Amino acids in dairy nutrition: How to improve protein efficiency

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Protein situation in Ruminants

- Animal production in Europe depends on SOYA importation and its price fluctuations
- Non GM production and demand increases (beef and dairy)
- Ecology : demand for a reduction of nitrogen effluents

➔ **ALTERNATIVES to SOYA EXIST**

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DAIRY RATION COST :
> 50% come from soya bean meal

Example of a dairy cow TMR :

INGREDIENTS 30 kg milk cow	Cost / T	Amont / day	Cost €/ day	% total cost
Grass silage	50	3.5 kg DM	0.175	**6.7**
Corn silage	50	14 kg DM	0.7	**26.7**
SOYA BEAN MEAL	375	4 Kg	1.5	**57.1**
Mineral feed	500	0.5 kg	0.25	**9.5**
TOTAL		22 KG DM	2.625	**100**

→ **57% OF RATION COST IS SOYA**
50 € / kl

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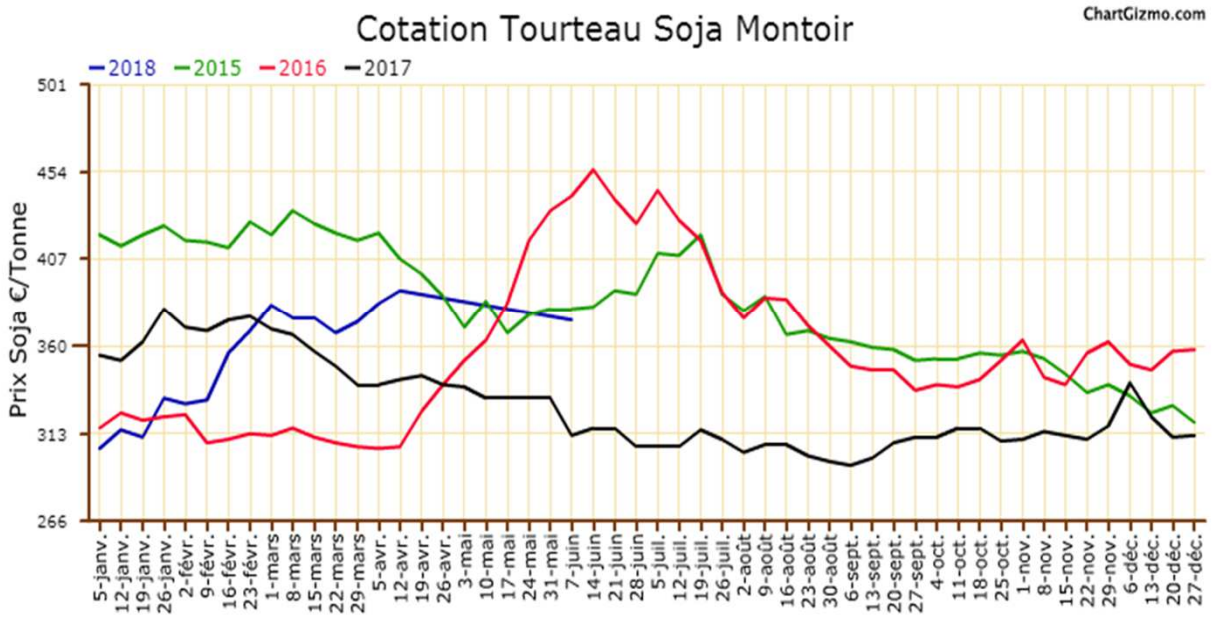
COST OF SOYA MEAL
highly variable



→ **Hard to manage production cost**

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ALTERNATIVES to SOYA …

INCREASE GRASS PART IN RATION ?

RISK = LOWER PERFORMANCES

Because grass quality varies a lot :
Weather, harvest time

OTHER MEALS ?

RAPESEED (1.4 kg rapeseed meal can replace 1 kg soya meal)
SUNFLOWER
BREWERS GRAIN
DISTILLERS
SOLUBLES
UREA

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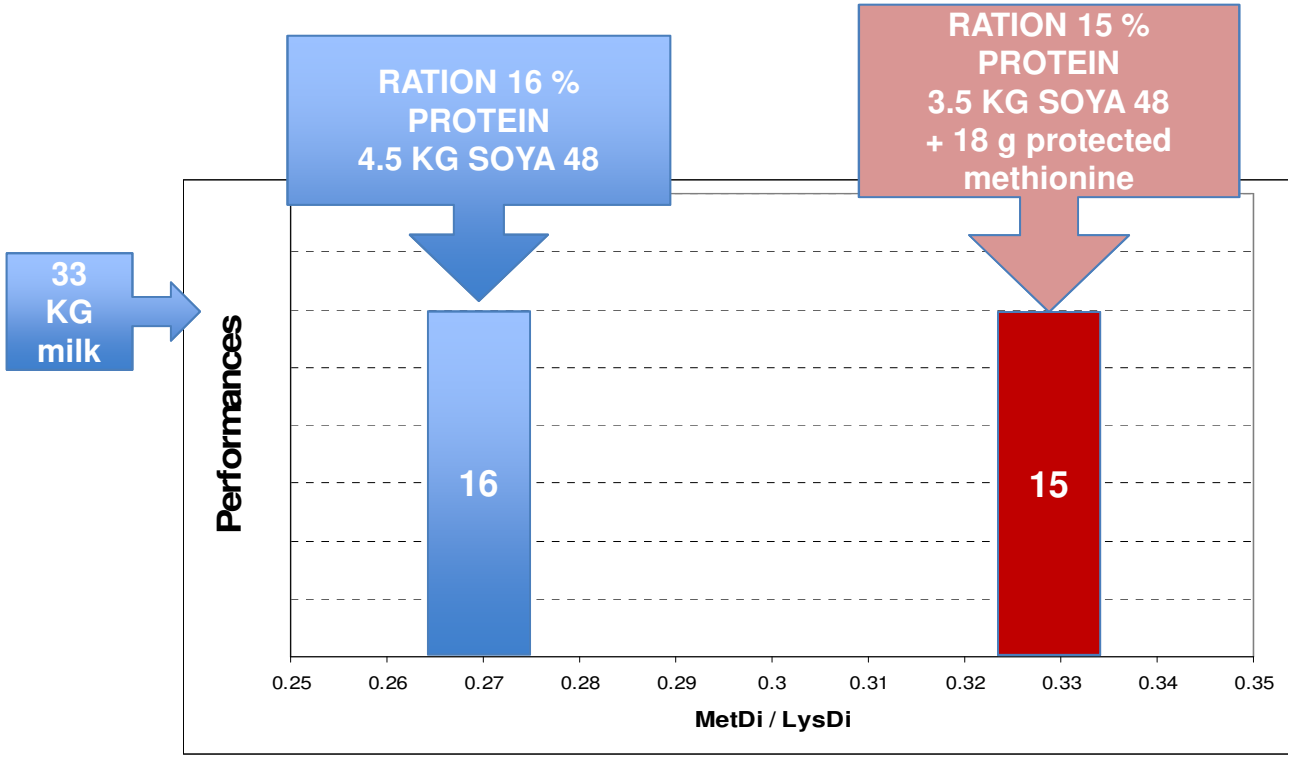
ALTERNATIVES to SOYA …

FORMULATION on AMINO-ACIDS : METHIONINE / LYSINE



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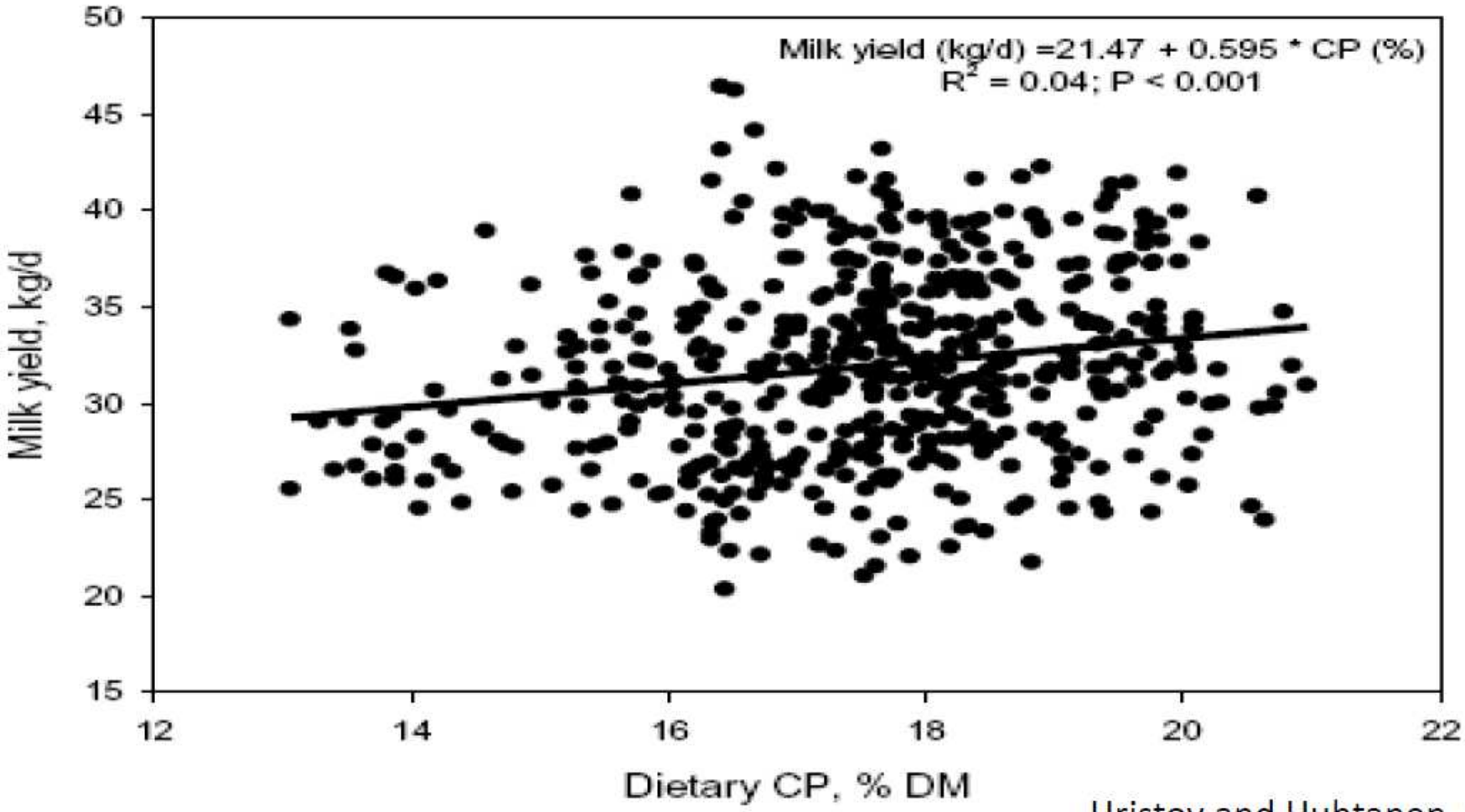
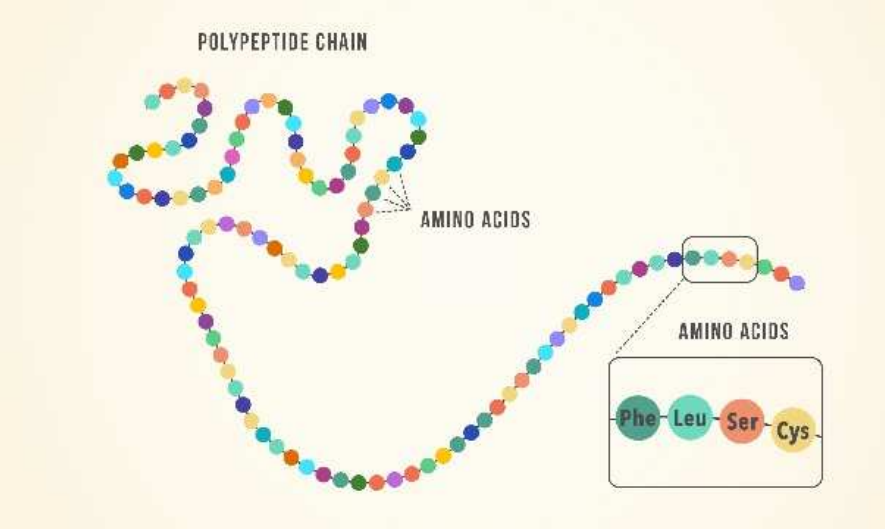
Crude protein is not a good criteria



