UP FARMING

Co-funded by the European Union

Erasmus+

PIEMONTE - GALICIA

PART 3

Updating sustainability application & communication in the livestock farming sector

PART 3

IMPROVING SUSATINABILITY

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UNIVERSITÀ DI TORINO

Dipartimento di Scienze Agrarie, Forestali e Alimentari

DISAFA
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LIVESTOCK ENVIRONMENTAL IMPACT

Air:
- ✓ CH_4
- ✓ NH_3
- ✓ CO_2
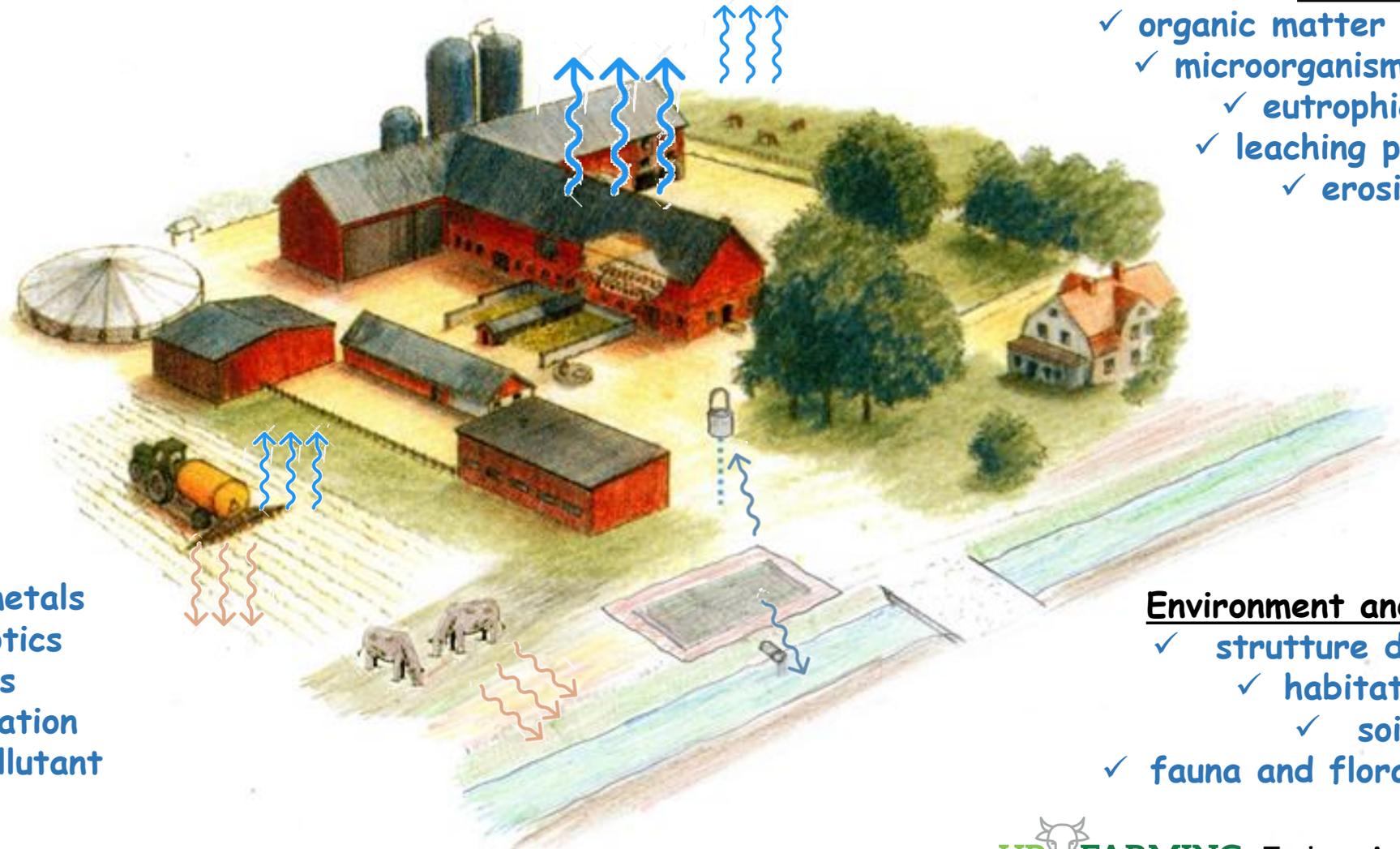- ✓ odours
- ✓ N_2O

Water:
- ✓ organic matter and nutrients
- ✓ microorganisms pathogen
- ✓ eutrophication
- ✓ leaching pollutant
- ✓ erosion

Soil:
- ✓ heavy metals
- ✓ antibiotics
- ✓ salts
- ✓ acidification
- ✓ micro-pollutant

Environment and landscape:
- ✓ strutture di stoccaggio
- ✓ habitat losses
- ✓ soiling
- ✓ fauna and flora contamination

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MAIN STARTEGIES

To reduce the livestock environmental impact could be possible act thru:

Nutritional / Feeding   short time

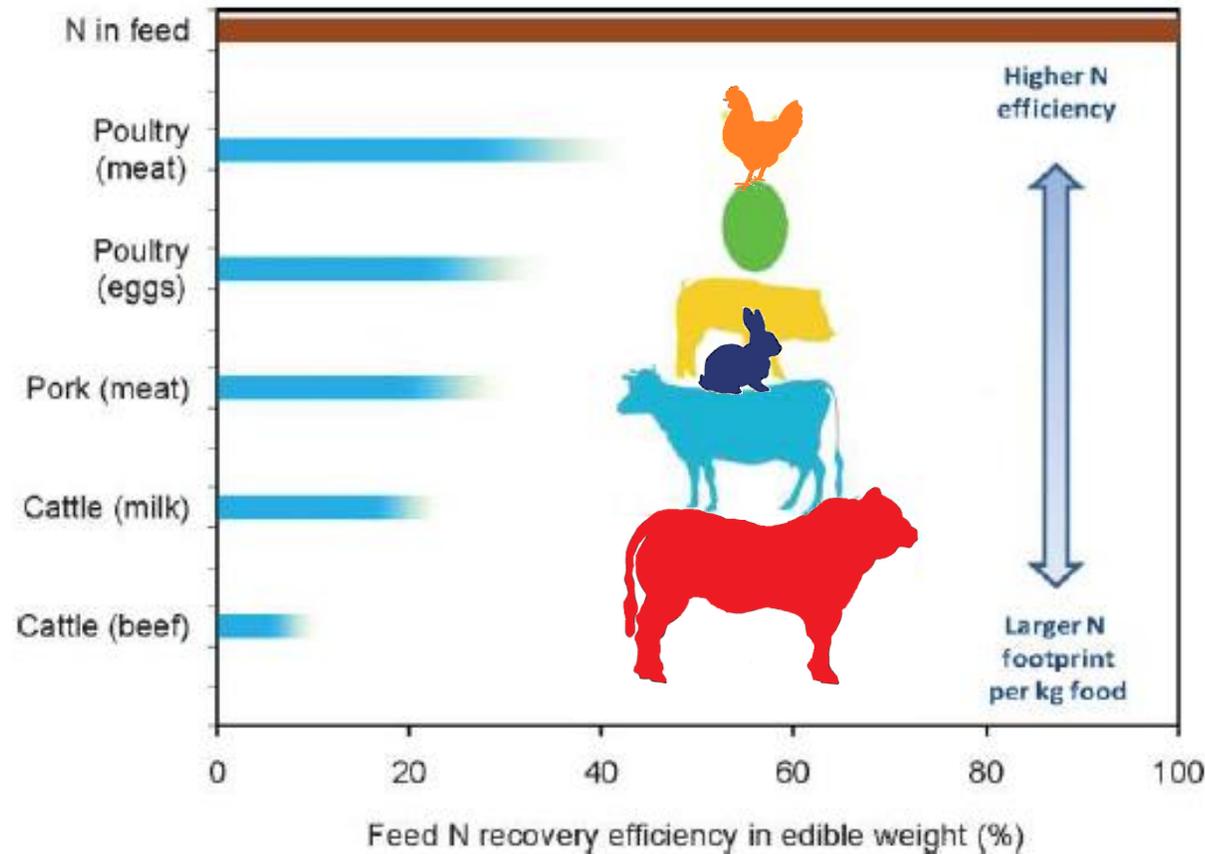Genetic improvement   medium/long time
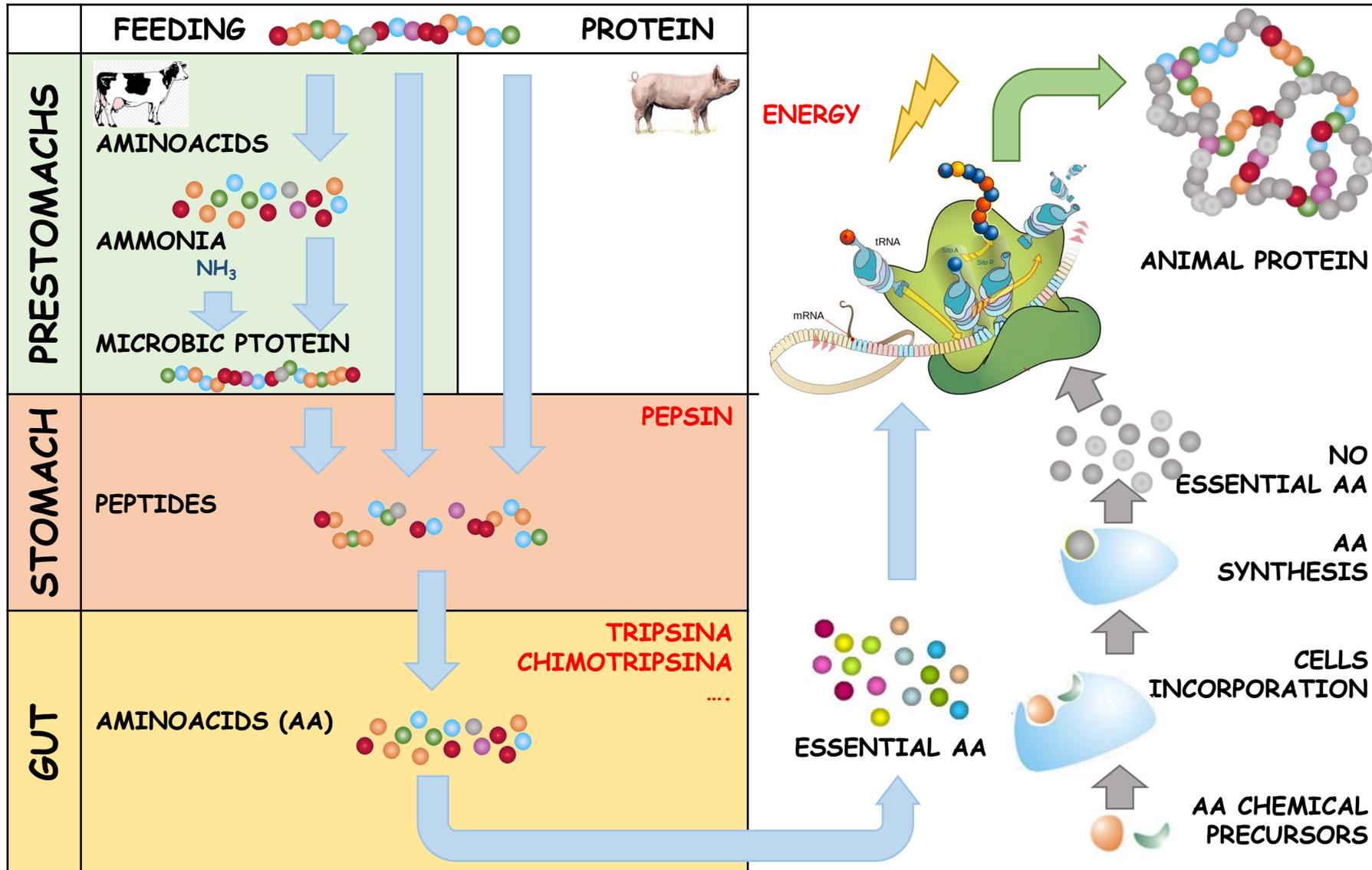
Management   long/medium time

DIET ACTIONS

REDUCTIONS OF NUTRIENT EXCRETIONS

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NITROGEN EFFICIENCY

Average efficiencies:

poultry 45%;

pork 30-35%;

rabbit 35%;

dairy cows 20-35%;

Beef 10%;

NITROGEN UTILIZATION

REDUCTION NITROGEN EXCRETIONS: THE IDEAL PROTEIN

DEFINITION:

The concept of ideal protein (IP) was developed more than 50 years ago and refers to a protein with an amino acid profile that exactly meets the animal's requirement so that all amino acids are equally limiting for performance and maximize Nitrogen retention

IP
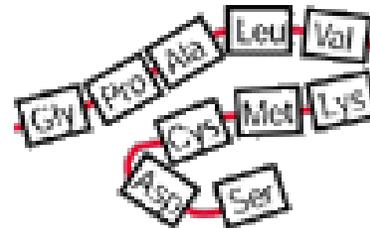- monogastrics ⟹ ingested proteins (or aa)
- ruminants ⟹ proteins (or aa) into small intestine

STRATEGY

To reduce crude protein CP content of the diet
adding synthetic amino acids

The amino acids must be in balanced reciprocal
ratio to each other, but also with the energetic
supplement (Net Energy) of the diet

Among amino acids Lysine is the limiting one

The ratio between aa is then expressed based on
this aa

SWINE REQUIREMENT

Fattening pigs requirements (50-100 kg LW)

| Fonti USA	NRC, 1998	KSU, 2007	NSNG, 2010		NRC, 2012	
	National Research Council, Washington D.C.	Kansas State University, Kansas Swine Nutrition Guide	National Swine Nutrition Guide		National Research Council, Washington D.C.	
Sesso, C=castrati, F=femmine	---	---	C	F	C	F
E.D., kcal/kg	3400	---	---	---	3402	3402
E.M., kcal/kg	3265	3350	3352	3352	3300	3300
E.N., kcal/kg	---	---	---	---	---	---
Lisina, %	0.75	0.84	0.93	1.01	---	---
Lisina dig., %	0.66	0.74	0.81	0.88	0,81	0,87
Metionina dig., %	0.18	0.22	0.24	0.26	0,23	0,25
Metionina + Cistina dig., %	0.39	0.42	0.49	0.53	0,46	0,49
Treonina dig., %	0.43	0.45	0.52	0.56	0,50	0,53
Triptofano dig., %	0.12	0.125	0.13	0.14	0,14	0,15
Isoleucina dig., %	0.37	0.41	0.45	0.49	0,43	0,46
Valina dig, %	0.45	0.48	0.53	0.57	0,53	0,57
Istidina dig., %	0.21	---	0.26	0.28	0,28	0,30
Leucina dig., %	0.67	---	0.81	0.88	0,82	0,88

