis	1	0.0017

Transmissible diseases and the concept of ”ZOONOSES”

Since long time is known that there are diseases that can be transmitted from animals to humans

These diseases are called “zoonoses”

In 1959 the World Health Organization (WHO) has adopted the following definition

"Naturally transmitted diseases and infections between vertebrate animals and humans"

viruses

MDPI

Review

Transmission of Hepatitis E Virus in Developing Countries

Mohammad S. Khuroo [1,2,*], Mehnaaz S. Khuroo [3] and Naira S. Khuroo [2]

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to know more…

https://www.mdpi.com/1999-4915/8/9/253/htm

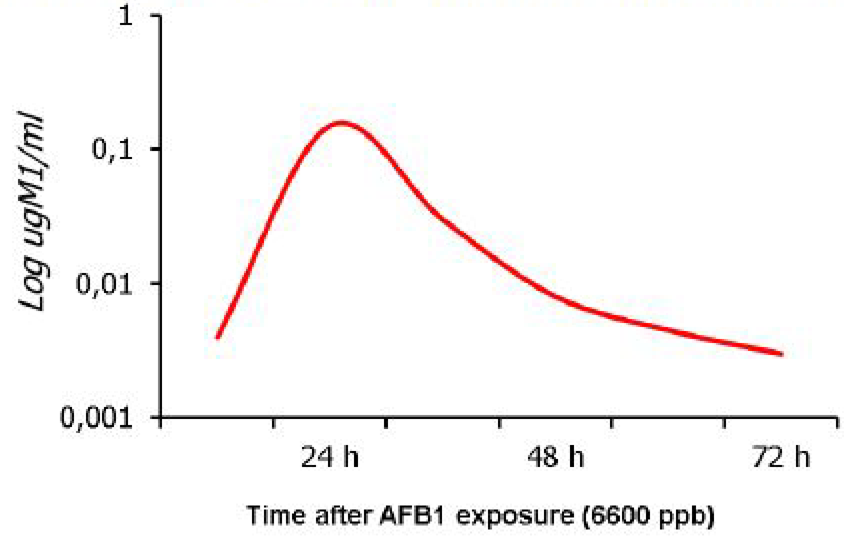
MYCOTOXINS

- ✓ organic molecules of biological origin
- ✓ Produced by fungi ("mold") on plants both in the field and during storage
- ✓ They are cause of poisoning in animals and humans (mycotoxicosis)

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

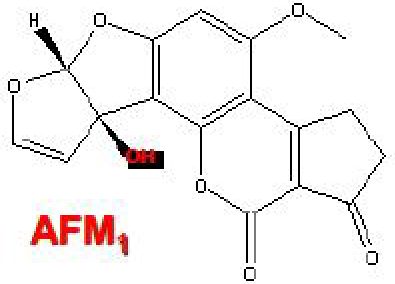
KINETIC OF AFM1 EXCRETION



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.

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

Dietary supplement with Olive Pomace

Table 6. Aggregated fatty acids and healthy indices observed in individual milk at the end of trial and after 30 days of ripening in the relative produced cheese

	Groups[1]							
	Milk				*Cheese*			
Item[2]	C	E	SEM	P	C	E	SEM	P
SFA	74.03	71.04	0.59	***	72.73	69.58	0.65	***
MUFA	20.46	23.36	0.52	***	21.07	24.18	0.53	***
PUFA	2.93	3.09	0.07	0.15	2.88	3.30	0.15	0.08
CLA	0.61	0.79	0.02	***	0.76	0.97	0.03	***
SFA/UFA	3.20	2.70	0.08	**	3.06	2.53	0.11	**
Atherogenic index	4.36	3.62	0.11	***	4.12	3.42	0.16	**
Thrombogenic index	4.74	4.07	0.13	**	4.56	3.84	0.11	***
DI[3]	10.66	10.19	0.66	0.63	9.57	9.77	0.32	0.66

[1]C = control diet; E = experimental diet supplemented with 2 kg on DM of dried olive pomace during 60 days
[2]expressed as percentage
[3]Desaturation index (cis-9 14:1/14:0 + cis-9 14:1)
*P<0.05; **P<0.01; *** P<0.001

Castellani et al., 2017

J. Dairy Sci. 102:1025–1032
https://doi.org/10.3168/jds.2018-15590

Short communication: Compositional characteristics and aromatic profile of caciotta cheese obtained from Friesian cows fed with a dietary supplementation of dried grape pomace