Hristov and Huhtanen, 2008

20 Amino acids



Essential AA	Non-essential AA
Arginine	Alanine
Histidine	Aspartic acid
Isoleucine	Asparagine
Leucine	Cysteine
Lysine	Glutamic acid
Methionine	Glycine
Phenylalanine	Glutamine
Threonine	Proline
Tryptophan	Serine
Valine	Tyrosine

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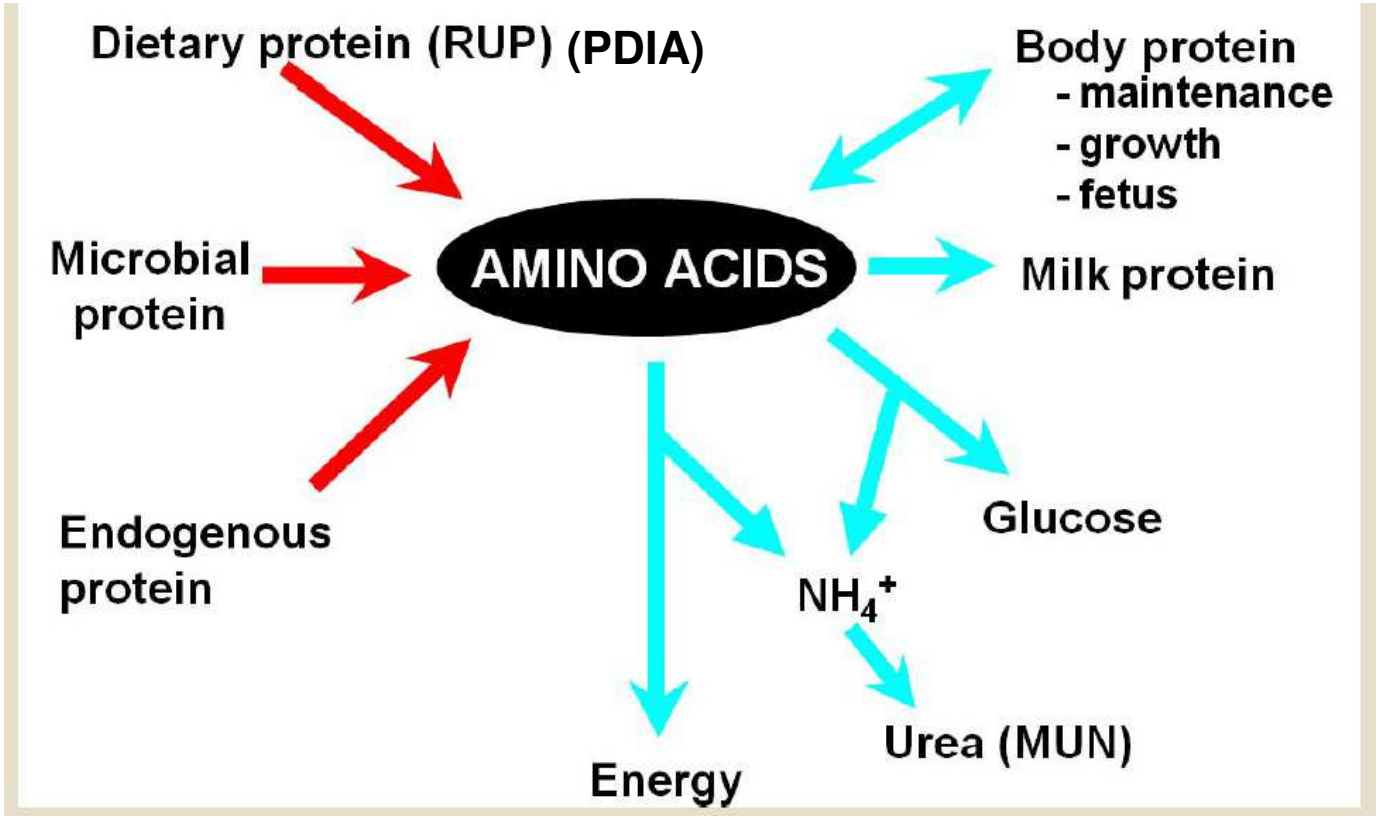
Supply and utilization of amino acids for the dairy cow



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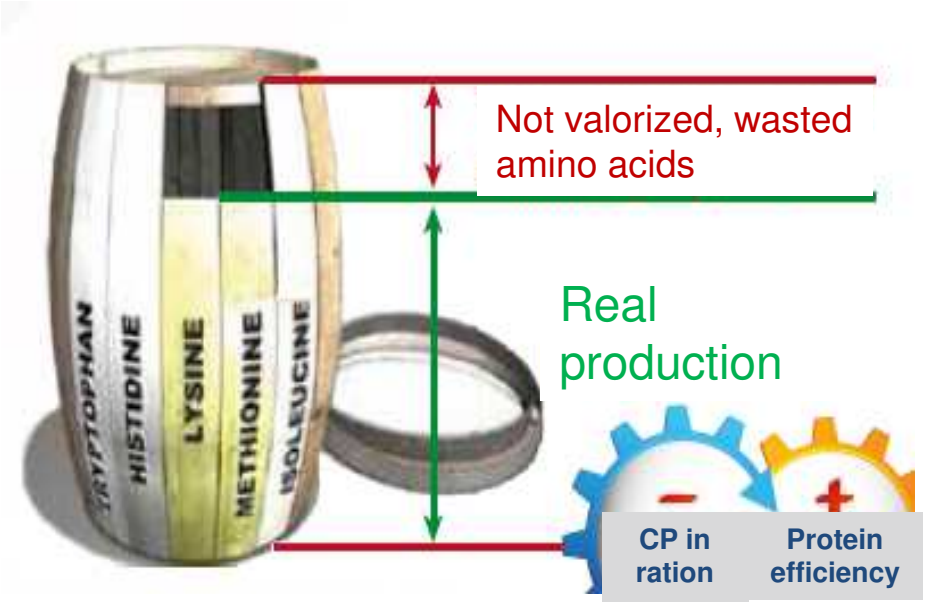
Limiting amino acids (Rulquin 2009)
LYSINE / METHIONINE

CLASSICAL RATION

OPTIMIZED RATION



The milk protein synthesis is maximal when the AA profile is optimized, above all for **LYSINE** and **METHIONINE**

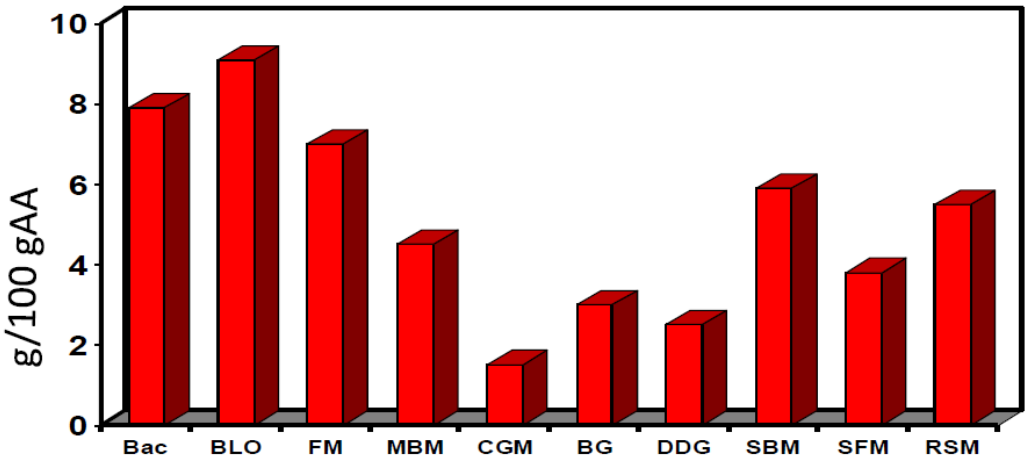
Table 1. Concentrations in CP of Lys and Met in milk[1], lean tissue[1] and rumen bacteria[1]; suggested optimum concentrations in MP[2], and break-point estimates of required concentrations in MP for maximal content of milk protein[3]