REDUCTION PROTEIC CONTENT OF THE DIET

To assure the requirement of Lysine (limiting aa) will have
excess in the quantities of the others aa
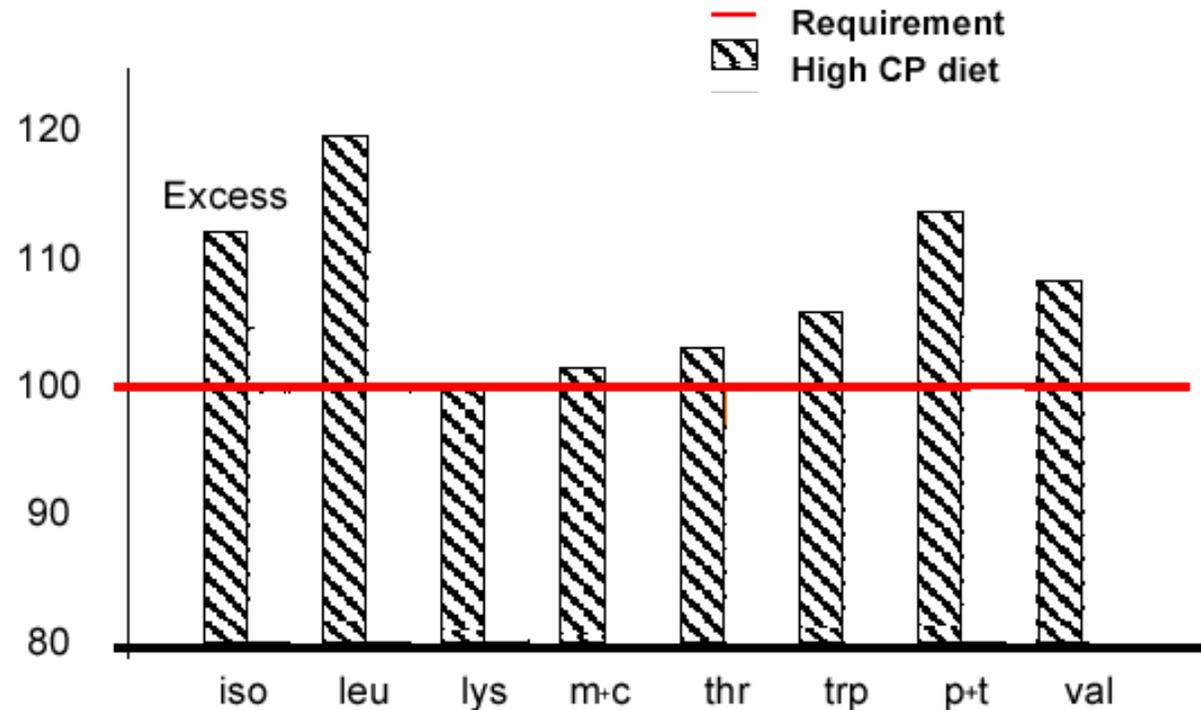
The availability of synthesis aa allow a decrement of the
diet crude protein

N EXCRETION REDUCTION APPLING THE CONCEPT OF IDEAL PROTEIN

It is possible reduce the feed protein and hence the N excretion, suppling the rations with synthesis excential aa
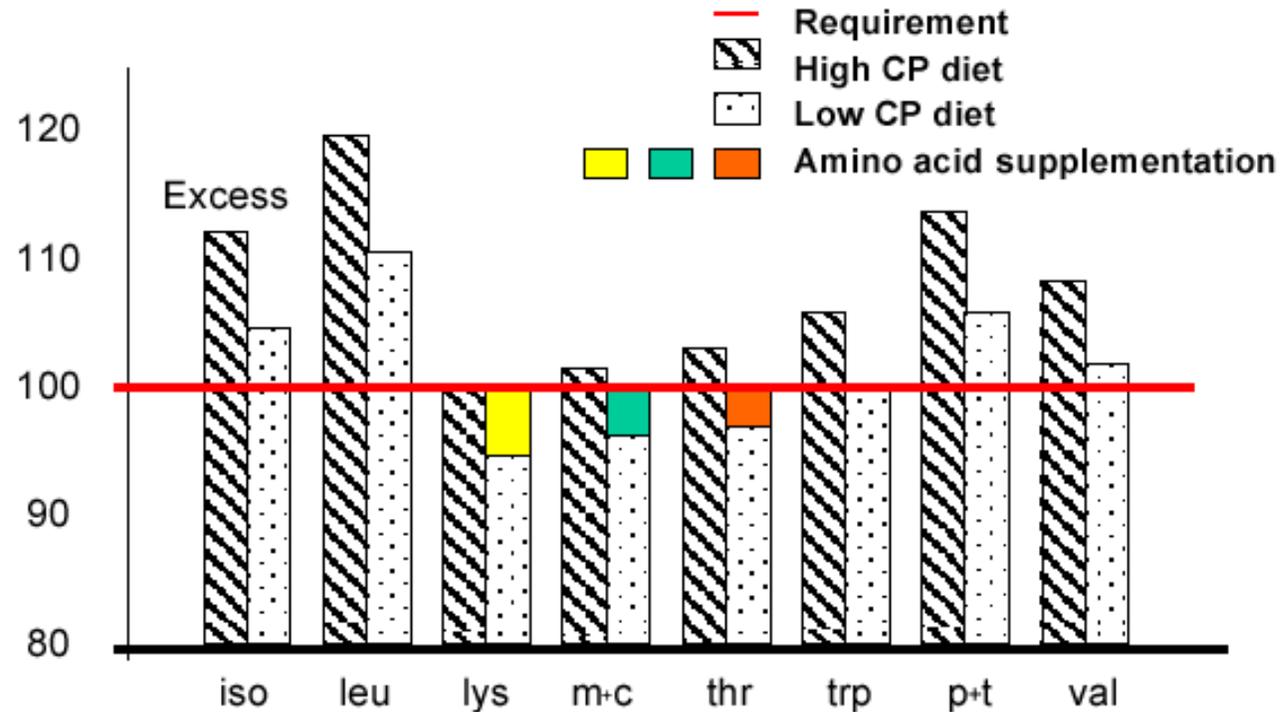
EXAMPLE FOR SWINE: 50-100 KG LW

AA	NRC 2012	Base (%)	+ Lys	+ Met	+ Thr	+Trp	+ Val
Proteina	---	17,84	16,14	15,97	14,96	13,08	12,81
Lisina d	0,81	0,81	0,81	0,81	0,81	0,81	0,81
Metionina d	0,23	0,25	0,23	0,23	0,23	0,23	0,23
Treonina d	0,50	0,57	0,51	0,50	0,50	0,50	0,50
Triptofano d	0,14	0,19	0,16	0,15	0,14	0,14	0,14
Valina d	0,53	0,76	0,68	0,67	0,62	0,53	0,53
Isoleucina d	0,43	0,68	0,60	0,59	0,54	0,44	0,43

CHANGE IN DIET FORMULATION

AA aggiunti	Base (%)	+ Lys	+ Met	+ Thr	+Trp	+ Val
Mais	55,0	55,0	55,0	55,0	55,0	55,0
Soia f.e. 47	24,2	20,0	19,0	16,2	10,9	10,0
Orzo	9,5	21,2	17,0	30,0	28,2	30,0
Crusca	7,0	---	4,5	3,4	1,0	---
Grasso	2,0	1,40	2,0	2,0	2,0	2,0
Lisina	---	0,14	0,16	0,25	0,42	0,45
Metionina	---	---	0,01	0,02	0,06	0,07
Treonina	---	---	---	0,04	0,12	0,13
Triptofano	---	---	---	---	0,03	0,03
Valina	---	---	---	---	---	0,01
Sali, vitamine	2,3	2,3	2,3	2,3	2,3	2,3
Totale	100	100	100	100	100	100

SIMILAR APPROACH FOR RUMINANTS BUT…

Optimizing, first the production of rumen microbic protein (nitrogen and energetic balancing of the diet), after applying the concept of Ideal Protein to gut level
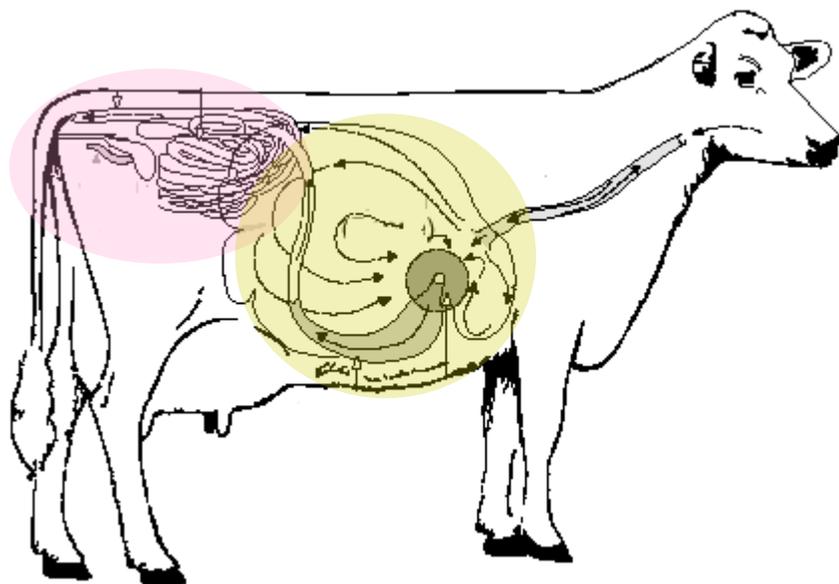
Rumen microorganism synthetize microbic protein (MP) and several essential aa

The MP has high biological value, AA composition near to the ideal protein and high digestibility

Lysine (L) and methionine (M) are the limiting aa in dairy cattle

Supplement correct ratio L/M: 3:1 protect by rumen degradation

RUMINAL PROTEIN DEGRADATION AND FERMENTABLE ENERGY

Protein metabolism is linked to energetic metabolism; to ruminal level N and fermentable energy are to be consider together
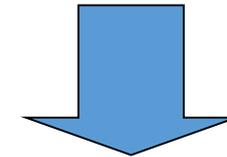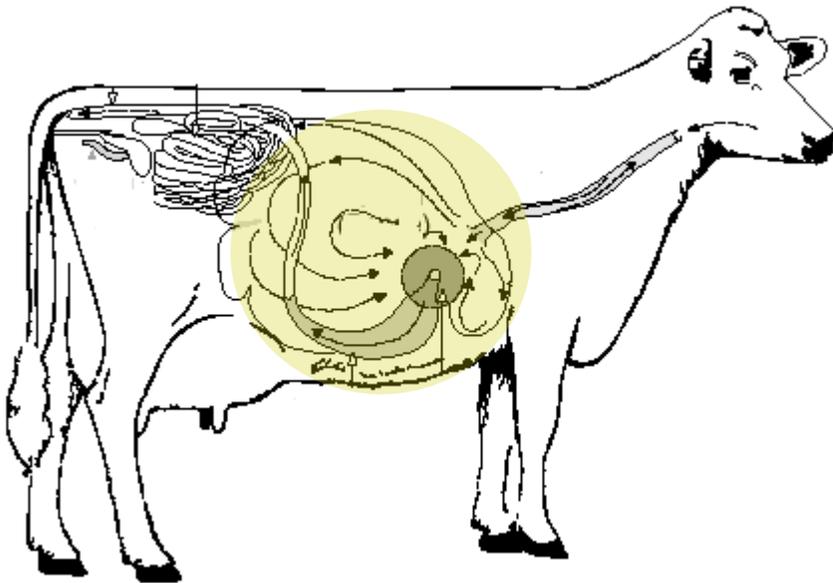
The degradable protein must be balanced and synchronized to energetic availability that depend by the quantity and quality of the diet carbohydrate
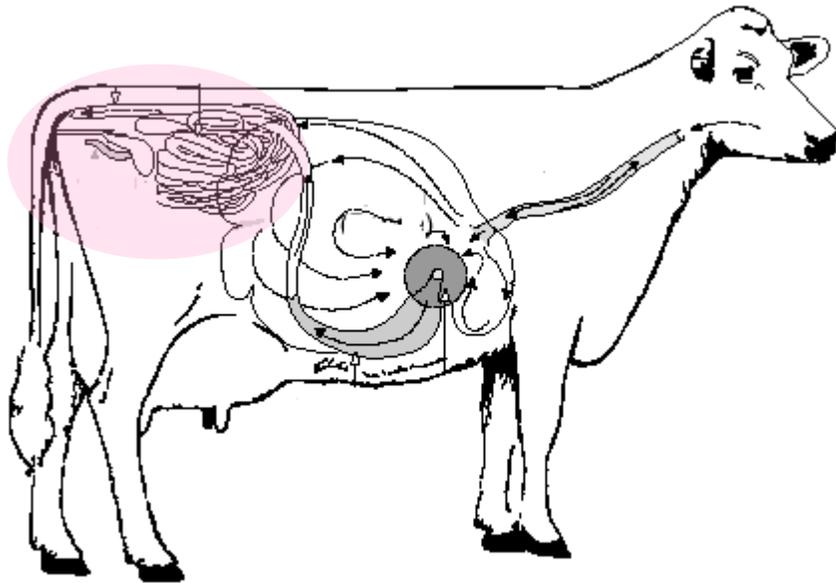
HOW EVALUATE THE DIET BALANCEMENT

Measure the level of the ureic N in the milk (MUN) or in the blood that are linked to the diet content of energy and N

High production cows
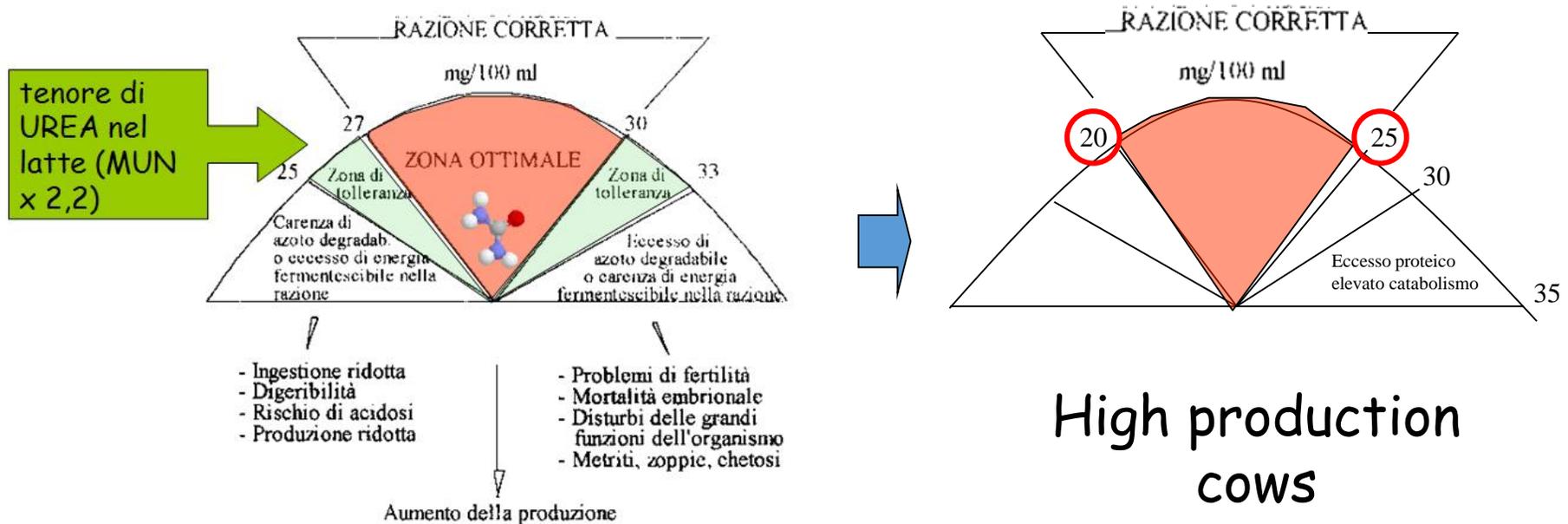
COW ESSENTIAL AMINO ACIDS

arginine, histidine, isoleucine, leucine, lysine, methionine (+cystine), phenylalanine (+tyrosine), Threonine, tryptophan, valine