	Bulk milk		
Item	GP−	GP+	*P*-value
C4:0	2.59 ± 0.38	2.49 ± 0.35	NS
C6:0	2.02 ± 0.24	2.00 ± 0.19	NS
C8:0	1.39 ± 0.21	1.35 ± 0.06	NS
C10:0	3.41 ± 0.37	3.39 ± 0.26	NS
C12:0	4.15 ± 0.39	4.17 ± 0.37	NS
C14:0	12.52 ± 1.39	12.71 ± 1.23	NS
C14:1	1.08 ± 0.08	1.13 ± 0.10	NS
C15:0	1.06 ± 0.11	1.17 ± 0.12	NS
C16:0	34.15 ± 3.85	33.31 ± 3.90	NS
C16:1	1.01 ± 0.08	1.13 ± 0.17	NS
C18:0	10.73 ± 0.58	10.81 ± 0.48	NS
C18:1 *trans*	0.64 ± 0.08	0.98 ± 0.11	**
C18:1 cis-9	17.20 ± 1.95	17.26 ± 2.18	NS
C18:1 *trans*-11	0.43 ± 0.04	0.40 ± 0.06	NS
C18:2	2.28 ± 0.23	2.60 ± 0.31	**
C18:3	0.46 ± 0.06	0.47 ± 0.07	NS
Rumenic acid	0.44 ± 0.03	0.38 ± 0.06	NS
Other	3.88 ± 0.32	4.33 ± 0.41	*

*$P < 0.05$; **$P < 0.01$.

Grape pomace is rich in linoleic acid (C18:2)

Ianni et al. (2019)

Items	Bulk milk		
	CG	EL+	p-value
C4:0	2.61±0.48	3.01±0.19	*
C6:0	3.24±0.57	4.09±0.32	*
C8:0	4.11±0.16	4.72±0.36	*
C10:0	14.73±2.55	13.18±1.02	ns
C12:0	9.19±1.03	8.63±0.66	ns
C14:0	15.75±1.29	15.04±1.03	ns
C15:0	1.08±0.09	1.01±0.08	ns
C16:0	27.27±2.38	27.00±1.71	ns
C17:0	0.62±0.04	0.46±0.03	ns
C18:0	3.42±0.12	3.80±0.19	*
SFA	**82.02±0.93**	**80.94±0.56**	ns
C14:1 c9	0.22±0.02	0.15±0.02	ns
C16:1 c9	0.65±0.05	0.42±0.04	ns
C18:1 t11	0.50±0.04	0.67±0.05	*
C18:1 c9	13.30±0.14	13.60±0.12	*
C18:1 c11	0.25±0.02	0.31±0.03	*
MUFA	**14.92±0.95**	**15.15±1.05**	ns
C18:2 c9,12	1.63±0.51	1.09±0.08	*
C18:2 c9, t11	0.38±0.03	0.50±0.04	*
C18:3 c9,12,15	1.05±0.54	2.32±0.16	*
PUFA	**3.06±0.21**	**3.91±0.32**	*
SCFA[1)]	5.85±0.53	7.10±0.26	**
MCFA[2)]	45.08±1.96	42.73±1.53	ns
LCFA[3)]	49.07±1.42	50.17±1.27	ns

Bennato et al. (2020)

Linseed is rich in linolenic acid (C18:3)