	Lys	Met		Lys	Met
Milk	7.7	2.6	Brewer's grains	4.1	1.7
Lean tissue	6.4	2.0	Canola meal	5.6	1.9
Rumen bacteria	7.9	2.6	Corn DDGS	2.2	1.8
Optimum concentration	7.2	2.5	Corn gluten feed	2.7	1.6
"Required" (NRC, 2001)	7.2	2.4	Corn gluten meal	1.7	2.4
			Cotton seed	4.3	1.7
Alfalfa silage	4.4	1.4	Linseed meal	3.7	1.8
Corn silage	2.5	1.5	Soybean meal	6.3	1.4
Grass silage	3.3	1.2	Sunflower meal	3.6	2.3
Barley	3.6	1.7	Blood meal	9.0	1.2
Corn	2.8	2.1	Feather meal	2.6	0.8
Oats	4.2	2.9	Fish meal	7.7	2.8
Wheat	2.8	1.6	Meat meal	5.4	1.4

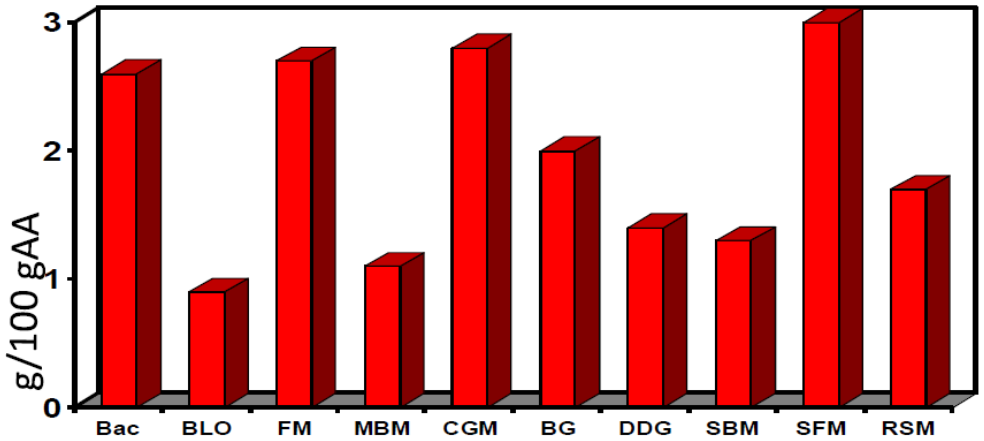
[1] Amino acid values for milk, lean tissue and rumen bacteria are from O'Connor et al. (1993), suggested optimum concentrations of AA in MP are from Doepel et al. (2004), and break-point estimates for required concentrations in MP for maximal content of milk protein and amino acid values for feeds are from NRC (2001).

Data from C. Schwab

Lysine in bacteria and supplements



Methionine in bacteria and supplements



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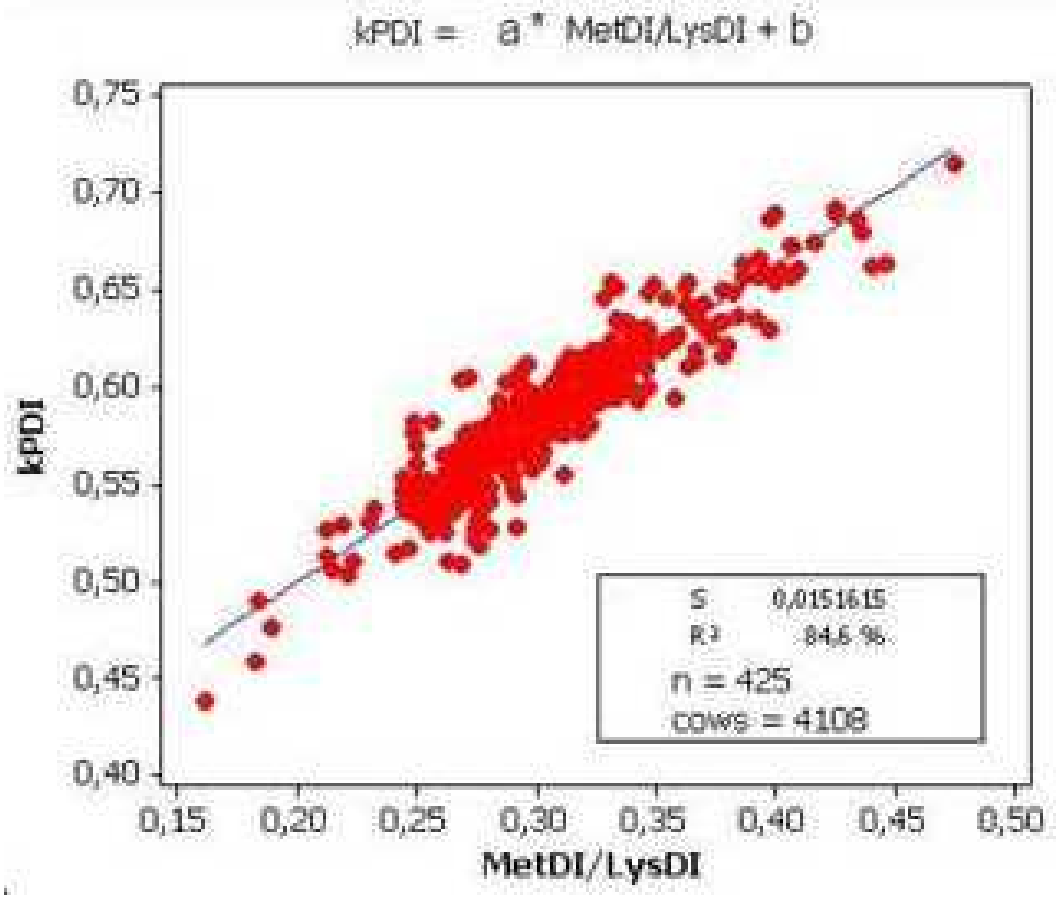
Efficiency of transformation into milk proteins



Rulquin (2009) :

The efficiency of PDI changes depending on the ratio of LYS/ MET amino acids in the ration

Optimum ratio Lys / Met = 3

- If LYS / MET = 4 , we need 32 * 0.53 = 60 g PDI / L milk 3,2% protein
- If LYS / MET = 3, we need 32 * 0.60 = 53 g PDI / L milk 3,2% protein

➔ 13 % higher yield

Major functions of AA

- **LYSINE :**
  - **Protein synthesis**
  - Reduction of nitric oxide synthesis, antiviral activity, protein methylation and acetylation
  - Structre and function of collagen

- **METHIONINE :**
  - **Protein synthesis**
  - Via Adenosylmethionine : Methylation of proteins and DNA, synthesis of creatinine, epinephrine and polyamines, regulation of gene expression, one-carbon-unit metabolism
  - Via homocysteine : Oxidant, inhibition of nitric oxide synthesis
  - Via Betaine : Methyation of homocystein to methionine,
  - Via Taurine: Anti oxydant, anti inflammatory, regulator of intracellular osmolality, conjugation with bile acids
  - Via gluthation : Synthesis of prostaglandins, signal transduction, cell proliferation (hepatocytes, lymphocytes, intestinal epithelial cells), elicitation of immune response, oocyte development, sperm production and maturation
  - ➔ **Methionine has many other roles than milk production**

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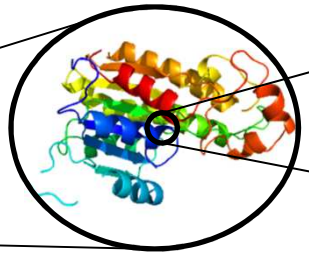
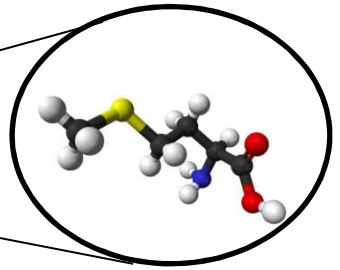
Methionine : an INDISPENSABLE nutrient

CP Ration



Digestible protein in intestine

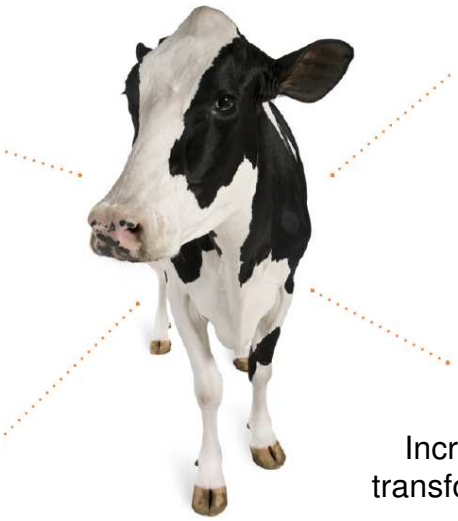


Methionine

Health and productivity of a cow are determined from the close up period.
Methionine is an indispensable nutrient for numerous metabolic processes :

Immunity :
Stimulates the production of antioxidants and reduces inflammation

Muscle :
Improves the efficiency of the transformation from feed protein to muscle protein



Liver :
Favorises lipid exportation from liver under the form of lipoprotein
Limits liver overloading

Udder :
Increases the efficiency of the transformation from feed protein to milk protein