Most feeds show insufficient levels of methionine and/or lysine relative to milk or microbial protein (beware of corn and soy based diets)
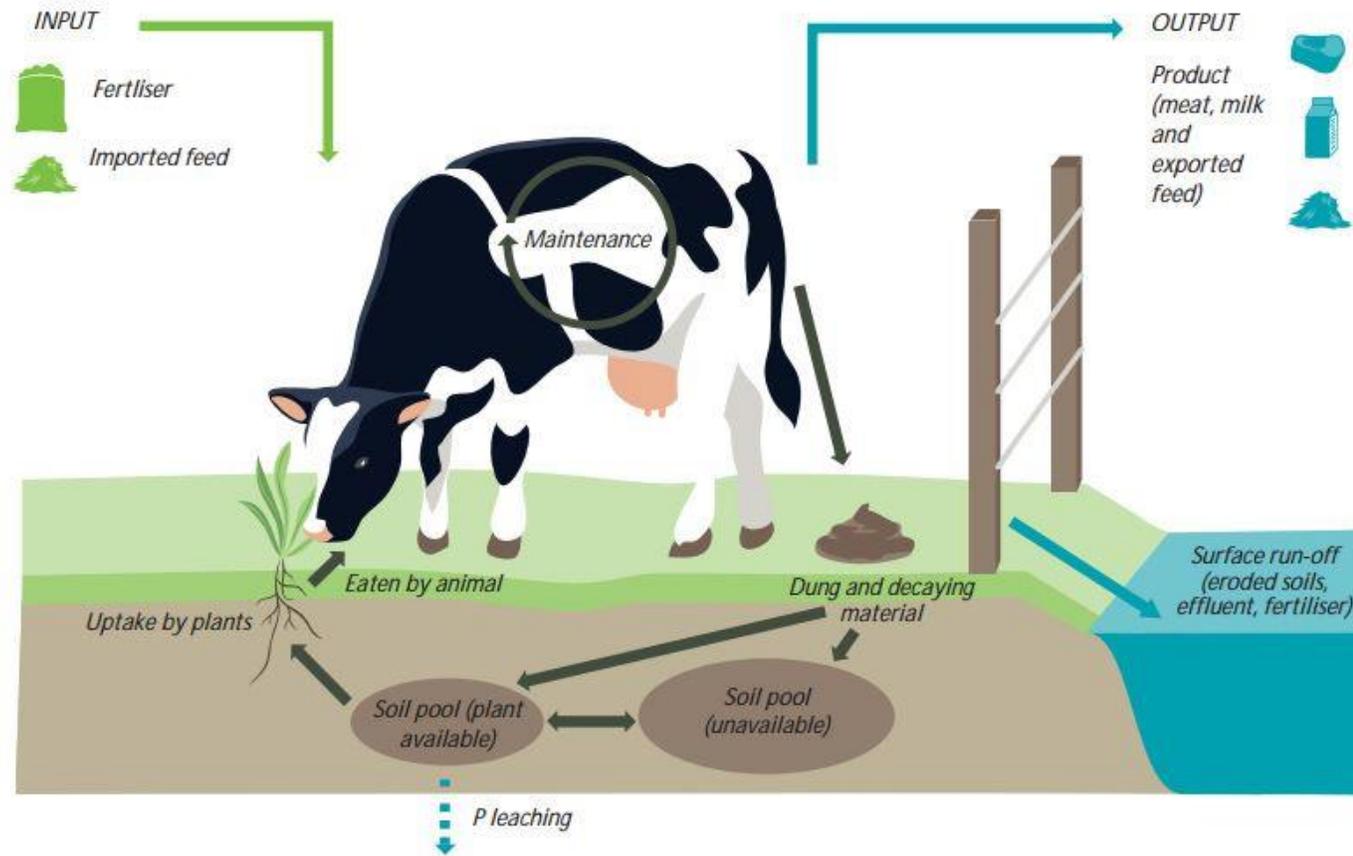
Lysine (L) and methionine (M) are the limiting aa in dairy cattle

Supplement correct ratio L/M: 3:1 protect by rumen degradation

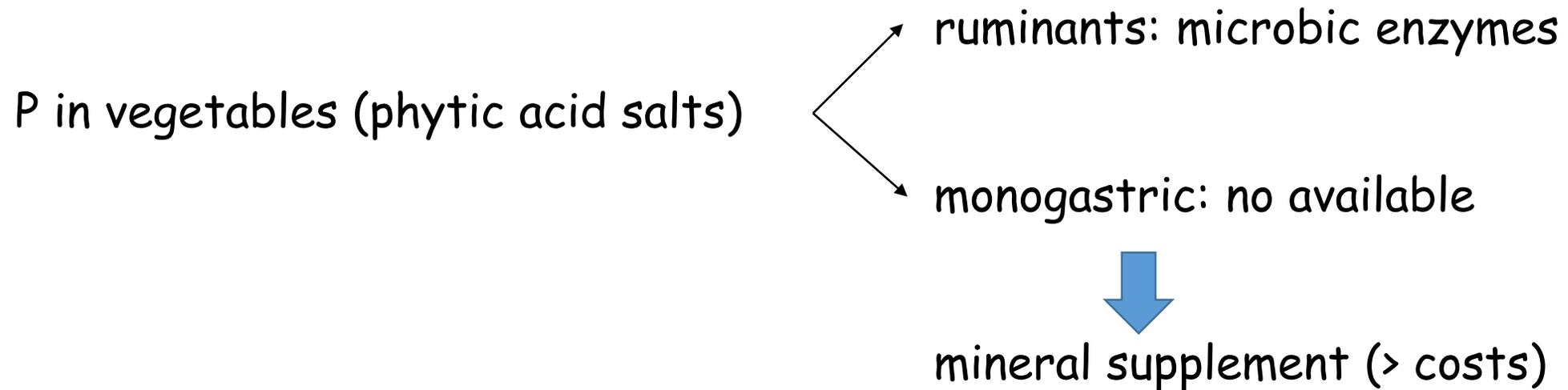# REDUCTION OF PHOSPHOROUS EXCRETIONS


Simplified phosphorus cycle

PHOSPHOROUS IN LIVESTOCK FEEDS

P is an essential element in animal nutrition so is often supplemented in excess (over requirements)

In vegetables is in phytic form (70%)

P in vegetables (phytic acid salts)

ruminants: microbic enzymes

monogastric: no available

mineral supplement (> costs)

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PHYTIC P AVALABILITY: ENZIME PHYTASE

Phytate are not digestible because the animal do not produce the enzyme phytase

(InsP6 = inositolo esafosfato)
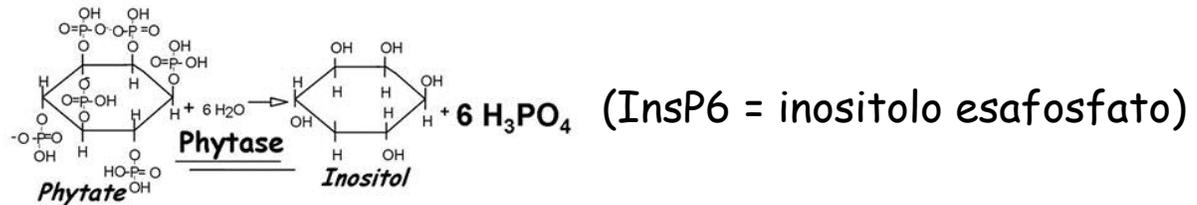
The enzymes phytase are produced by vegetables and microrganism (also by the rumen microbes)
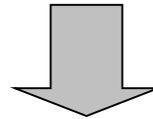
Less problem for the ruminants

IMPROVING P DIGESTIBILITY IN MONOGASTRICS

Addition of synthesized phytase, produced from mycetes
(particularly *Aspergillus ficuum, A. niger A. oryzae, Saccharomyces cerevisiae, Peniophora lycii*) and bacterium (*E. coli*)
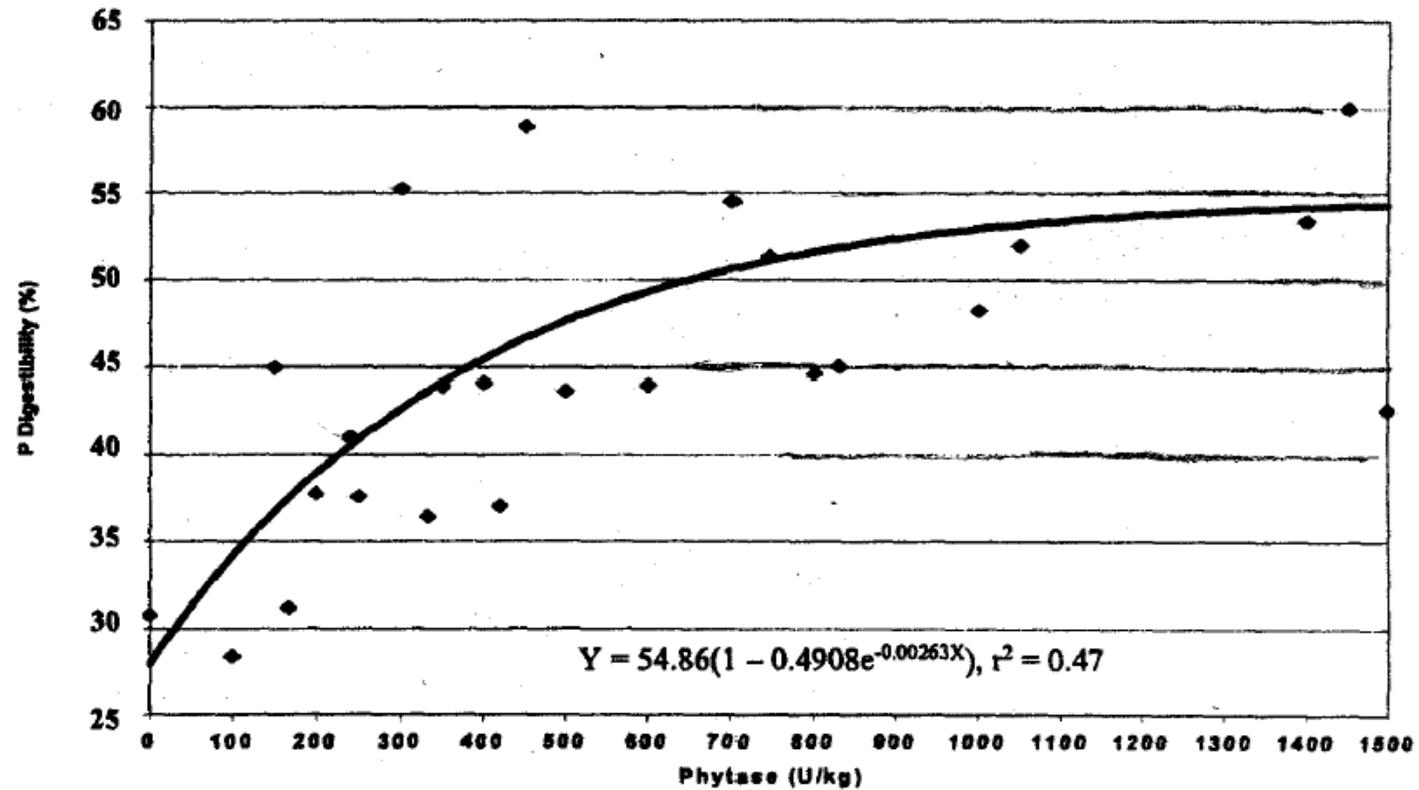
The commercial phytase acts at two pH level:

5,5 e 2,5

It is possible increase P digestibility up to 65%

IMPROVING P DIGESTIBILTY

$$Y = 54.86(1 - 0.4908e^{-0.00263X}), r^2 = 0.47$$

Kornegay (1998)