Proteins in feed vs proteins in milk

Low proteins or higher content of non degradable protein

↓

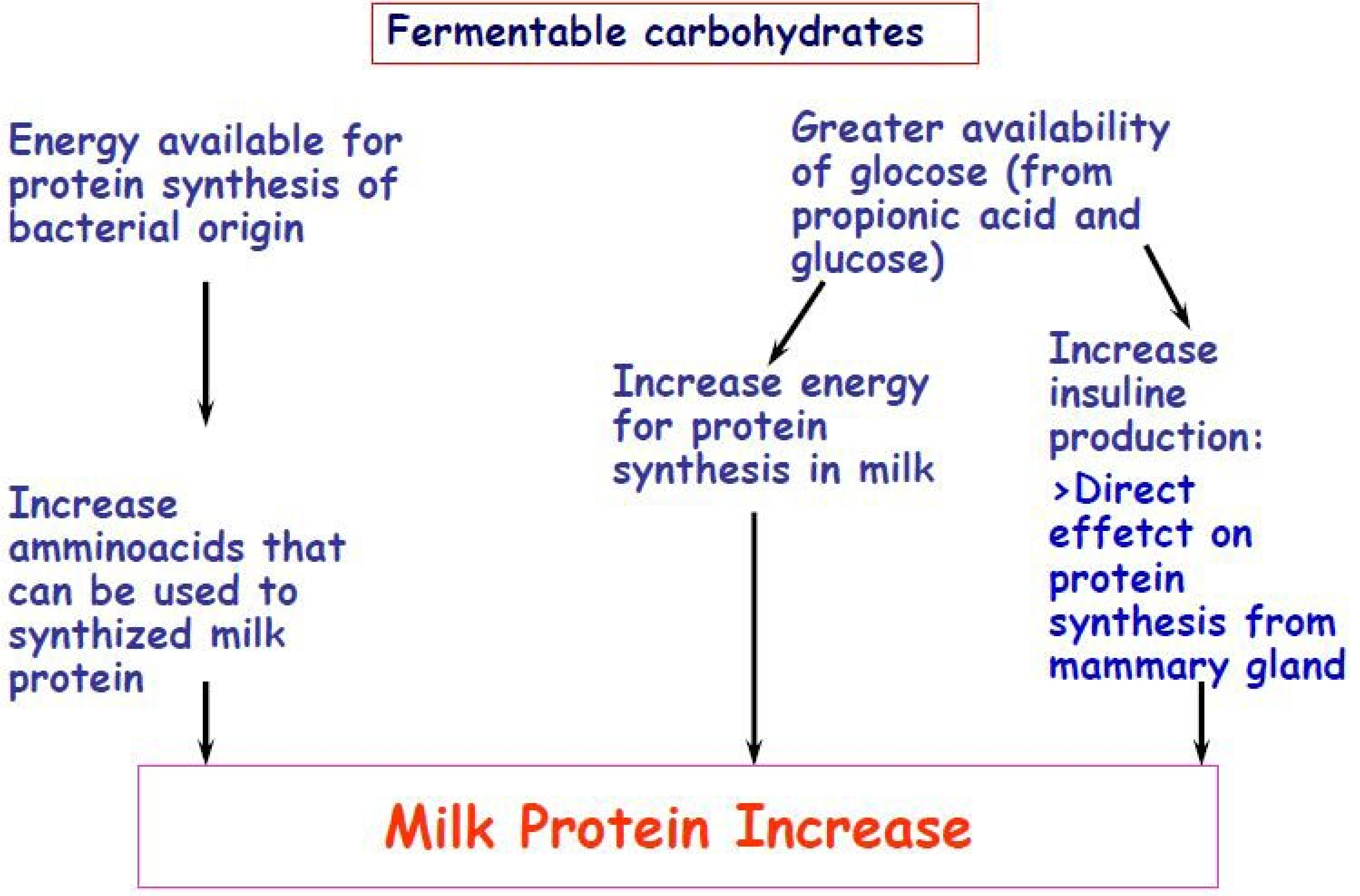
↓ % Milk proteins

Excess of proteins (above requirements)

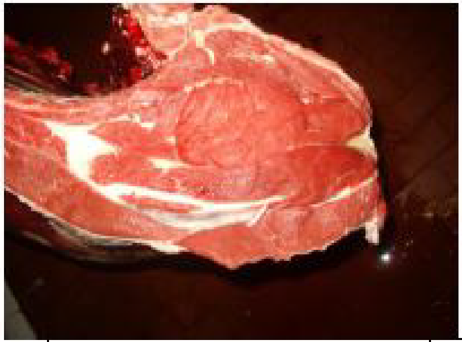
↓

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

Energy of the diet vs milk protein



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

LIPIDS

- Membrane fat (as phospholipid)
- Intermuscular fat (between the muscles)
- IMF Intramuscular fat
- Subcutaneous fat

✓Fat content varies widely depending on species and the cut

✓ Ruminant fat has a higher SFA and a lower polyunsaturated:saturated fatty acids (PUFA:SFA) ratio than non-ruminant fat, due to hydrogenation of dietary unsaturated fatty acids in the rumen