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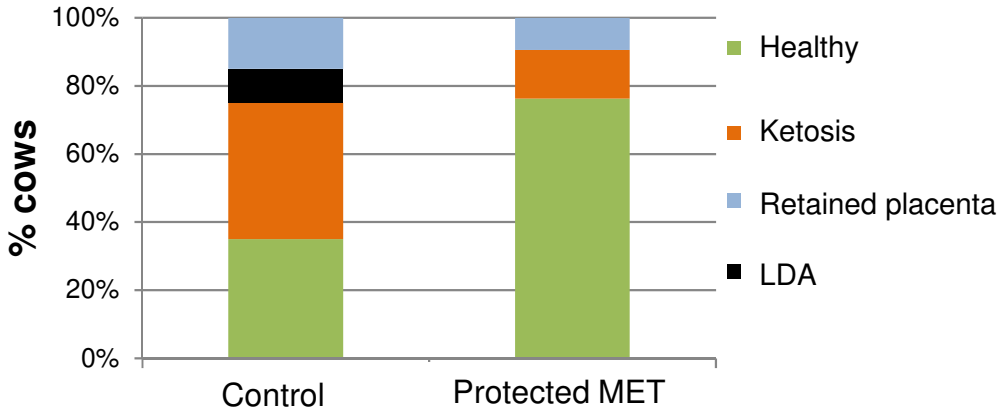
Cows in good health

Protected methionine divides per 2 the metabolic diseases incidence



Trial realised 21 days before calving to 30 days after, on 41 dairy cows (Zheng Zhou, 2015)

Average health costs: 106 €/cow/year
(Eilyps, 2015)
Cost of a ketosis: 250 €/case
Fœtal membranes retention : 200 €/case
LDA: 340 €/case

GAIN with protected MET : 53 €/cow/year
106/2 = 53€

Cows fed with protected methionine have a limited lipidic storage and produce more natural antioxydants.
Those cows are in better conditions to face the parturition stress and associated risks.

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Cost of peripartum diseases

(Compilation Dr Chuck Guard 1998- Hutjens 2005)

Diseases	% Mortality	% culling	Delay to conception (days)	Milk loss Kg	Cost / case
Milk fever	4	5	13	130	**330 €**
Dystocia	1	2.2	12	178	**160 €**
Retained placenta	1.5	6	15	250	**200 €**
Ketosis	0.5	5	20	230	**250 €**
DA	2	8	12	400	**340 €**
Mastitis	2	10	10	200	**200 €**
Metritis	1	10	25	250	**250 €**

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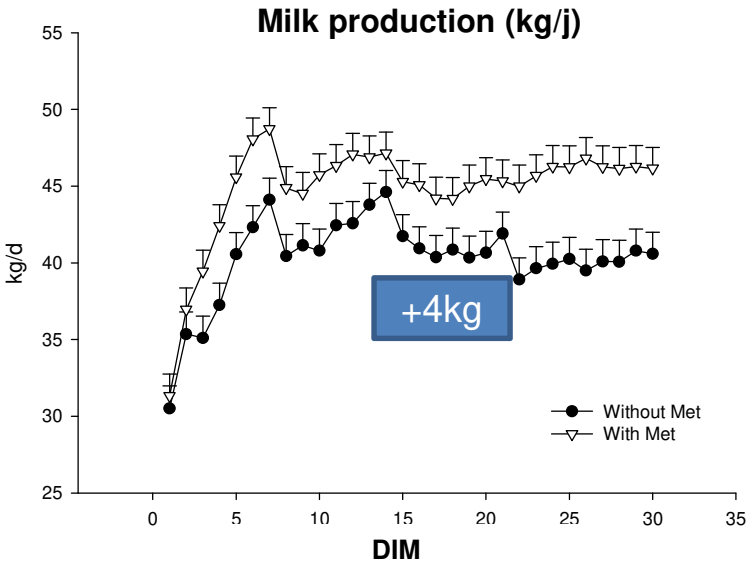
More productive dairy cows

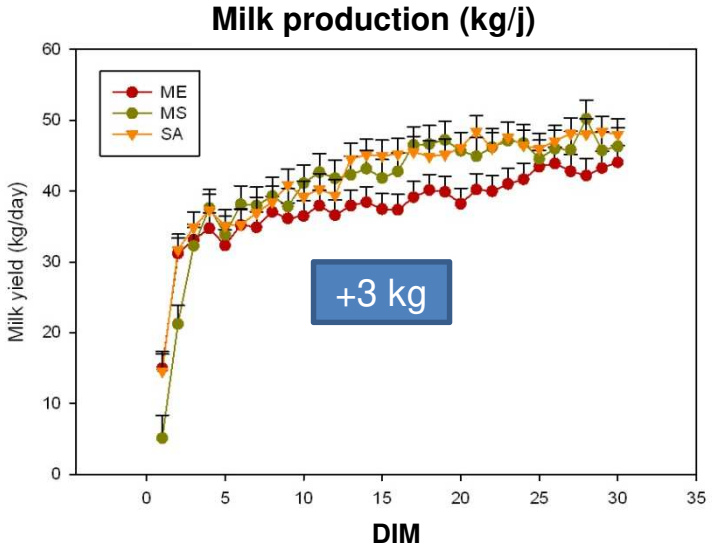
Protected methionine allows + 7% milk production on one lactation cycle

Particularly when started before calving

ECM



Source: Zhou et al, 2015



Source: J. S. Osorio, J. Dairy Sci. 96, 2013

Production increase is only the expression of a better dairy cow health. Methionine's first objective is to cover the animal needs (liver & immunity).

Gain with protected MET :
+189 €/DC/year
9000 l milk x 7% = 630 l x 0,3 €/l = 189€

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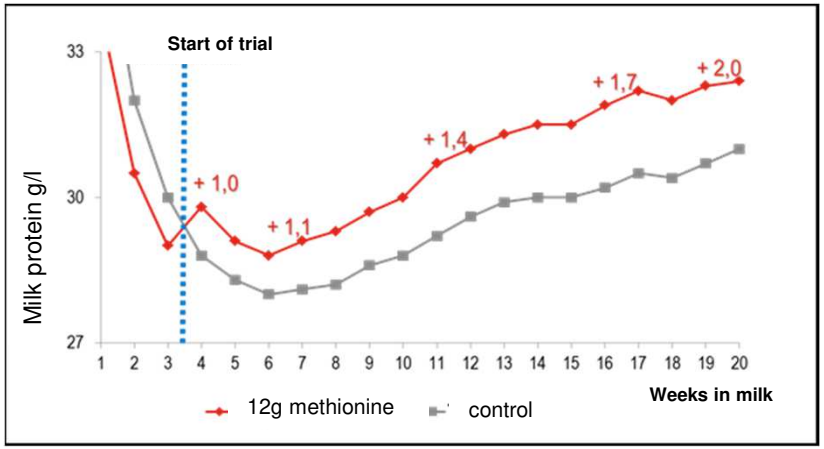
More efficient dairy cows

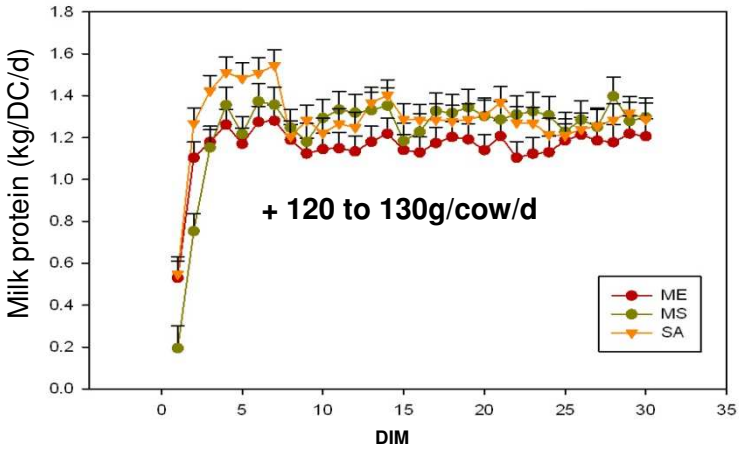
Protected methionine allows a milk protein rate increase of 1,44 g/l

Milk protein (g/kg)



Source : Institut d'Elevage/EDE, 1996

Milk protein (kg/DC/d)

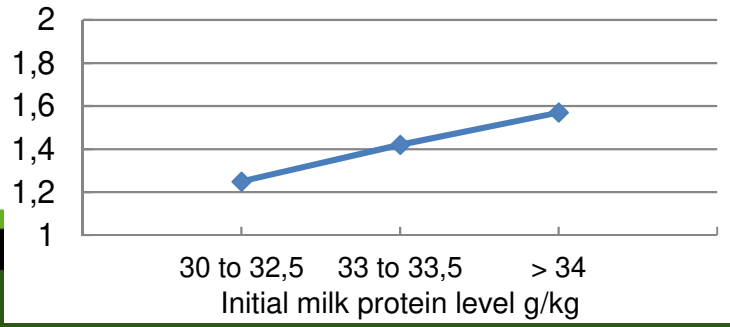


Source: J. S. Osorio, J. Dairy Sci. 96, 2013

Observed increase of the milk protein after one week of use for 17 000 cows : **+ 1,44 g/kg**

With a high milk protein rate, protected methionine effect is stronger !