DIET ACTIONS

REDUCTIONS OF GASEOUS EMISSIONS

METHANE: RUMINANTS VS MONOGASTRIC

EMISSION FACTOR
(kg CH_4/head/year)
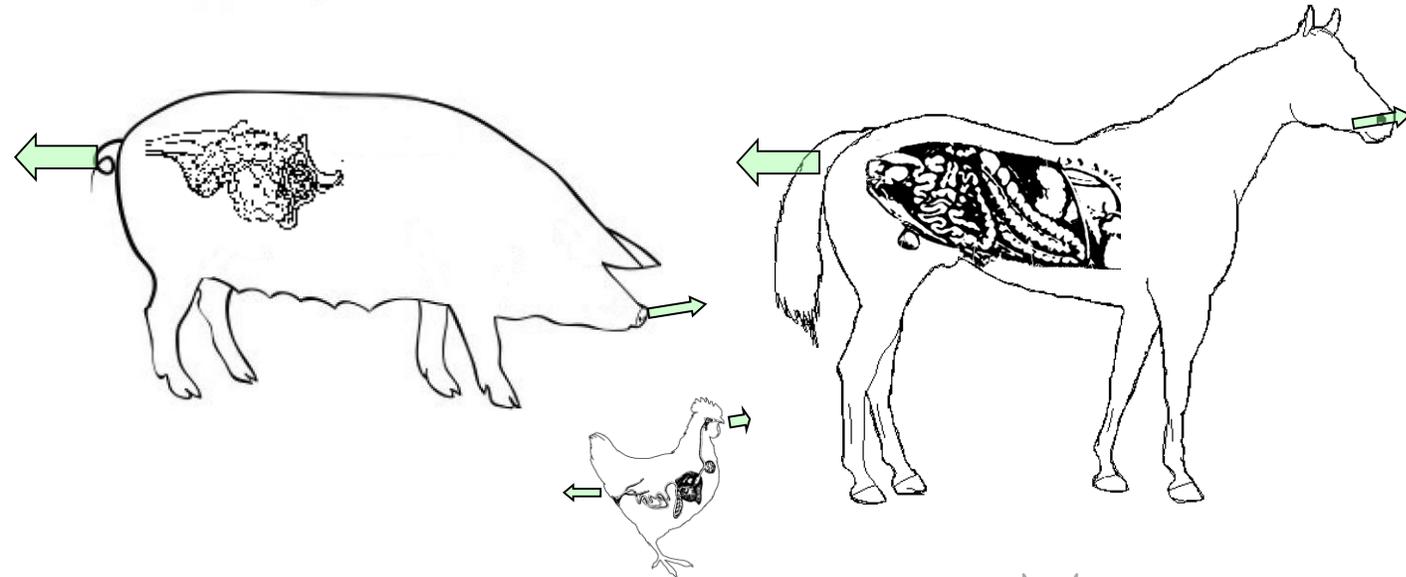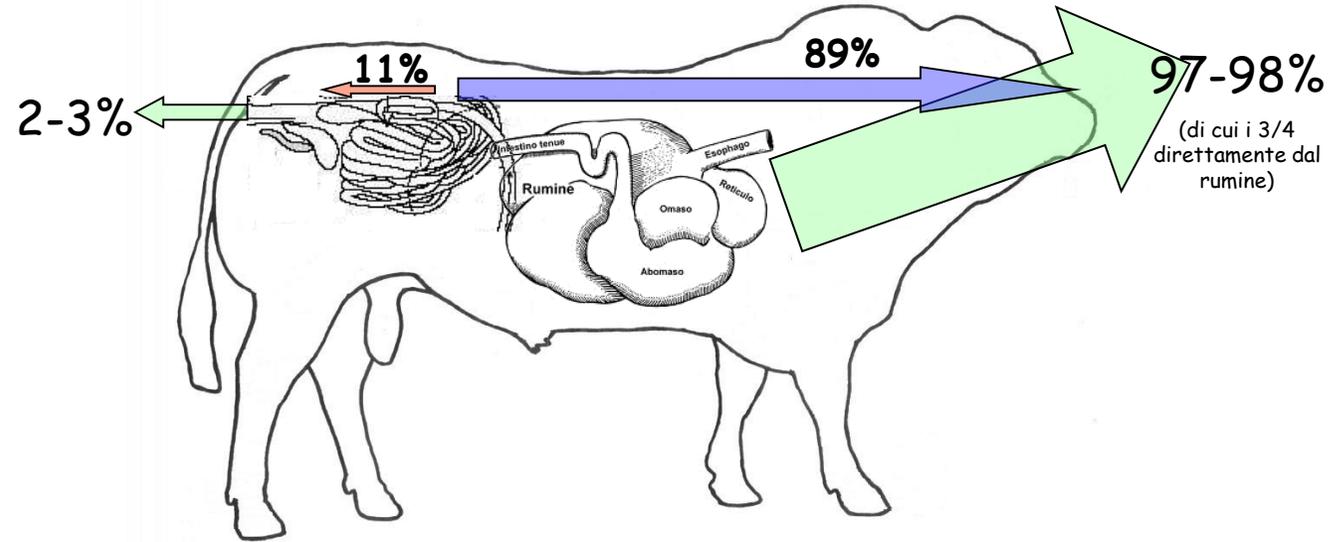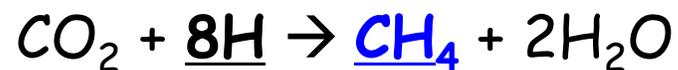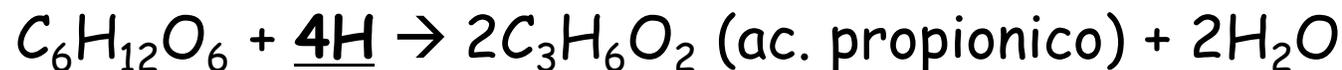
Dairy cows

120-130

Beef cattle

50-60

Horse

15-20

Swine

1-2

Poultry

0,01-0,02

11%

89%

2-3%

97-98%
(di cui i 3/4 direttamente dal rumine)

Intestino tenue · Esophago · Rumine · Reticulo · Omaso · Abomaso

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METHANOGENESIS

GLUCOSIO $\longrightarrow$ FERM. MICROBICA = AGV + ANID. CARB. + H + ALTRO

$$C_6H_{12}O_6 + 2H_2O \rightarrow 2C_2H_4O_2 \text{ (ac. acetico)} + 2\,CO_2 + \underline{\mathbf{8H}}$$

$$C_6H_{12}O_6 + \underline{\mathbf{4H}} \rightarrow 2C_3H_6O_2 \text{ (ac. propionico)} + 2H_2O$$

$$C_6H_{12}O_6 \rightarrow C_4H_8O_2 \text{ (ac. butirrico)} + 2CO_2 + \underline{\mathbf{4H}}$$

$$CO_2 + \underline{\mathbf{8H}} \rightarrow \underline{CH_4} + 2H_2O$$
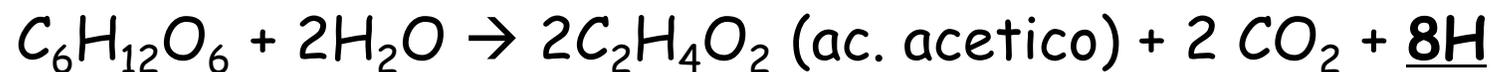
AGV e gas:	ac. acetico (65-75%)	
(vacca da latte)	ac. propionico (15-20%)	CO_2, CH_4 (500-700l/d)
	ac. butirrico (10%)	

DIAGRAM OF THE PATHWAYS LEADING TO METHANOGENESIS
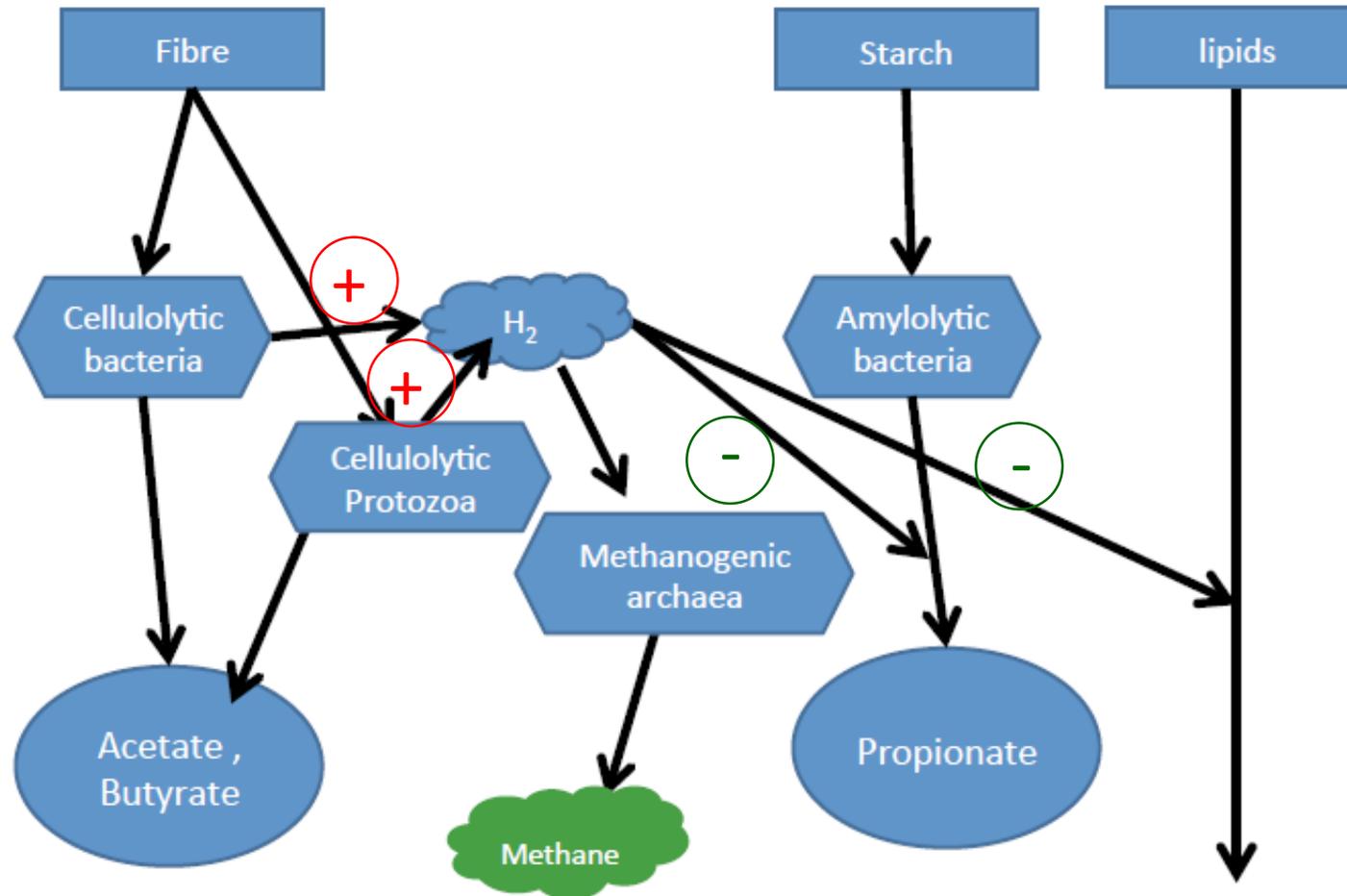
METHANOGENESIS REDUCTION: DIET STRATEGIES

Strategy	Effect	Availability
Fiber quality	++	YES
Concentrate/Forage	++	YES
Incr. performance	+/+++	YES
Diet quality	++	YES
Feeding techniques	++	YES
Fermentation velocity	++/+++	YES
Supplementation	+/++	YES
Protozoa reduction	++/+++	NO
Inhibitory substances	++++	at the moment NO
3-nitro-ossi-propanolo	++++	YES
Ionophore substances	+	in EU NO
Electron receptor	+/++++	YES /NO
Promot. ac. propionic	+	YES
Sobst. bioactive	++	YES (suini?)
Fatty acids	+++	YES
Probiotics	+	YES

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METHANOGENESIS REDUCTION: DIET SUPPLEMENTATION

Strategy	Effect	Availability
Fiber quality	++	YES
Concentrate/Forage	++	YES
Incr. performance	+/+++	YES
Diet quality	++	YES
Feeding techniques	++	YES
Fermentation velocity	++/+++	YES
Supplementation (urea, salts)	+/++	YES
Protozoa reduction	++/+++	NO
Inhibitory substances*	++++	at the moment NO
3-nitro-ossi-propanolo	++++	YES
Ionophore substances	+	in EU NO
Electron receptor	+/++++	YES /NO
Promot. ac. propionic	+	YES
Sobst. bioactive	++	YES (suini?)
Fatty acids	+++	YES
Probiotics	+	YES
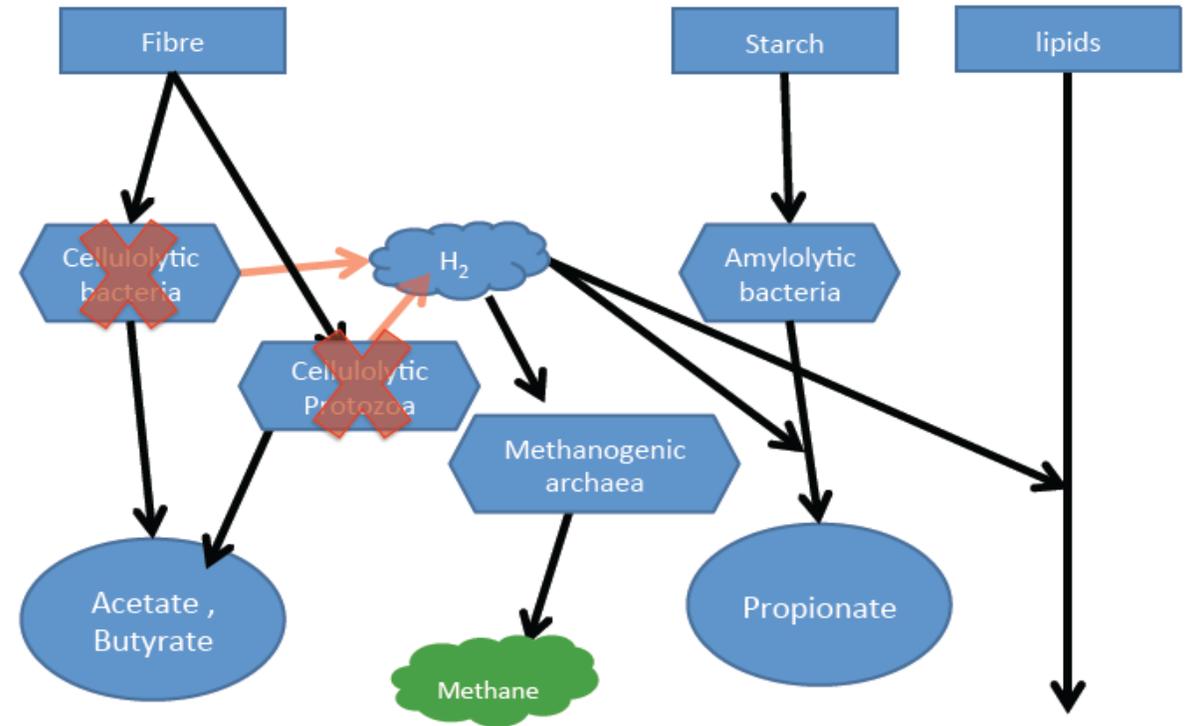
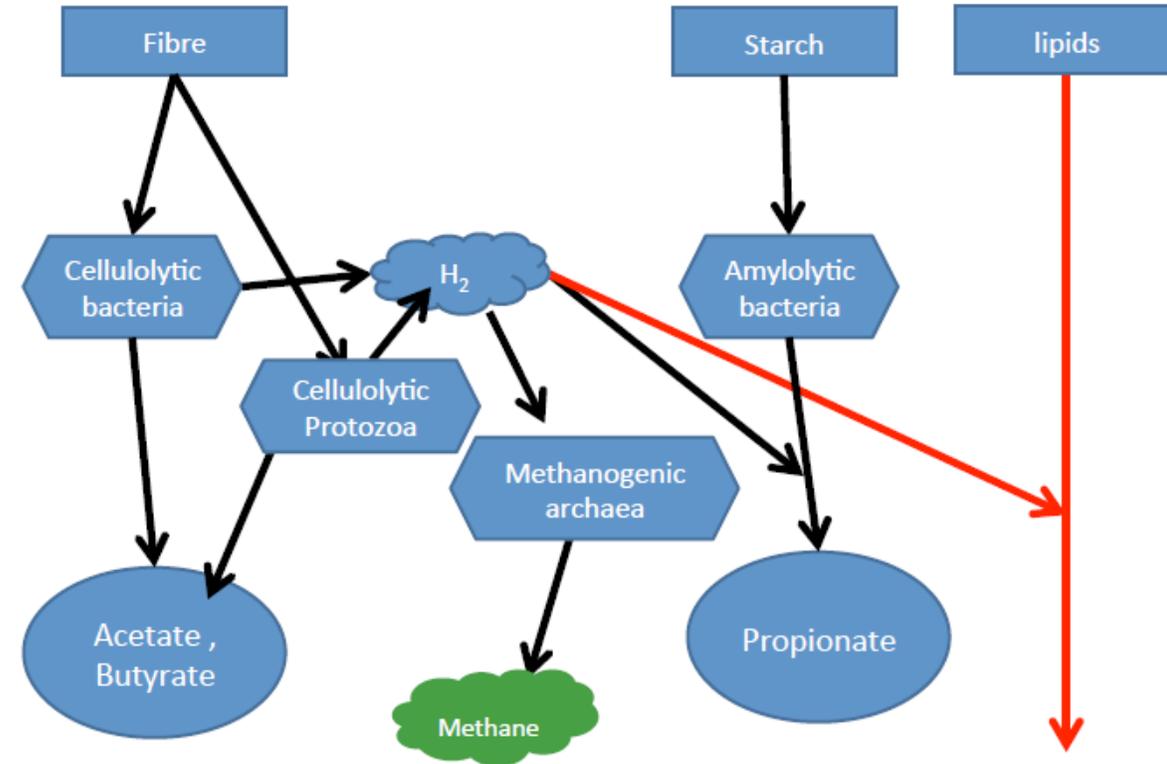* bromoclorometano, 2-bromo-etano solfonato, cloroformio, ciclodestrine, etc.