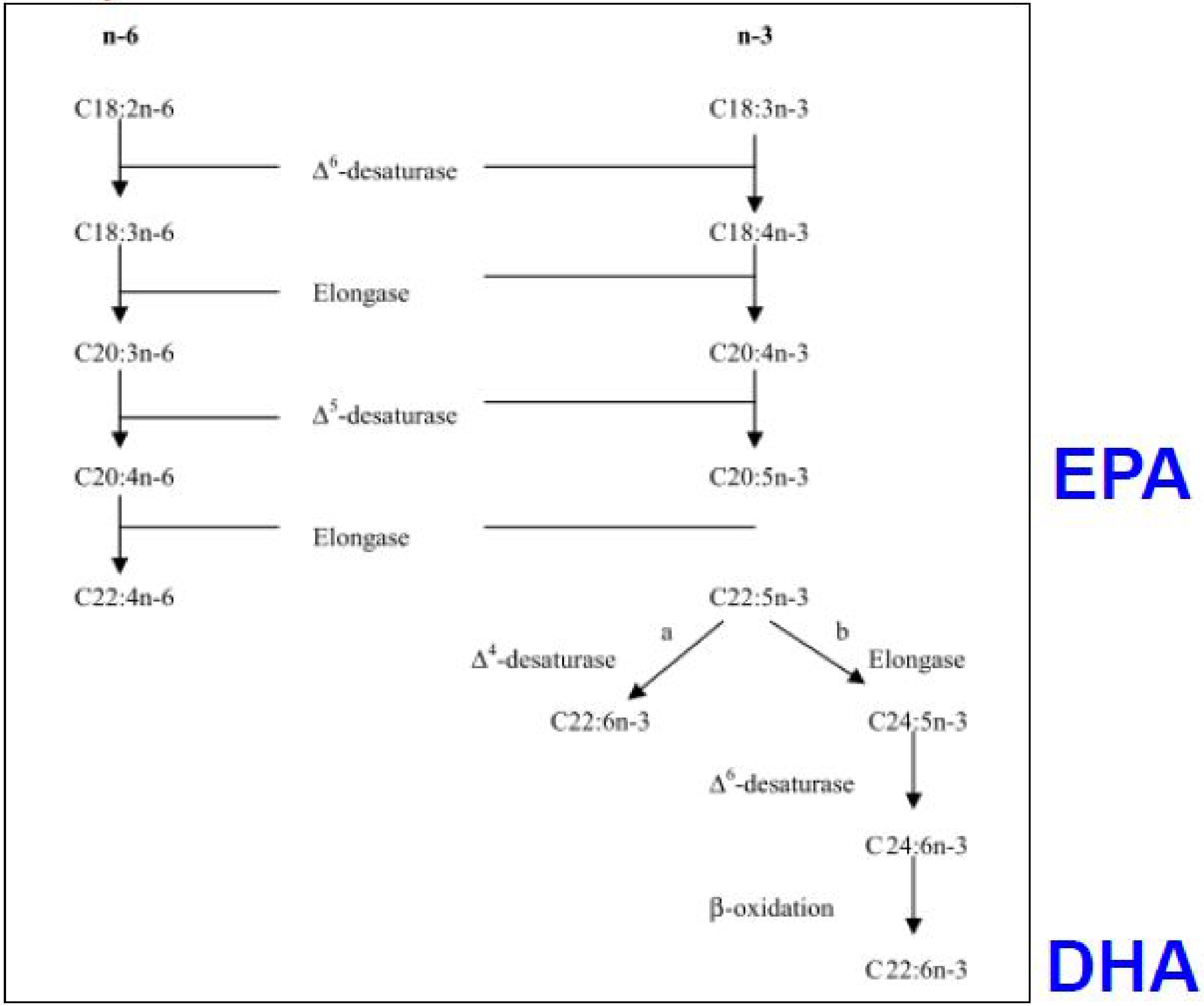
A ratio of PUFA to SFA (called P:S) above of 0.45 and a ratio of ω6:ω3 below of 4.0 are required in the diet to reduce health diseases related to food consumption

FATTY ACIDS PROFILE IN BEEF, PORK AND CHICKEN

% Fatty acids	Beef	Pork	Chicken
Palmitic acid	24-27%	23-25%	22-24%
Stearic acid	**19-21%**	15-17%	8-11%
SFA	**47-51%**	39-43%	34-37%
Oleic acid	28-30 %	**38-44%**	26-30%
MUFA	33-39%	**47-51%**	28-32%
Linoleic acid	3-4%	5-6%	**19-21%**
Linolenic acid	1-2%	0,5-1%	0.5%
PUFA	8-10%	8-10%	**30-32%**

The intramuscular fatty acid composition of the monogastric animals, and in particular the triacylglycerols are a reflection of the dietary fatty acids (High PUFA in fed High PUFA in meat).
In ruminants the biohydrogenation in the rumen (i.e. saturation of the dietary unsaturated fatty acids) is responsible for the smaller variations in intramuscular fatty acid composition (High PUFA in diet High CLA and SFA in meat).