Milk protein rate increase in g/kg

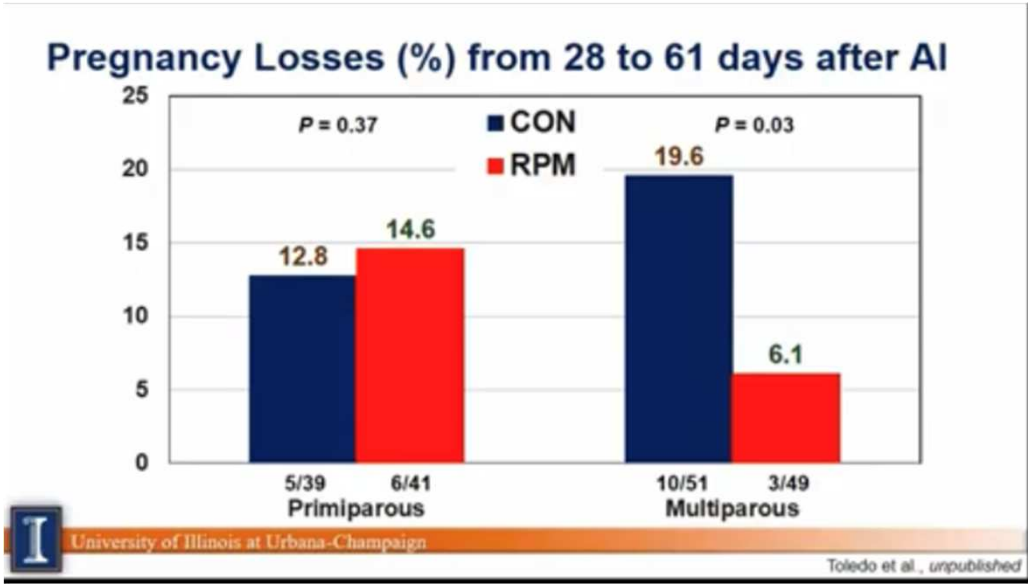


Gain with protected methionine: +85 €/DC/year

Ex : 1,44g/kg x 6,6€ x 9000 l = 85€

Better fertility

- New data show that:
  - Methionine is correlated with quality of follicle (size + oestrogen synthesis)
  - Methionine decreases preg loss between 28 to 60 days of pregnancy



Reminder : Cost of + 1 day open over 120 DIM = 3€

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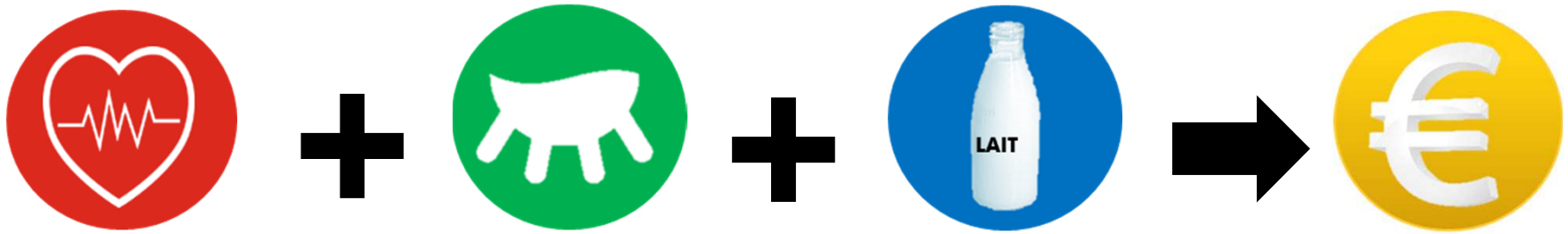
More profitable cows



Good Health + **+ productive** + **+ efficient** → **+ profitable**

Health fees divided by 2 → **50 €/DC/year**

+630 kg of milk, → **180 € /DC /year**

+1.44 g PR + 9.84 €/1000 kg, → **80 €/DC/year**

Total : + 310 €/DC/year
Investment: 74 €/DC

Net profit: 236 €/DC

Return on investment : 1 / 4

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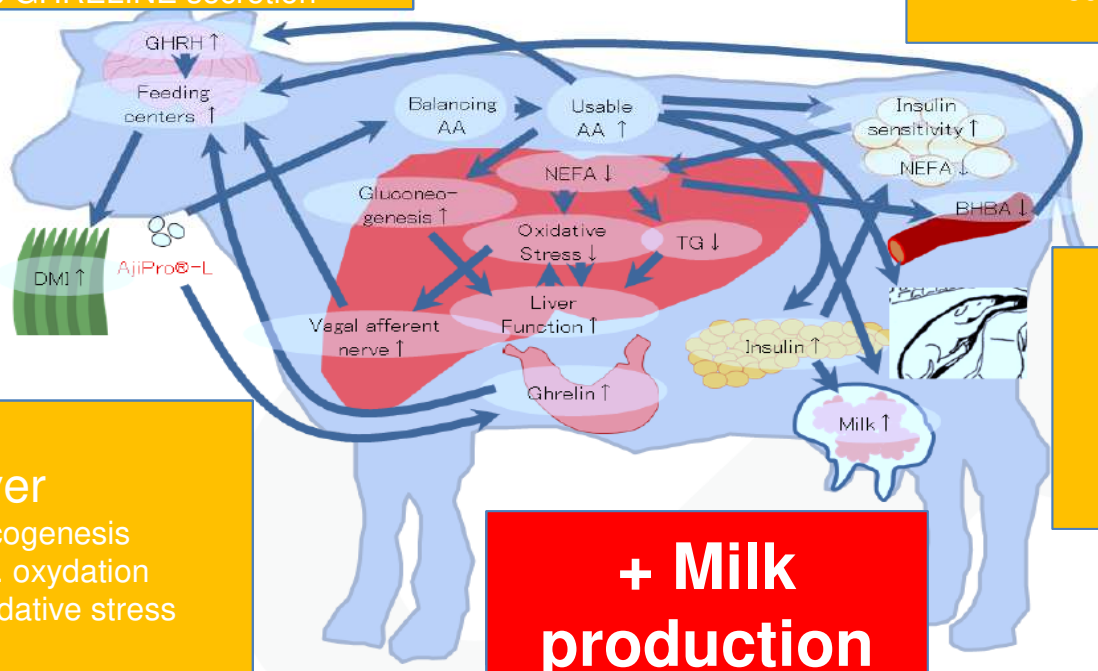
Effect of protected LYSINE

Lipids metabolism
+ sensibility INSULINE
Reduces lipomobilisation
Reduces blood BHBA
Reduces blood NEFA

Speculated Mode of Action of lysine during transition period

Direct effect on appetite
Stimulates the growth hormone
Stimulates the GHRELINE secretion



Liver
+ Neoglucogenesis
Reduces B. oxydation
Reduces oxydative stress

+ Milk production

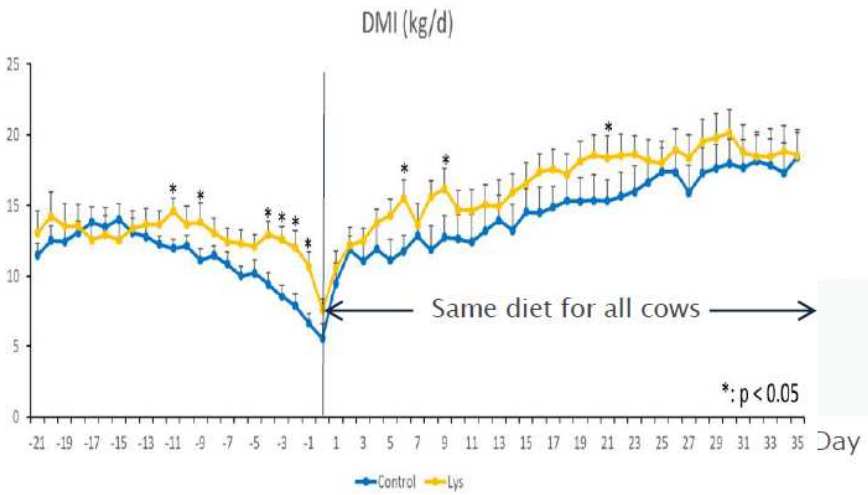
Nutrition Fetus
+ assimilation AA
+ glucose transporters
+ calves digestive functions

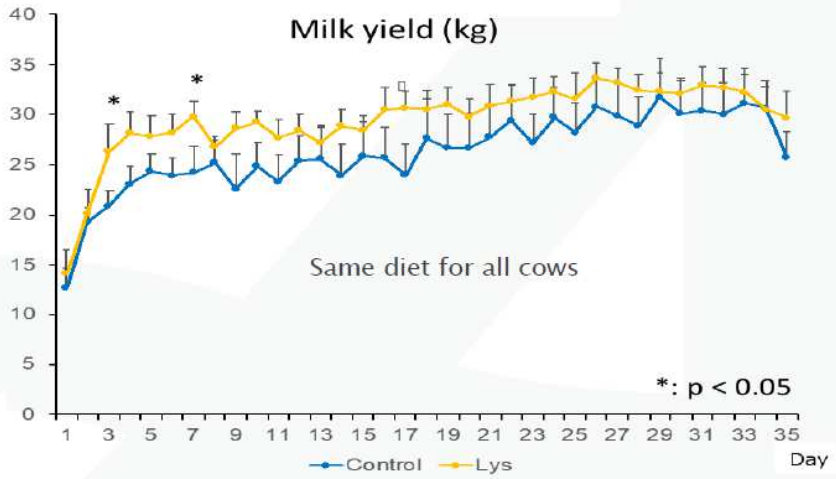
Effect of Lysine on close up cows

Exp1. Results : DMI and Milk Production

T278 Supplementation of rumen-protected lysine (AjiPro-L) during the close-up dry period affect prepartum feed intake and lactation performance in dairy cows. S. Ishimaru*[1], H. Funo[2], M. Nakamura[2], I. Shinzato[3], Y. Ohta[3], K. Nakagawa[3], A. Haruno[3], T. Obitsu[1], and T. Sugino[1], [1]*The Research Center for Animal Science, Graduate School of Biosphere Science, Hiroshima University, Higashihiroshima, Japan,* [2]*Shimane Prefectual Livestock Technology Center, Izumo, Japan,* [3]*Ajinomoto Co., Tokyo, Japan.*

Sugino et al., JDS. Vol. 101, Suppl. 2





+ 2 kg DMI before and after parturition DMI remains high even after stopping lysine supplementation at calving.

+ 5 kg milk production in the group which received lysine before calving.