METHANOGENESIS REDUCTION:
METHANOGEN BACTERIA INIBITION

Strategy	Effect	Availability
Fiber quality	++	YES
Concentrate/Forage	++	YES
Incr. performance	+/+++	YES
Diet quality	++	YES
Feeding techniques	++	YES
Fermentation velocity	++/+++	YES
Supplementation	+/++	YES
Protozoa reduction	++/+++	NO
Inhibitory substances	++++	at the moment NO
3-nitro-ossi-propanolo	++++	YES
Ionophore substances	+	in EU NO
Electron receptor	+/++++	YES /NO
Promot. ac. propionic	+	YES
Sobst. bioactive	++	YES (suini?)
Fatty acids	+++	YES
Probiotics	+	YES

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METHANOGENESIS REDUCTION:
FATTY ACIDS SUPPLEMENTATION

Strategy	Effect	Availability
Fiber quality	++	YES
Concentrate/Forage	++	YES
Incr. performance	+/+++	YES
Diet quality	++	YES
Feeding techniques	++	YES
Fermentation velocity	++/+++	YES
Supplementation	+/++	YES
Protozoa reduction	++/+++	NO
Inhibitory substances	++++	at the moment NO
3-nitro-ossi-propanolo	++++	YES
Ionophore substances	+	in EU NO
Electron receptor	+/++++	YES /NO
Promot. ac. propionic	+	YES
Sobst. bioactive	++	YES (suini?)
Fatty acids	+++	YES
Probiotics	+	YES

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GENETIC IMPROVEMENT STRATEGIES

REDUCTIONS OF NUTRIENT AND GASES RELEASE

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UP FARMING Torino, April 2023

GENETIC ACTIONS

Indirectly

Increasing the efficiency of the animals

Directly

Towards specific genetic selection

IMPROVEMENT OF THE PRODUCTION EFFICIENCY

Genetic improvement aims to increase the efficiency of the animals, as the ratio between unit of feed ingested and unit of animal product (food) obtained
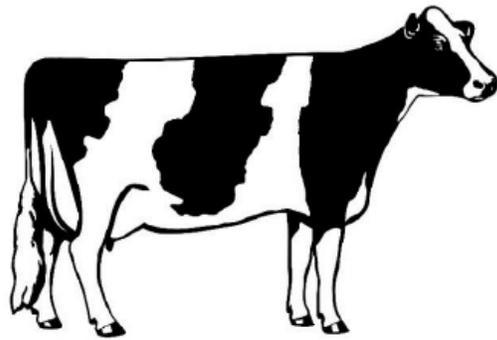
More product units are obtained from a single animal, greater is the efficiency because the impacts are distributed over a greater quantity of product

SELECTED BREEDS vs NON SELECTED BREEDS
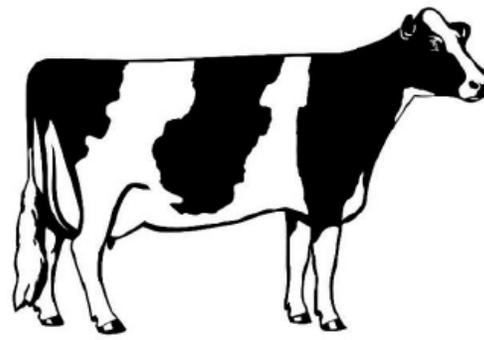
-20% CH_4 Emissions
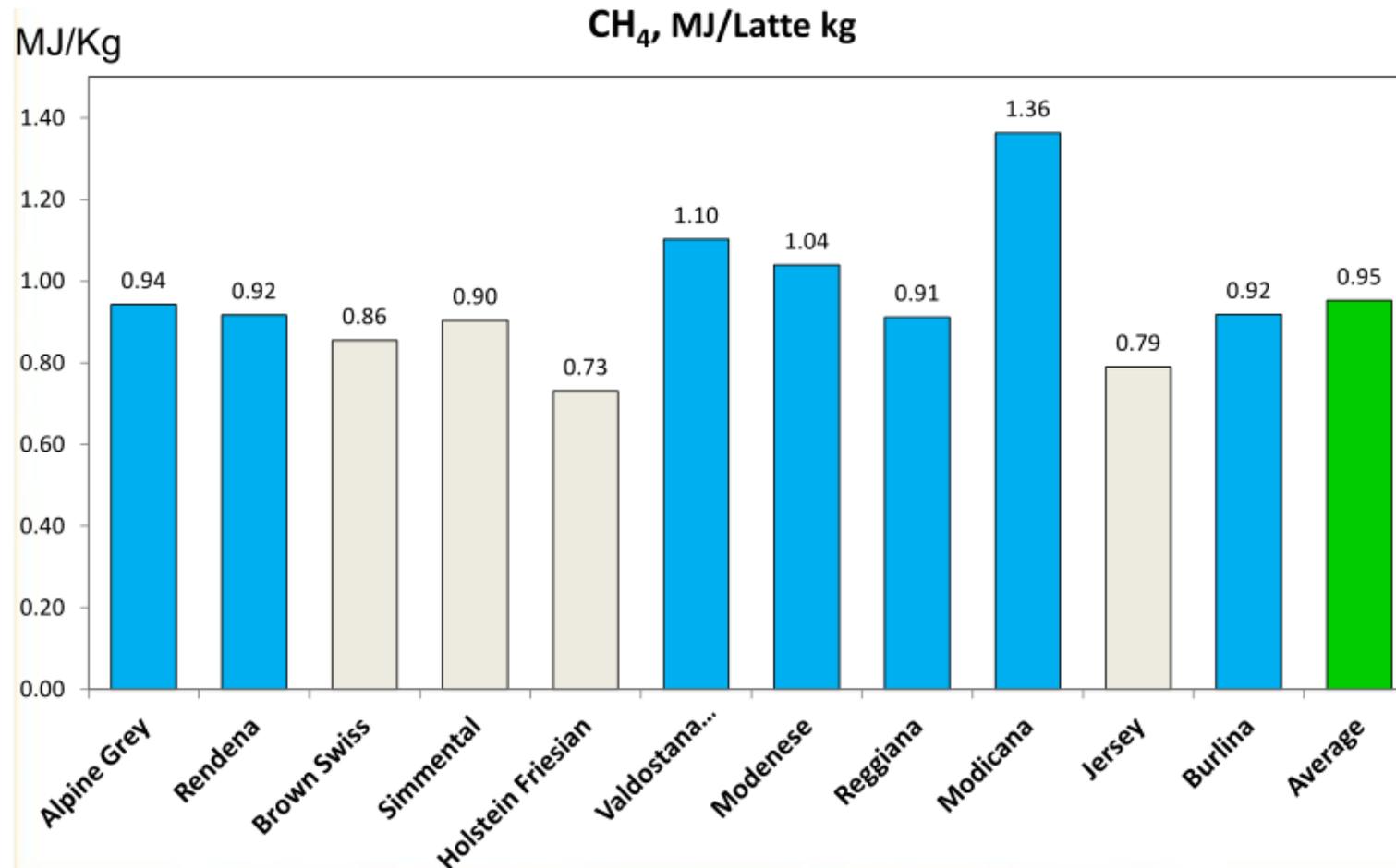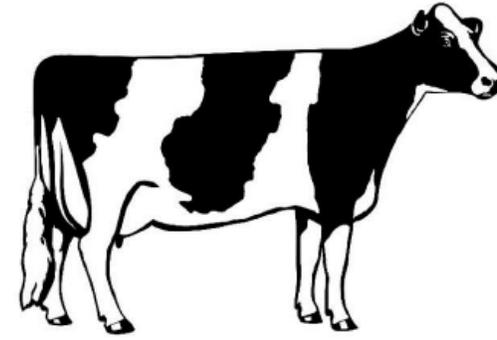
PRODUCTIVE EFFICIENCY IMPROVEMENT: EFFECT ON N EXCRETION

40 kg milk/day

20 kg milk/day   20 kg milk/day

99 kg N to soil/year
(7,8 g N to soil/kg milk)

157 kg N to soil/year (+59%)
(12,7 g N to soil/kg milk)

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PRODUCTIVE EFFICIENCY IMPROVEMENT: EFFECT ON CH$_4$ EMISSIONS

40 kg latte/d
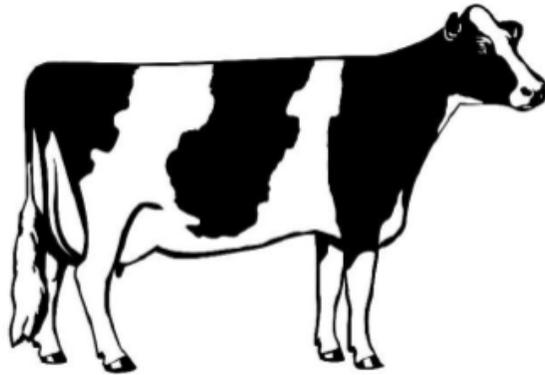
20 kg latte/d   20 kg latte/d

148 kg metano/anno
(11,7 g CH$_4$/kg latte)
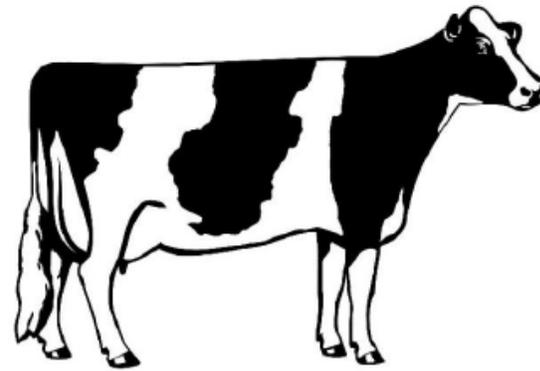
234 kg metano/anno (+58%)
(18,6 g CH$_4$/kg latte)

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UP FARMING Torino, April 2023
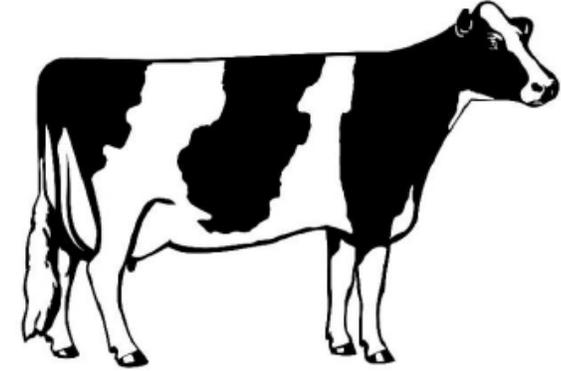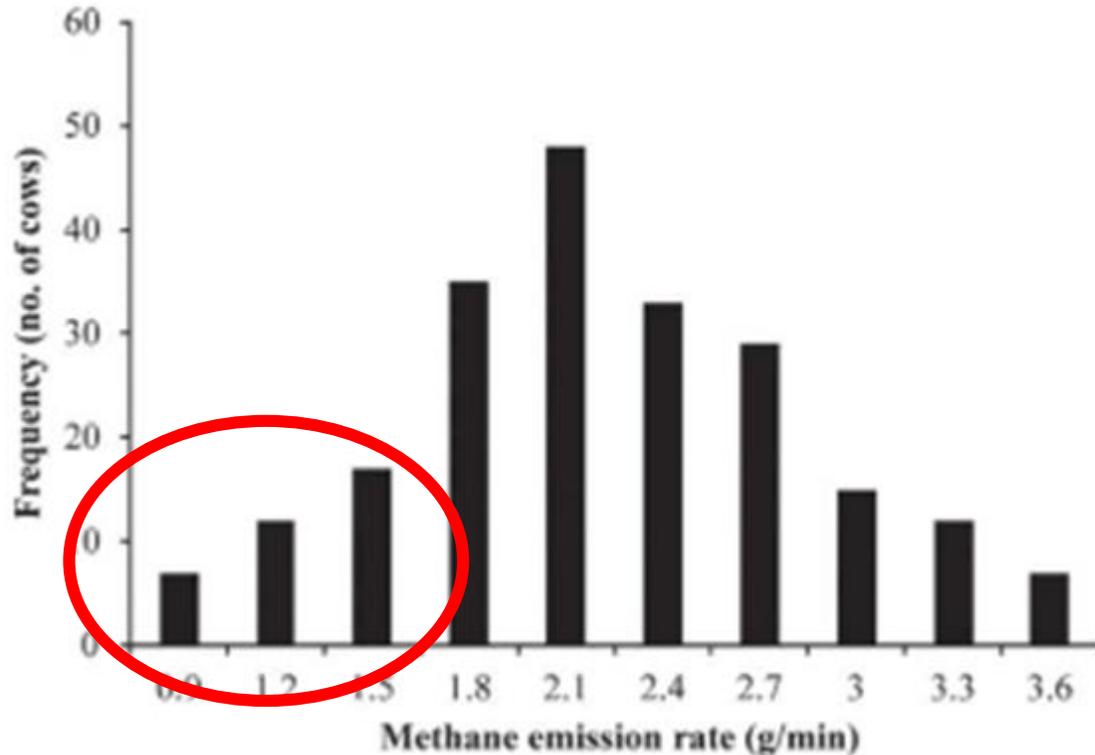
PRODUCTIVE EFFICIENCY IMPROVEMENT: EFFECT ON GWP

% variation in gases emission due to genetic improvement (UK – 1988-07):

	CH_4	NH_3	N_2O	GWP_{100}
Laying hens	-30	-36	-29	-25
Broilers	-20	-10	-23	-25
Pigs	-17	-18	-14	-15
Dairy cows	-25	-17	-30	-16

SELECTION FOR LOW EMISSIONS

Selecting for reproduction the animals with low emissions it is possible improve the presence of this character into the cattle population

METHANE EMISSIONS MEASUREMENT

Metodo	Accuratezza*	Rif. Bibl.
Camera respiratoria	1.00	Place et al., 2011
Head hoods	0.96	Place et al., 2011
Tecnica del tracciante SF6	0.83	Munoz et al., 2012
Green Feeder	0.89	De Haas et al., 2012
Detector laser	0.80	Chagunda e Yan, 2011
Metodi all'infrarosso (FTIR)	0.89	Garnsworthy et al., 2012

* Rispetto alla camera respiratoria

Buona accuratezza, ma misurabile su pochi animali e in pochi studi

Respiration chamber Golden standard!