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



Increasing the long chain n-3 PUFA in meat

-Dietary supplementation of fish oil and fish meal, increased especially EPA (eicosapentaenoic acid or ω3) and DHA (docosaesaenoic acid or ω3)

- Use of vegetables oil (linseed oil, sunflower oil, olive oil)

- Use of higher plant rich in n-3 (rapeseed meal, linseed)

- Use of forage, pasture (in ruminants)

- Decreasing concentrate content in ruminants
- Use formaldehyde treatment in linseed reduces biohydrogenation degree in ruminant

CLA in RUMINANT

Among fats of animal origin those of ruminants are higher sources of CLA.
In particular the cis-9, trans-11 isomer C18:2, which is produced from microbial hydrogenation of dietary linoleic and linolenic acids in the rumen. In addition, CLA is synthesized in adipose tissue starting from trans-11 octadecenoic acid (vaccenic acid) by 9-desaturase enzyme

IMPROVE CLA CONTENT IN BEEF INTRAMUCOLAR FAT

- decreasing the amount of grain in the diet
- including forage in the diet or grazing on pasture
- fed Linolenic acid sources (linseed or forage)
- fed high concentrate diets (sunflower cake or grape) rich in Linoleic acid
- Feeding fish oils
- feeding supplement with rumen protected CLA

CLA in MONOGASTRIC

Incorporating CLA in the diet of pigs resulted in increased deposition of SFA (C14:0, C16:0 and C18:0) and a decrease in MUFA (mainly C18:1).

Fed hydrogenated fat, rich in trans C18:1 isomers (vaccenic), resulting in a higher c9t11CLA (rumenic) content in the adipose tissue of pigs.

Dietary supplement of oil rich in CLA in swine, may increase LDL/HDL cholesterol ratio (not good for health).

Dietary CLA decreased the content of polyunsaturated fatty acid and increased CLA in chicken muscles.