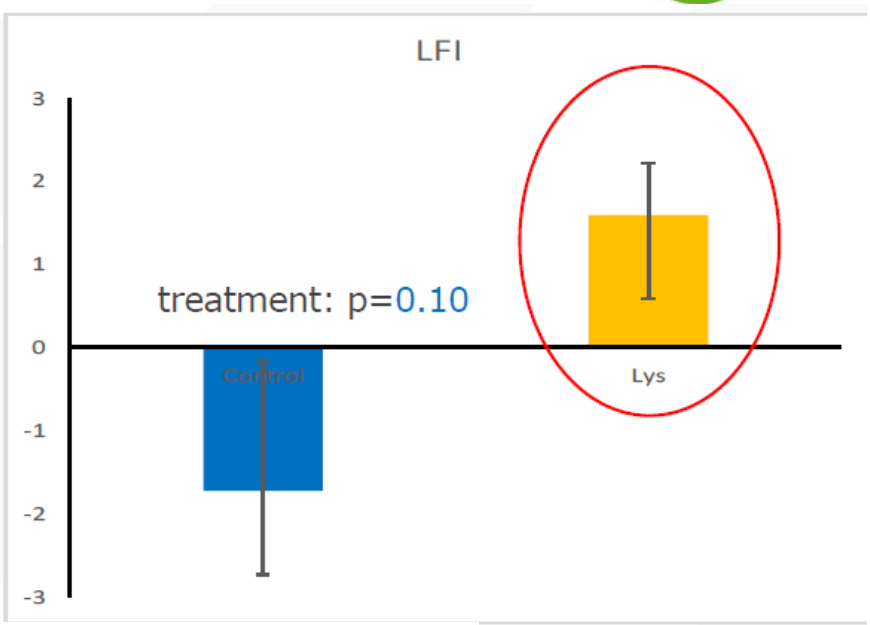
	MP	Lys di	Met di
Control	1150 g	97 g	26 g
Protected LYS	1150 g	80 g	26 g

Effects of Lysine on close-up cows

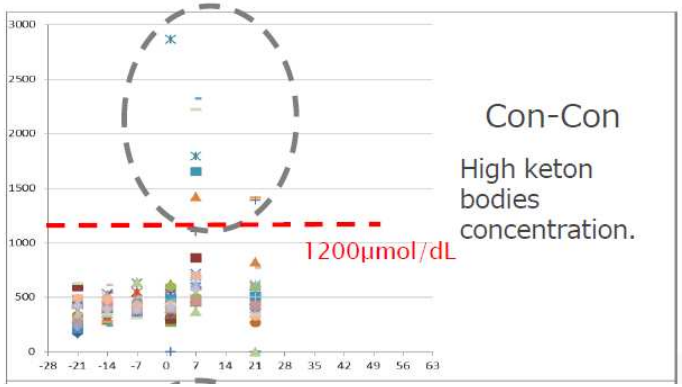
Liver is in better conditions

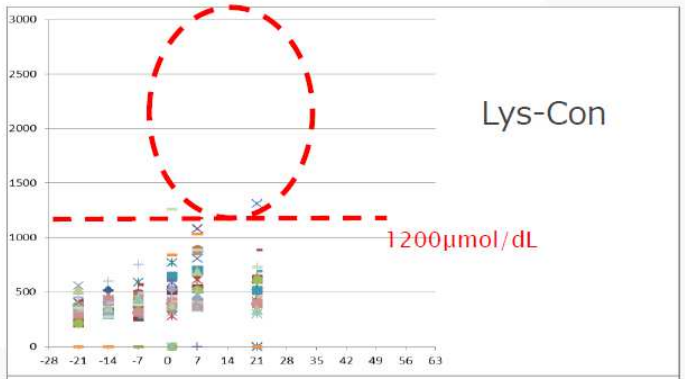
Better LFI : Liver function index
- Bilirubine
- Cholestérol
- Albumine

Less ketone bodies
Better energy status



Exp.2 Results : Blood BHBA Concentration





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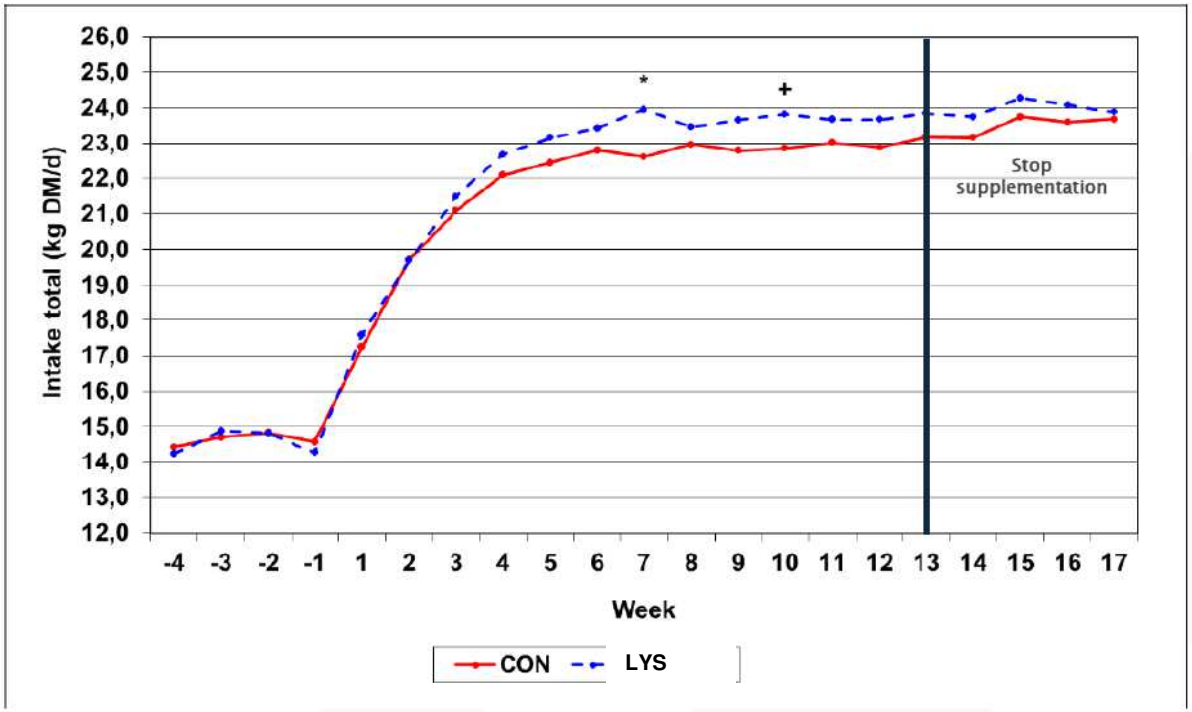
Trial EU : effects of protected lysine (lys-MP 7.7-7%) on transition cows -W4 to W12

EU TRIAL Results : Impact on Dry Matter Intake

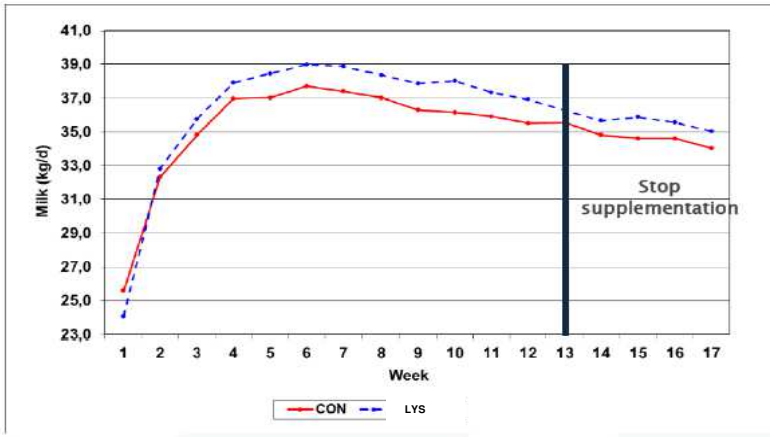


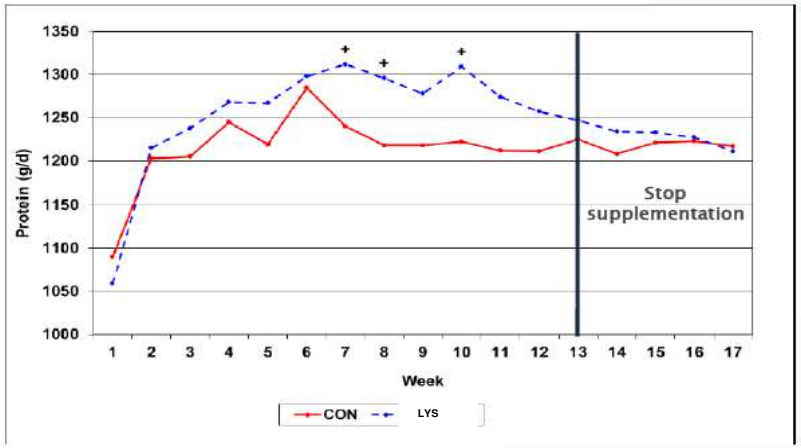
Supplementation in lysine increases DMI 0.5 to 1 kg / d
4 weeks after stopping the supplementation, DMI is back to the control group level

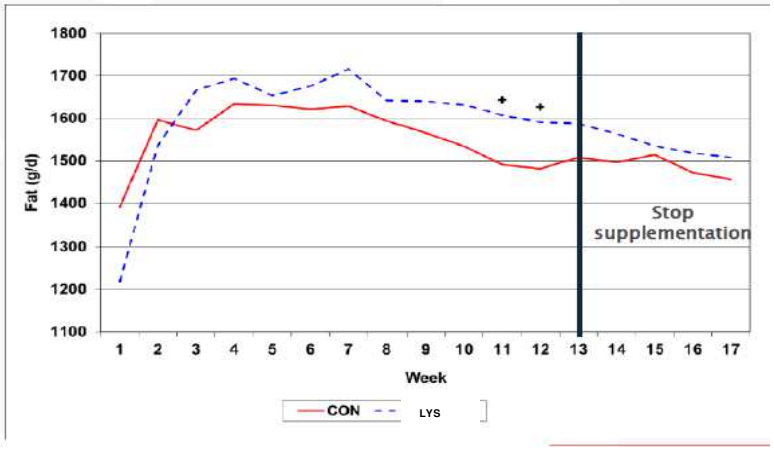
Trial EU : effects of protected lysine (lys-MP 7.7-7%) on transition cows -W4 to W12