Head hoods

Laser

GreenFeeder

FTIR

SF6

PHENOTYPE CORRELATED TO CH$_4$ EMISSIONS

Dry matter inteake and diet characteristics:

Dairy		
	Equation [1d]	CH$_4$ (MJ/d) = 4.08 ($\pm$ 1.32) + 0.0678 ($\pm$ 0.00905) $\times$ ME intake (MJ/d)
	Equation [2d]	CH$_4$ (MJ/d) = 3.23 ($\pm$ 1.12) + 0.809 ($\pm$ 0.0862) $\times$ DMI (kg/d)
	Equation [3d][2]	CH$_4$ (MJ/d) = 8.56 ($\pm$ 2.63) + 0.139 ($\pm$ 0.0563) $\times$ forage (%)
	Equation [4d]	CH$_4$ (MJ/d) = 3.14 ($\pm$ 1.88) + 2.11 ($\pm$ 0.407) $\times$ NDF (kg/d)
	Equation [5d]	CH$_4$ (MJ/d) = 5.87 ($\pm$ 1.77) + 2.43 ($\pm$ 0.556) $\times$ ADF (kg/d)
	Equation [6d]	CH$_4$ (MJ/d) = 1.21 ($\pm$ 2.39) + 0.0588 ($\pm$ 0.0121) $\times$ ME intake (MJ/d) + 0.0926 ($\pm$ 0.0366) $\times$ forage (%)
	Equation [7d]	CH$_4$ (MJ/d) = 1.64 ($\pm$ 1.56) + 0.396 ($\pm$ 0.0170) $\times$ ME intake (MJ/d) + 1.45 ($\pm$ 0.521) $\times$ NDF (kg/d)
	Equation [8d]	CH$_4$ (MJ/d) = 2.16 ($\pm$ 1.62) + 0.493 ($\pm$ 0.192) $\times$ DMI (kg/d) – 1.36 ($\pm$ 0.631) $\times$ ADF (kg/d) + 1.97 ($\pm$ 0.561) $\times$ NDF (kg/d)

Data set	Equation no.	RMSPE%[1]	ECT%[2]	ER%[3]	ED%[4]	R^2
	Moe and Tyrrell (1979b)	41.6	0.0795	38.9	61.0	0.14
	Blaxter and Clapperton (1965)	19.1	12.2	8.59	79.3	0.67
Dairy	Equation [1d]	29.3	6.72	0.62	92.7	0.53
	Equation [2d]	25.6	5.19	3.90	90.9	0.65
	Equation [3d]	20.6	26.3	16.6	57.1	0.56
	Equation [4d]	35.0	12.1	6.06	81.8	0.46
	Equation [5d]	35.4	26.3	16.6	57.1	0.56
	Equation [6d]	37.7	7.62	10.1	82.2	0.38
	Equation [7d]	29.5	8.46	4.36	87.2	0.59
	Equation [8d]	28.2	8.01	5.67	86.3	0.63

Ellis et al., 2007; J. Dairy Sci.

MANAGEMENT ACTIONS

REDUCTIONS OF NUTRIENT AND GASES RELEASE
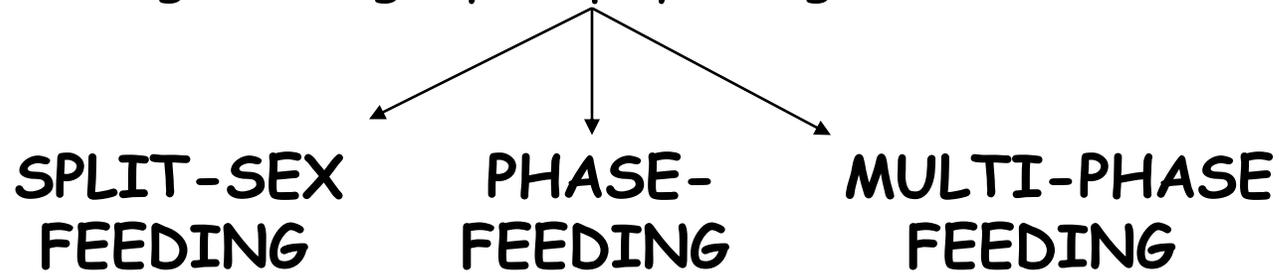
FEEDING SYSTEMS: SPLITTING IN GROUPS

To split the herd into homogeneous groups allow to have similar requirements

Devices, as self-feeder systems, can help the farmer

FEEDING SYSTEMS

It is possible to split the animals according gender, age, category or physiologic status

SPLIT-SEX FEEDING

PHASE-FEEDING

MULTI-PHASE FEEDING

Allows to better adapt the feed to the needs of the different categories of animals reared, in the various stages of growth

SPLIT-SEX FEEDING

Due to the differences induced by sex hormones, dietary feeding requirements changes (ingestion capacity, voracity, metabolic distribution of nutrients)

⬇
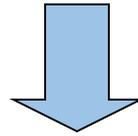
Potential to produce lean meat
male > female > castrated male

Sex hormones also depress ingestion

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SPLIT-SEX FEEDING: THE CASE OF SWINE

Effects of sex on the rate of growth of fattening pigs,
according to the animal live weight

Intervallo peso, kg	Prove, n°	Maschi Castrati	Femmine
25 – 50	8	100,00	91,03
50 – 100	25	100,00	95,12
Oltre 100	13	100,00	100,19

The females, under 100 kg of LW growth less than males and reach the same performance over 100 kg LW

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SPLIT-SEX FEEDING: THE CASE OF SWINE

Effects of sex on ingestion rate

Intervallo peso, kg	Prove, n°	Maschi Castrati	Femmine
25 – 50	8	100,00	91,93
50 – 100	24	100,00	92,26
Oltre 100	8	100,00	89,17

Females compared to males showed, stably, a 10% reduction for ingestion rate

SPLIT-SEX FEEDING: THE CASE OF SWINE

Effects of sex on the conversion rate

Intervallo peso, kg	Prove, n°	Maschi Castrati	Femmine
25 – 50	8	100,00	101,84
50 – 100	24	100,00	97,04
Oltre 100	8	100,00	92,22

Females progressively improve feed conversion as weight increases

SPLIT-SEX FEEDING: THE CASE OF SWINE

Protein deposition in males (♂ dotted line) and females (♀ solid line) in weight range 24-120 kg
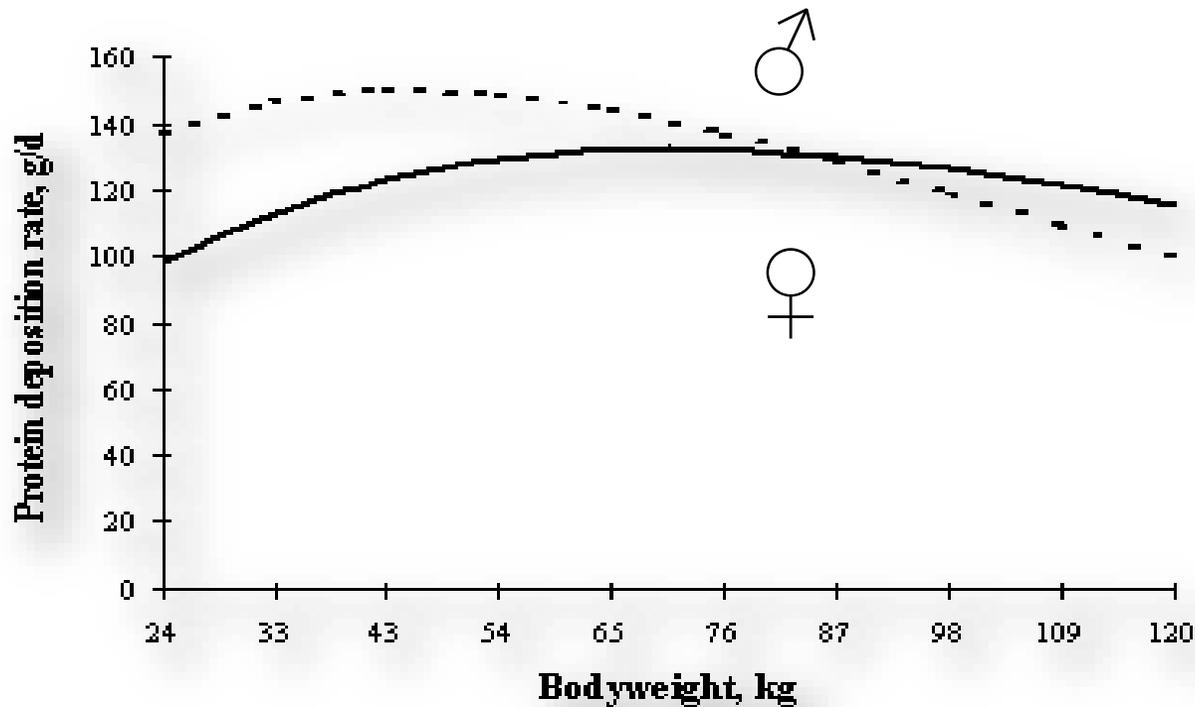
Lorschy e coll., 2005

✓ Females progressively increase the ratio of protein and fat deposition, comapred to the males

✓ Therefore, if at 100 kg differences in carcass composition already emerge, those differences are amplified with increasing weight

PHASE FEEDING

It is based on the principle that nutritional requirements change
with age or physiological stage of the animal

With age:
a) Proportionally increase the maintenance requirements
b) Change growth potential
c) Change the ratio between protein to deposited fats
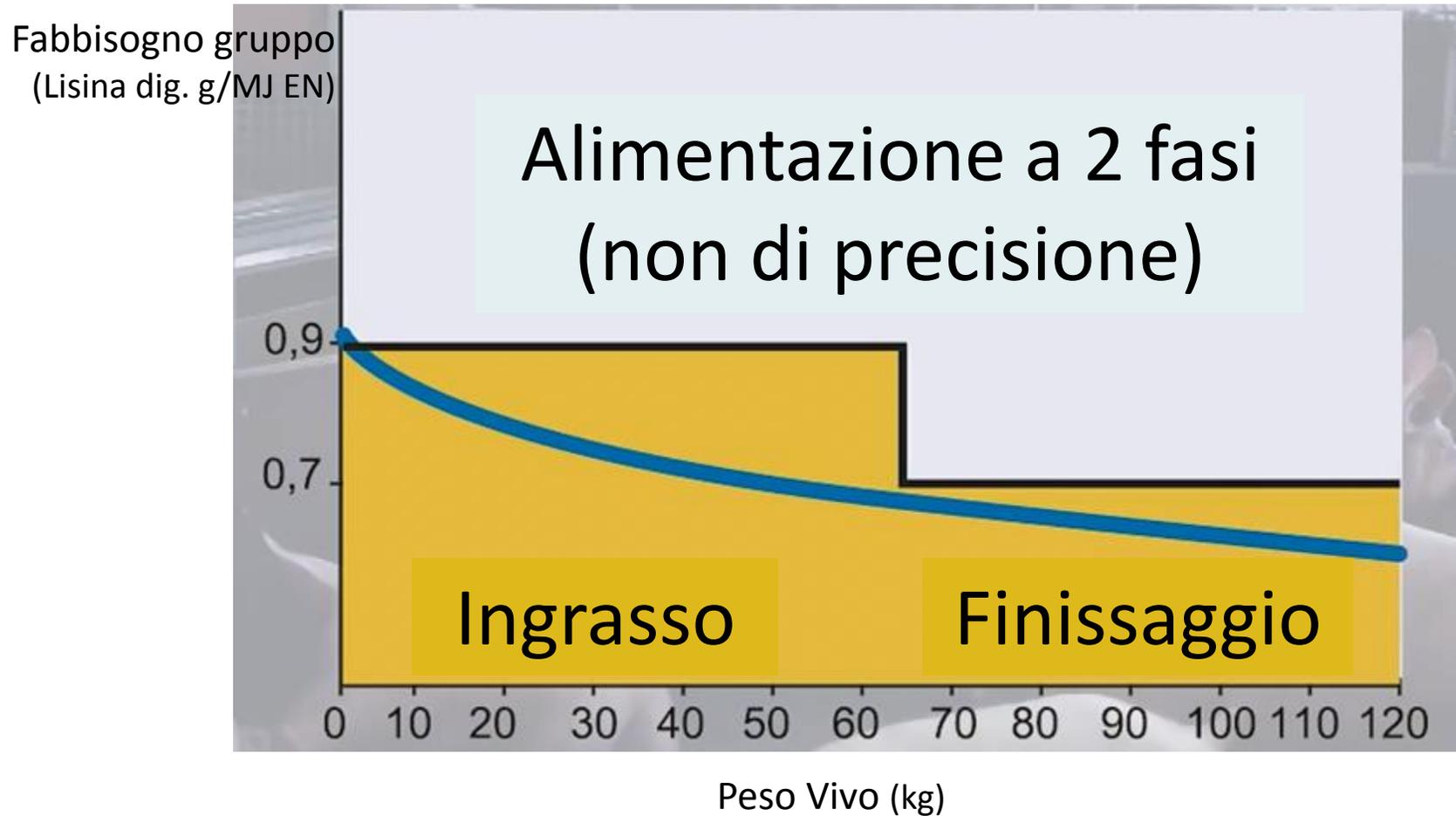d) Increases ingestion capacity