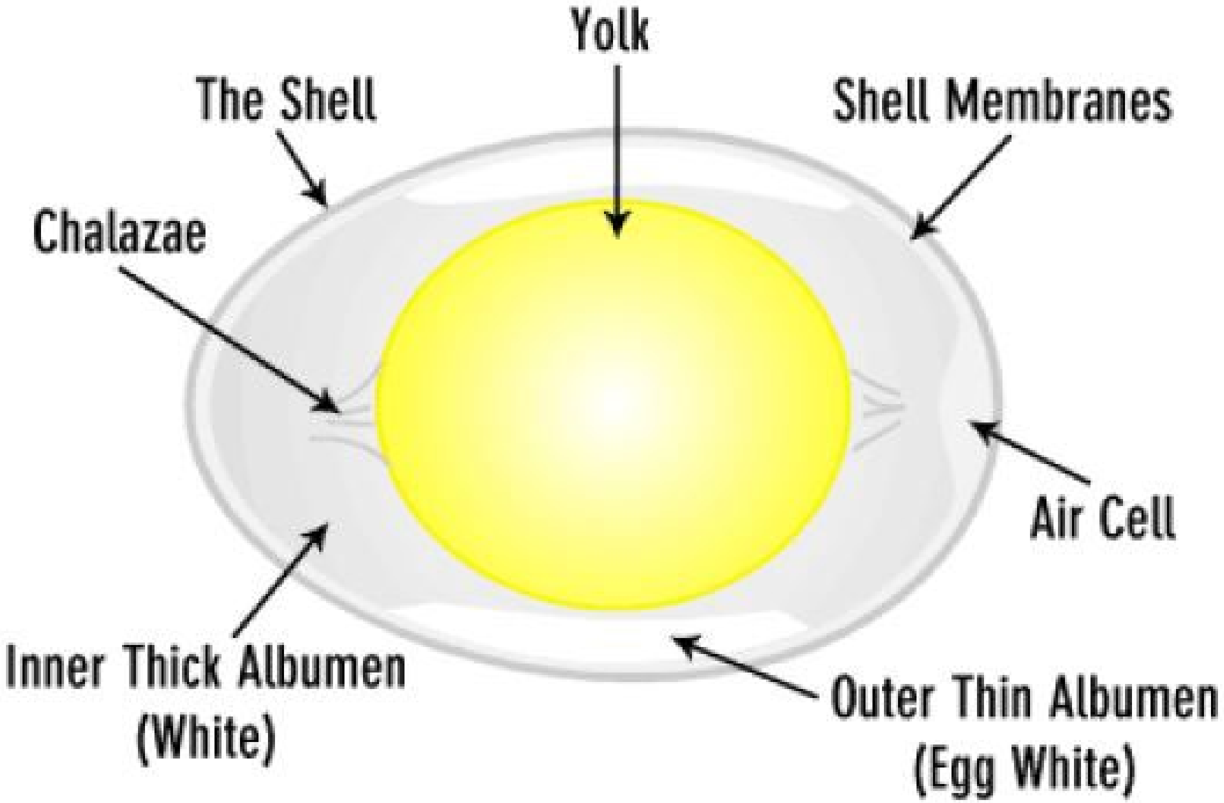
Rumen Transformation of Lipids

by Dr. Tom Jenkins, Clemson University

https://www.youtube.com/watch?v=My
O_Raiv14w

Feeding and Eggs quality

Eggs "anatomy"



EGG COMPOSITION

SHELL (9% of the total)
99% DM
98% Minerals
96% Calcium Carbonate
1% Magnesium Carbonate
1% Calcium phosphate
2% Protein (Mucoprotein)

ALBUMEN (63% of the total)
87-89% Moisture
11-13% DM
10-11% Protein
0.5-0.7% Ash
Soluble vitamins (B1-B2-PP)
0.5-0.8% Glucose

YOLK (23% of the total)
46-48% Moisture
51-53% DM
16-17% Protein
33-34% Lipids →
1-1.5% Ash
Liposoluble vitamins

– Triglycerides	65%
– Phospholipids	30%
– Cholesterol	4%
– SFA	35-40%
– MUFA	40-50%
– PUFA	3-4%

Whereas amino acids and total protein are hardly affected by dietary treatments, minerals, fat-soluble vitamins, and lipids, fatty acids are easily modified through feed manipulation.

ALBUMEN QUALITY

Nevertheless, there are reports of albumen quality:

- decreasing with increasing dietary protein and amino acid content
- increasing with increased dietary lysine concentration
- increasing with ascorbic acid supplementation
- increasing with vitamin E supplementation, especially at high ambient temperatures

Dietary effect on shell quality

The ratio of calcium to phosphorus in the diet is important as high levels of phosphorus may interfere with the absorption of calcium from the gut, resulting in reduced shell quality.

Vitamins such as Vitamin D are necessary for calcium metabolism and must be included in the diet.

Adequate levels of vitamin C are essential for normal good health and may also help to alleviate the effects of stress.

Phytase supplementation has been shown to improve egg shell quality, and the effects of phytase supplementation are modified by the levels of calcium and nonphytate phosphorus in the diet.

Yolk quality
(Colour is feeding)

The fatty acid profile of the egg yolk is clearly affected by the fatty acid profile of hen diets, particularly polyunsaturated acids.

Starting from linoleic (n-6) and linolenic (n-3) acids, n-6 and n-3 series of long-chain polyunsaturated fatty acids (PUFA) are synthesized, especially EPA and DHA.

INCREASING THE LEVELS OF THE n-3 FATTY ACIDS

- ADD FISH OIL IN THE DIET
- ADD MARINE MICROALGAE IN THE DIET
- ADD LINSEED IN THE DIET

LONG-CHAIN FATTY ACIDS ARE MORE susceptible TO OXIDATION BECAUSE OF THEIR DOUBLE BONDS (diet enriched with antioxidant, like vitamin E and C)

DIETARY CLA EFFECTS ON EGGS QUALITY

The weight of the yolk, albumen, and shell decreased linearly with increasing dietary CLA.

Concentration of CLA in the yolk lipids increased quadratically with increasing dietary CLA

The supplementation of CLA to the diets had clear effects on the yolk lipids:

- decrease in MUFA (oleic) and PUFA (linoleic, linolenic, and archidonic acids)

- increase in saturated fatty acids (SFA) (myristic, palmitic, and stearic acids)

Supporting scientific papers

Milk and Dairy Products

- https://www.sciencedirect.com/science/article/pii/S0022030218311056
- https://www.mdpi.com/2304-8158/9/2/168
- https://www.sciencedirect.com/science/article/pii/S0022030217307853
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6946995/

Meat

- https://www.mdpi.com/2076-2615/9/8/578

Eggs

- https://www.ajas.info/journal/view.php?doi=10.5713/ajas.19.0309