EU TRIAL Results : Impact on Milk production & solids

	Control	LYSINE
Milk yield (kg)	35.2	36.3
Fat Protein Corrected Milk (kg)	37.8	38.9
% fat	4.43	4.40
% protein	3.45	3.44
Corr. milk 7%	**39.6**	**40.65**



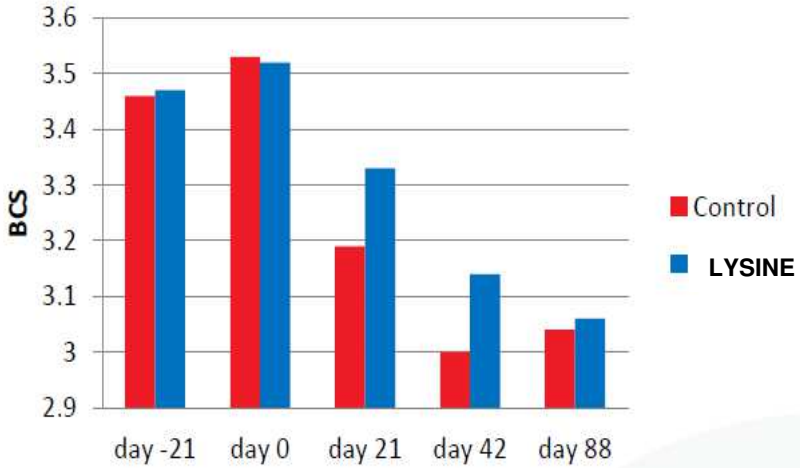


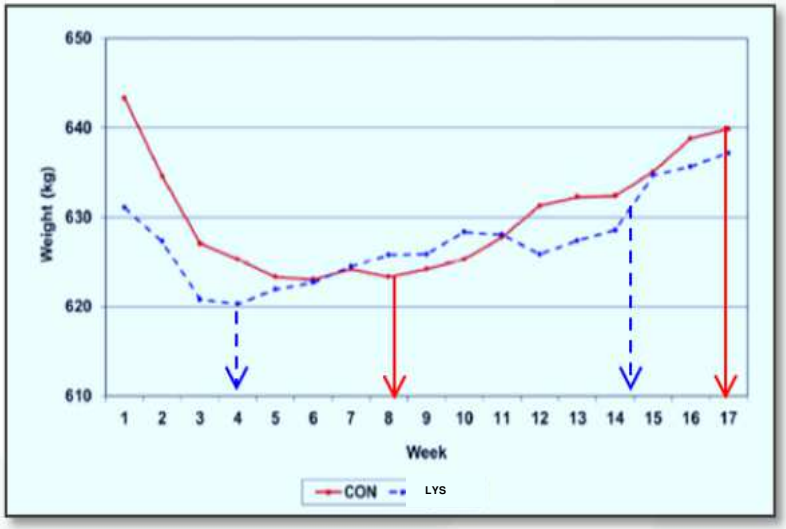


The supplementation in lysine increases the production of 1 kg / d
Back to control group production 4 weeks after stopping Lysine
Protein and fat rate remain the same

Trial EU : effects of protected lysine (lys-MP 7.7-7%) on transition cows -W4 to W12

Results : Impact on Body weight, Body Condition Score & BHBA





	Control	LYSINE	Difference
BHBA at calving (mmol/l)	0.60	0.46	-0.14

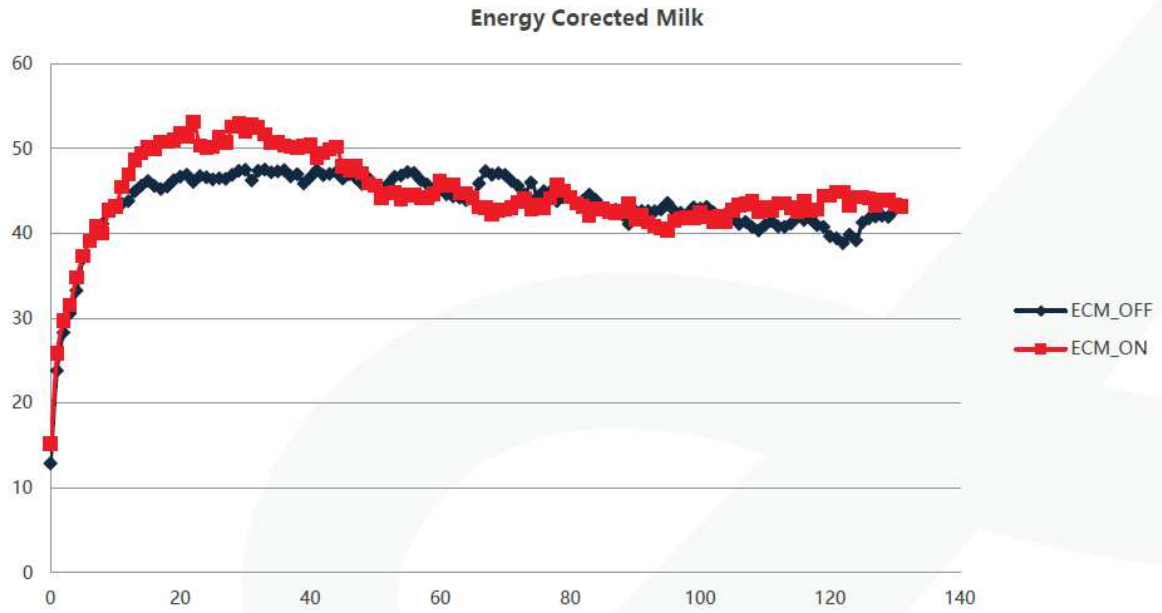
Supplementation of Lysine :

Reduces weight losses
Speeds up the weight recovery

Reduces the ketone bodies in relation with a better energetic status

Trial / 125 g Protected Lysine (2 months) on a whole herd
Gaec Toulou 22 St Jean kerdaniel

Lactation curve in period off vs period on



Higher peak, corresponds to the farmer's observations

Clear effect on beginning of lactation ➔ + 3 KG milk

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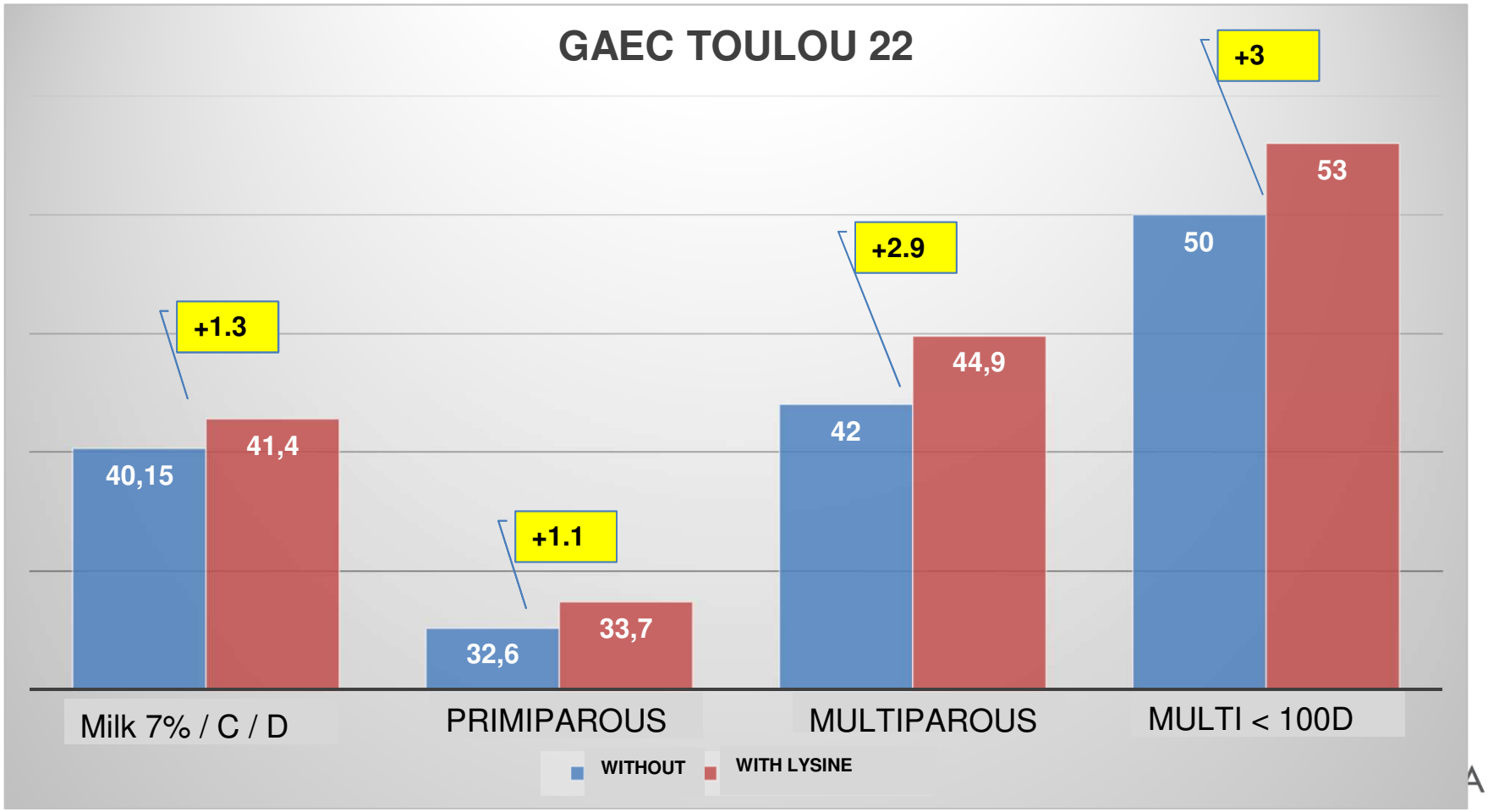
Trial Brittany / 50 g protected lysine (2 months)
Gaec Toulou 22 St Jean kerdaniel