Decrease the amino acids requirement => formulation of diets
with progressively lower protein content
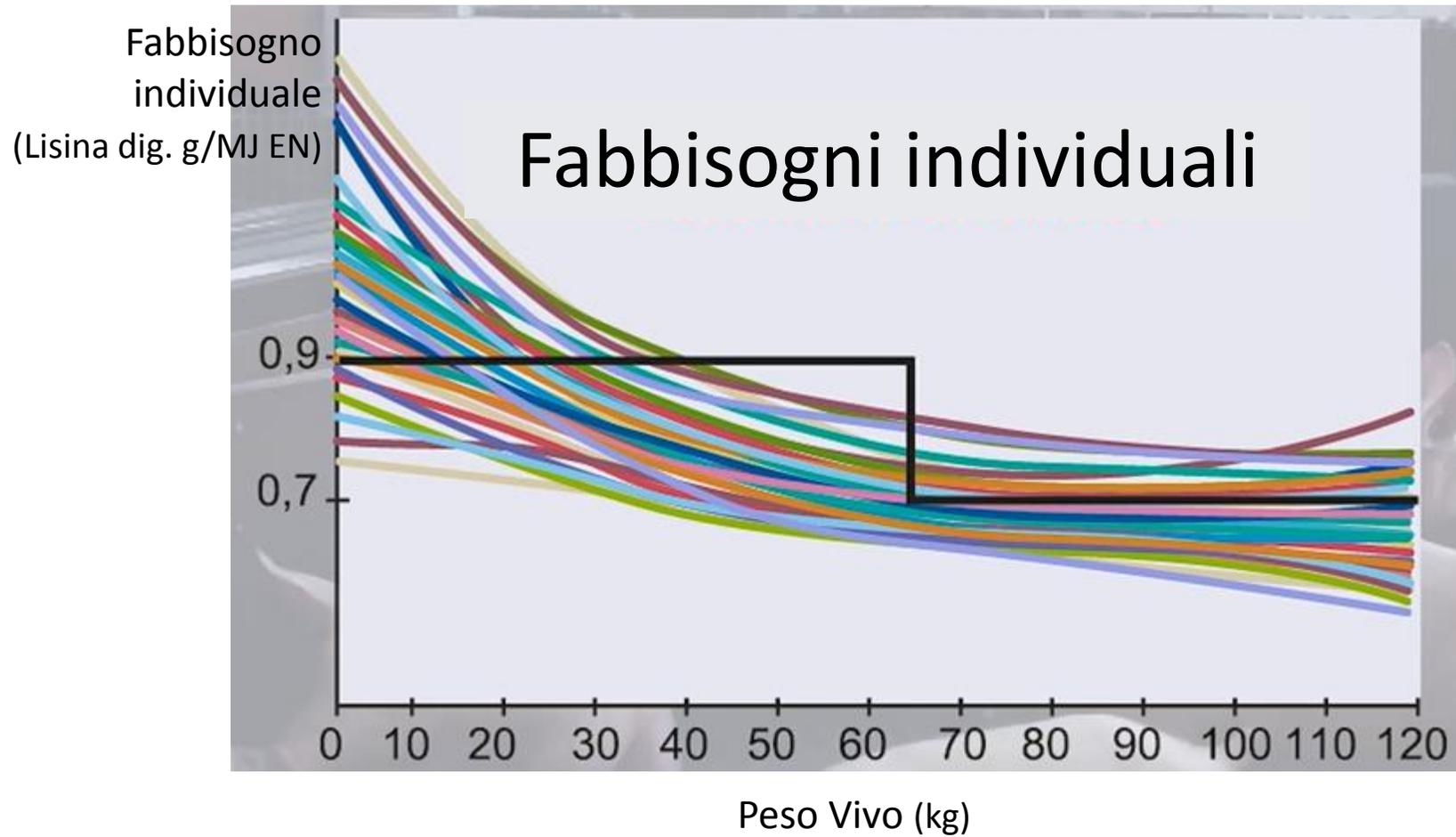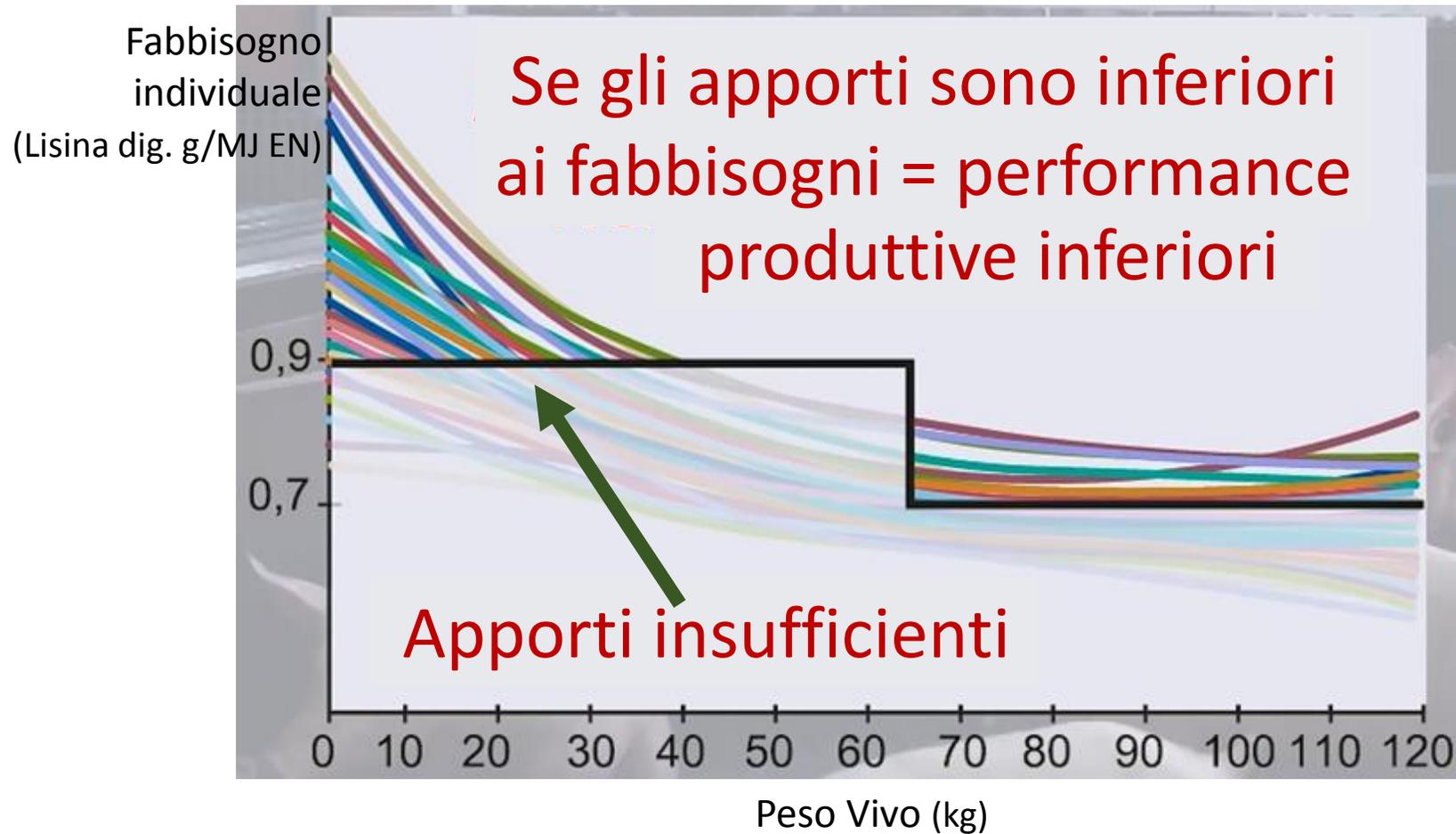Allows fine adjustment among essential aa

PHASE FEEDING
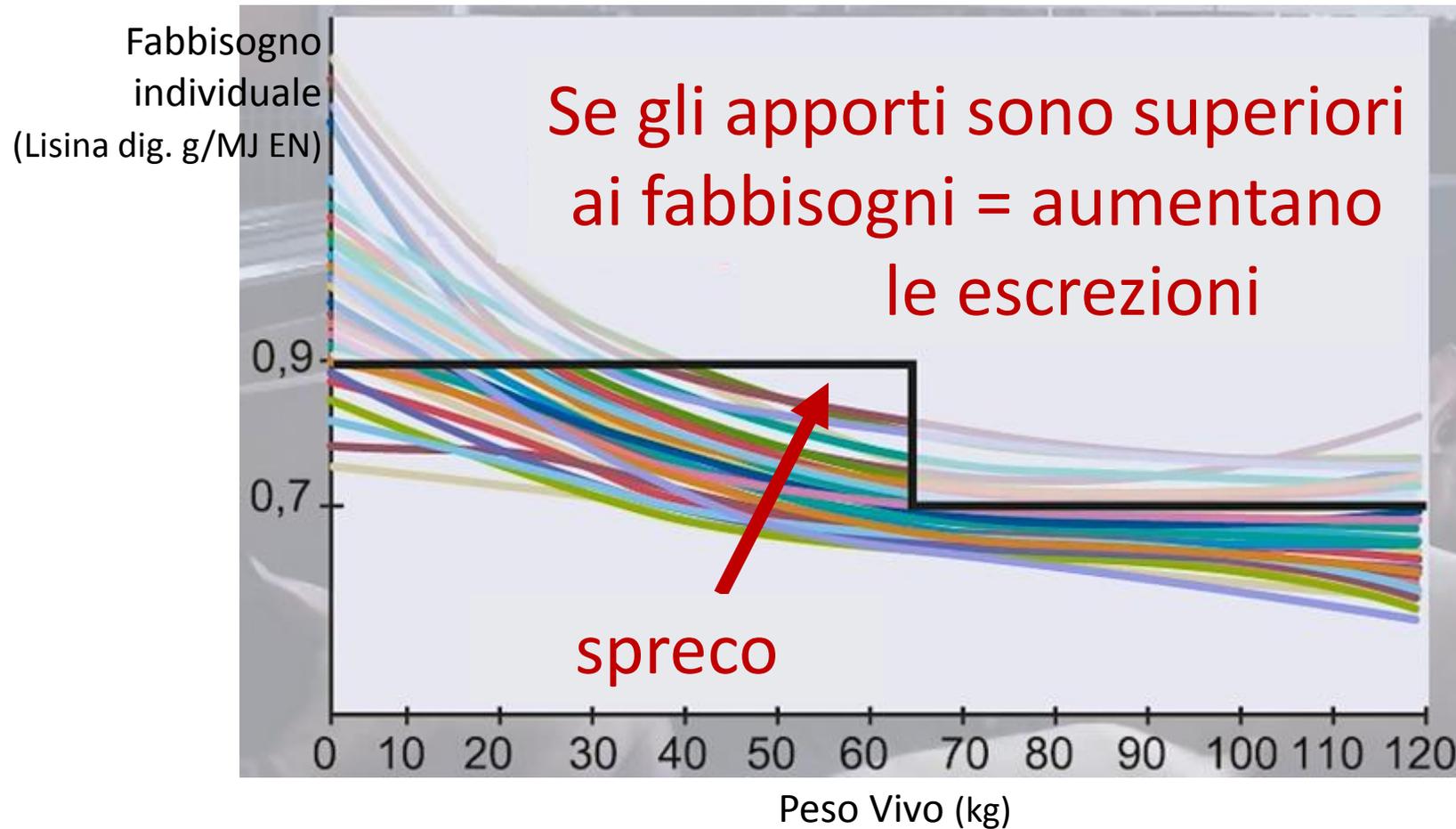
EXAMPLE OF PRECISION FEEDING FOR PIGS

Fabbisogno gruppo
(Lisina dig. g/MJ EN)

Alimentazione a 2 fasi
(non di precisione)

0,9

0,7

Ingrasso   Finissaggio

0 10 20 30 40 50 60 70 80 90 100 110 120

Peso Vivo (kg)

EXAMPLE OF PRECISION FEEDING FOR PIGS

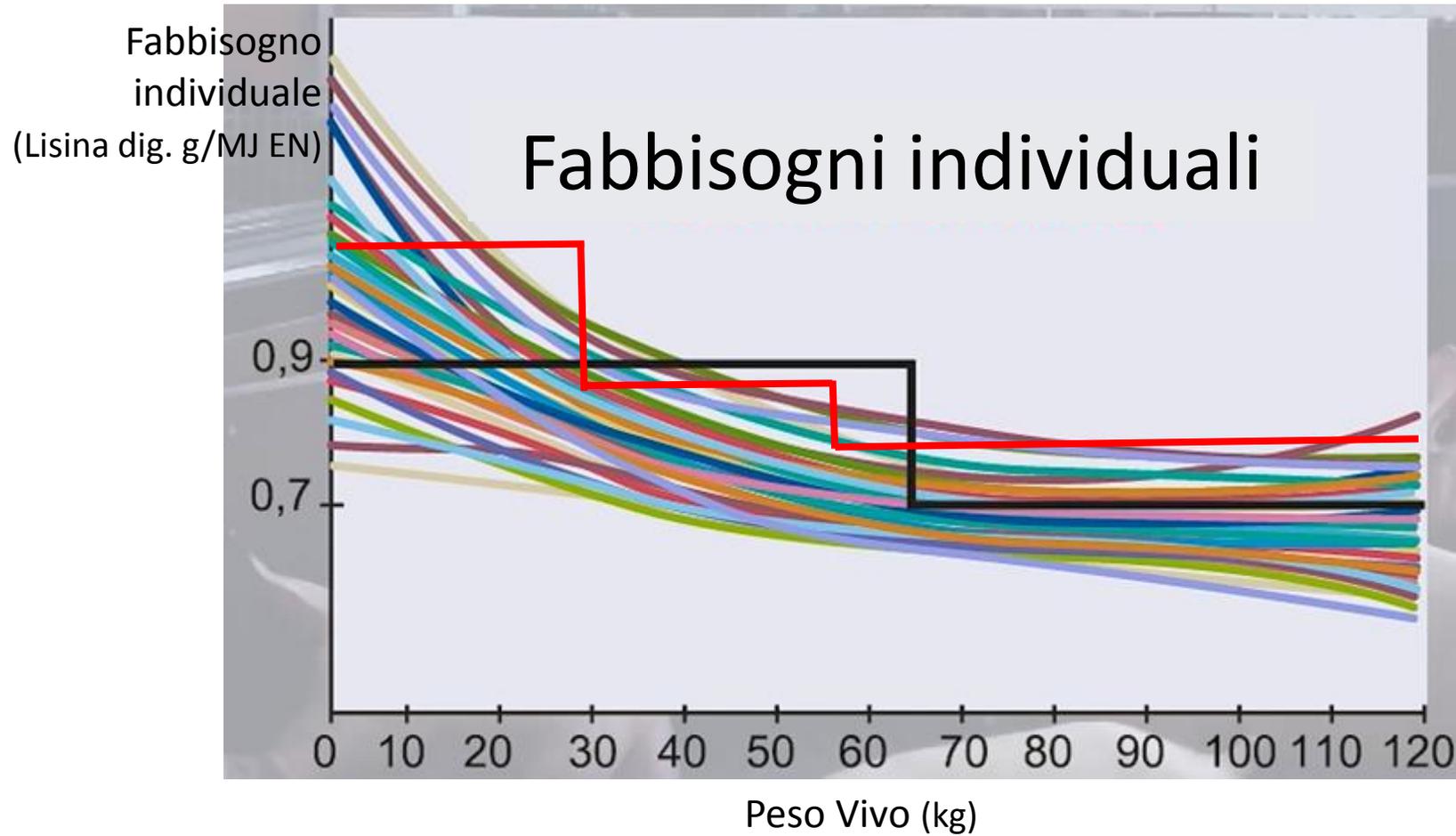Fabbisogno individuale (Lisina dig. g/MJ EN)

Fabbisogni individuali

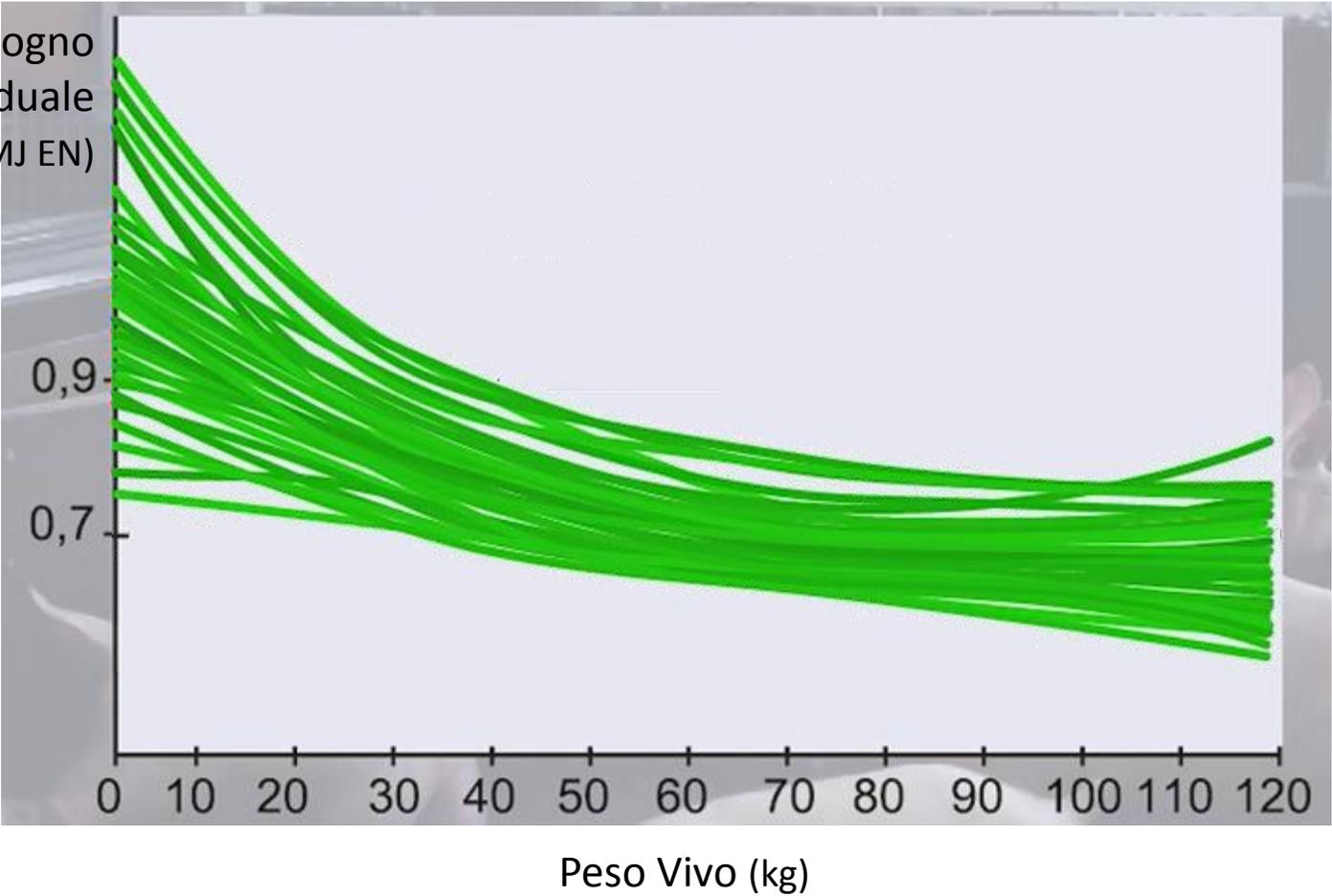Peso Vivo (kg)

EXAMPLE OF PRECISION FEEDING FOR PIGS

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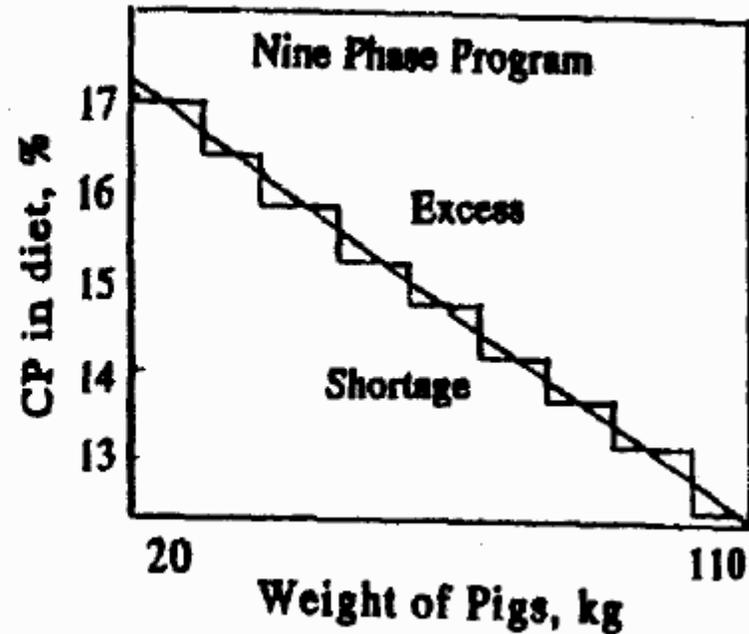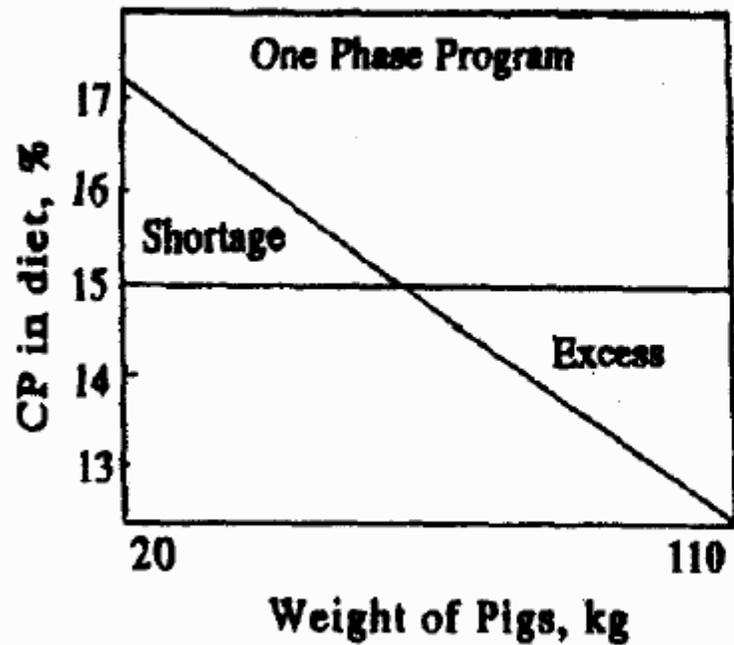
EXAMPLE OF PRECISION FEEDING FOR PIGS
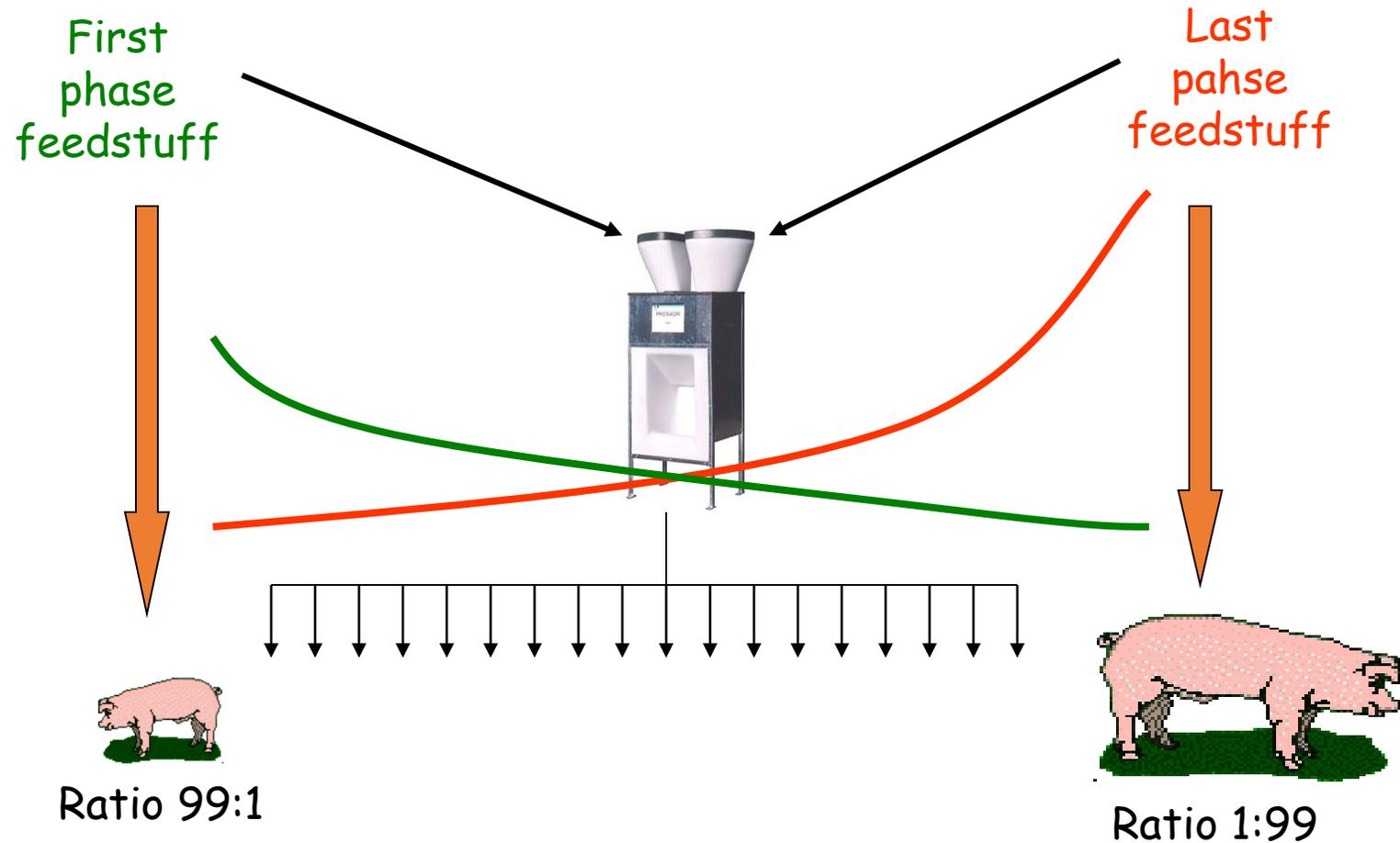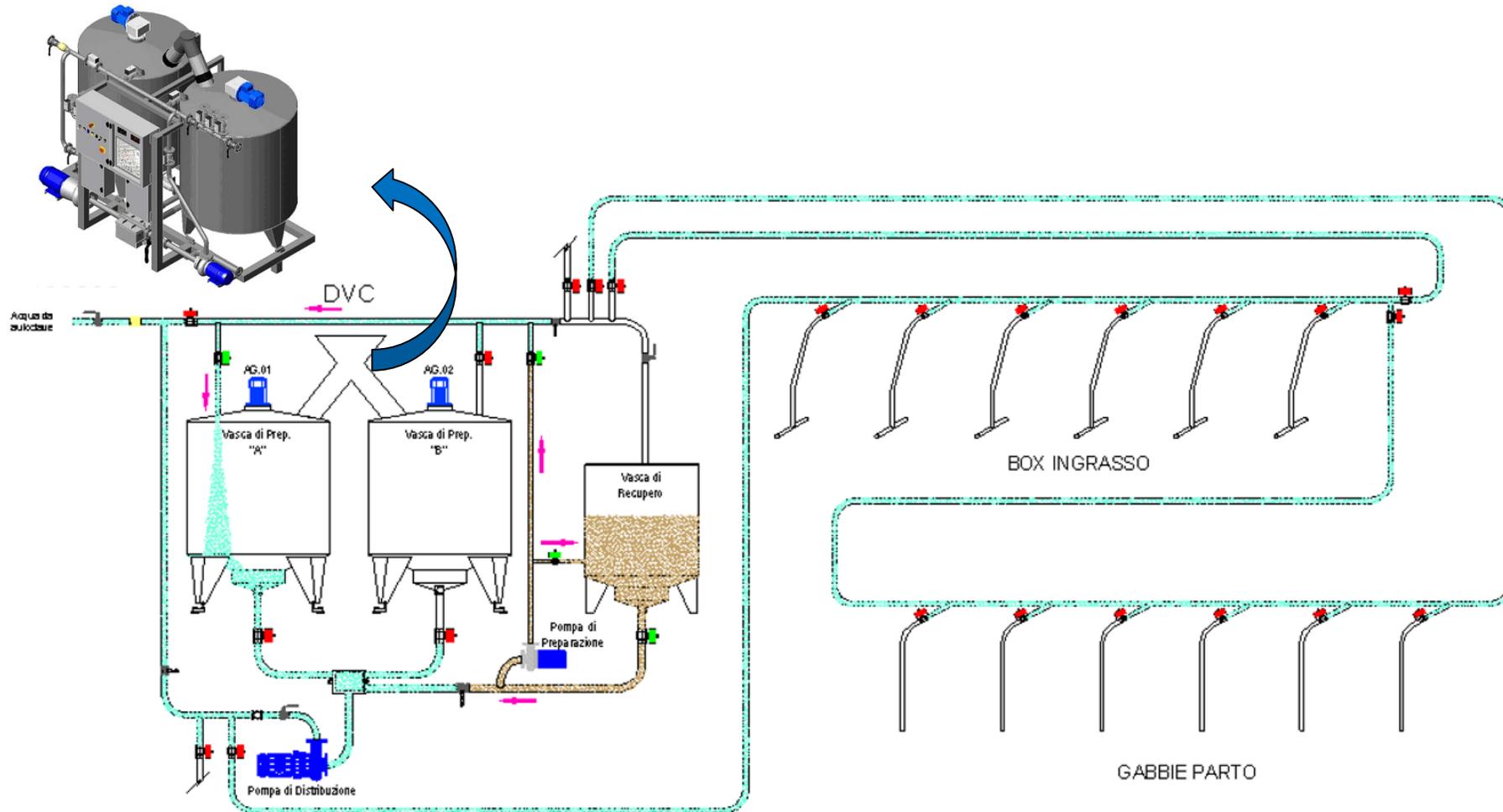
EXAMPLE OF PRECISION FEEDING FOR PIGS

Fabbisogno individuale (Lisina dig. g/MJ EN) vs Peso Vivo (kg)

EXAMPLE OF PRECISION FEEDING FOR PIGS

Fabbisogno individuale (Lisina dig. g/MJ EN)

Peso Vivo (kg)

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MULTIPHASE FEEDING SYSTEM

First phase feedstuff

Last pahse feedstuff

Ratio 99:1

Ratio 1:99

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UP FARMING Torino, April 2023

MULTIPHASE FEEDING SYSTEM IN A SWINE LIVESTOCK

PRECISION FEEDING

Requires precise knowledge of the "inputs":

Head characteristics	Live weight, ADG, productions, physiological status, … (transponder, boli ruminali, bilance, termocamere, parametri fisiologici, …)	
Requirements	Based on nutrient availability (P available, aa digestible, Real Absorption Coefficients or Digestive utilization, Net Energy, …)	
Feed characteristics	Rapid systems analysis (NIR)	
Quantities actually administered/ consumed	Real-time correction systems for the weight of feed rations according to their characteristics	

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