GAEC TOULOU DAGORN	MILK	04/08/19		
dairy breed HOLSTEIN weight kg 670				
kg milk : 40 fat g/L : 40 protein g/L : 33				
Feedstuff	kg as fed	kg DM	Nutrients	/kg DM
			CP g	155
			UFL	0.95
Wheat straw	0.30	0.26	PDI g	100
			BPR	7
			Ca g	7.38
Corn silage	42.00	14.18	P g	3.84
			DCAD meQ	277
Grass silage	10.00	3.00	DM %	42%
			Conc. %	30%
			fat g	27.7
			Sugar g	34
			Starch g	270
Soybean meal	1.20	1.06	Lys/Met	3.22
SBM ROBOT	2.00	1.76		
			ADF g	181
HYDROLYZED WHEAT	3.00	2.40	NDF g	328
			NDF f %	27.7
			CF g	161
PROTECTED LYSINE + METHIONINE	0.14	0.13		
CONCENTRATE FEED 3 L	2.70	2.36		
			Ration cost € / d	4.00
Mineral Premix	0.65	0.65	price milk €/kl	0.33
SALT	0.04	0.04	milk 7% in L	40.4
			€/KL	96.0
			Feed efficiency	1.61
Total ration kg	**62.1**	**25.9**	IOFC / VL	9.34

PROTECTED LYS+METH mixed to the trough :

Decreases soya meal at the trough -0.5 kg

Decreases milk urea 220 mg

Dungs more homogeneous

Health +++

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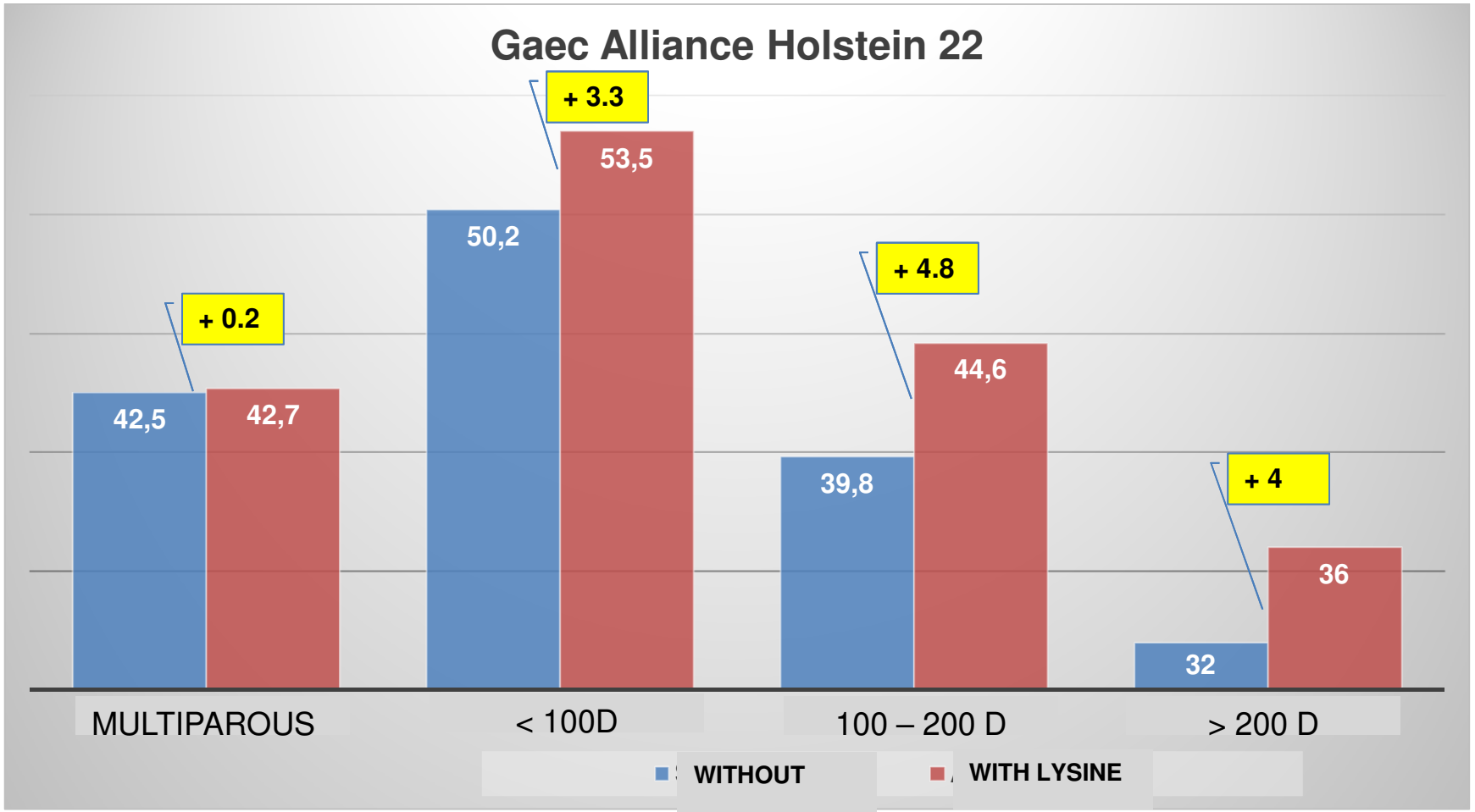
Trial / 125 g Protected Lysine
Gaec ALLIANCE HOLSTEIN 22
Individual distribution on robot on multiparous < 100DIM et > 40kg



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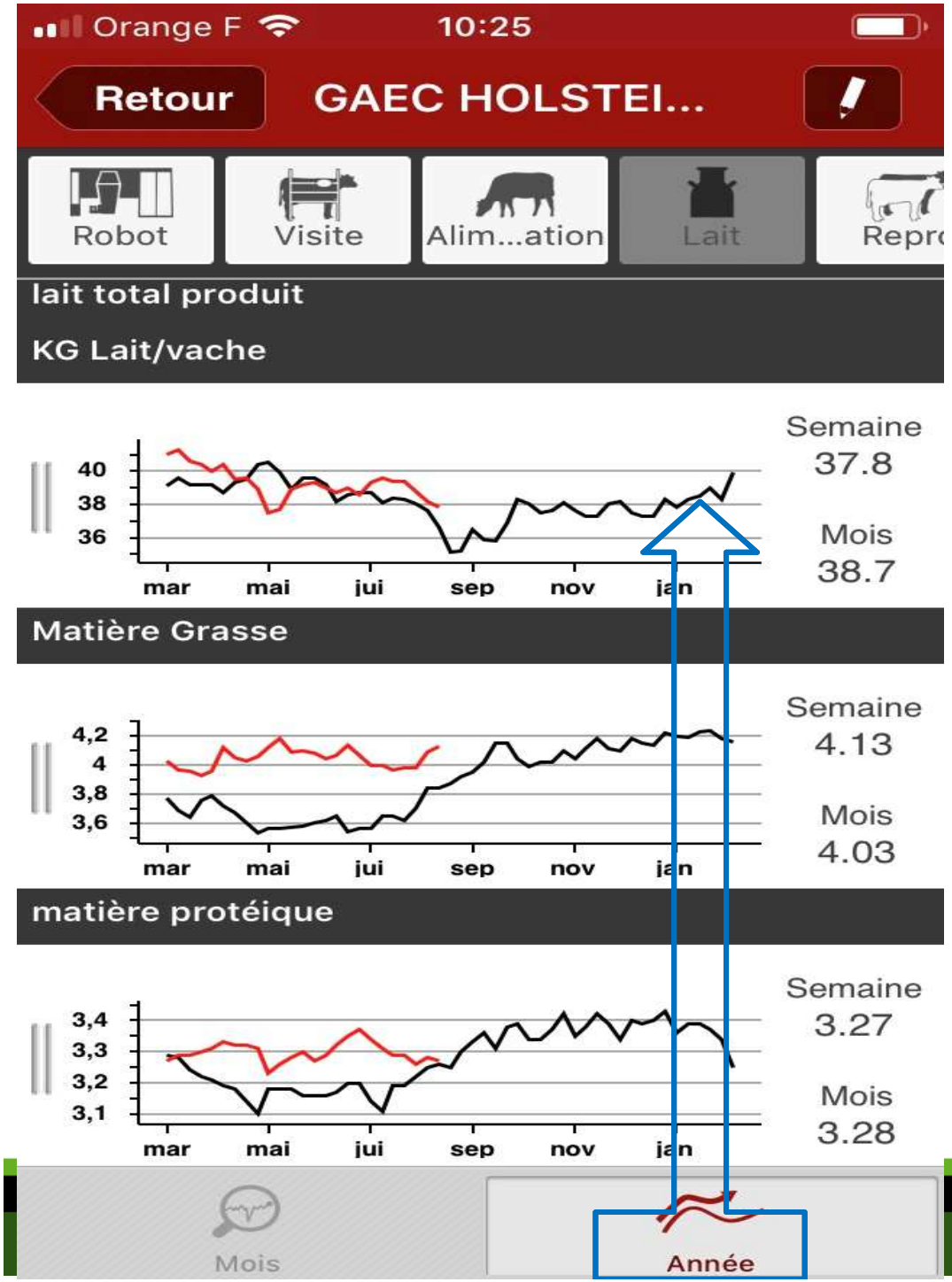

Gaec ALLIANCE HOLSTEIN

effect optimisation LYS/MET and Systali

from 2019 February

Gain + 2 pt Fat rate
Gain + 1 pt Protein rate
Qty milk = same
Price milk + 12 € / kl
Milk income + 0.47 €
TMR cost = same
GM/DC = + 0.47 € / Cow / d

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GAEC HOLSTEIN ALLIANCE	PRIMI + MULTI		27/08/19	
dairy breed HOLSTEIN Weight kg 680		kg milk : 37.2 fat g/L : 42.5 protein g/L : 33.8		
Feed stuffs	kg as fed	kg DM	Nutrients	/kg DM
			CP g	157
			UFL	0.91
			PDI g	98
			BPR	12
			Ca g	7.79
Corn silage	34.00	12.92	P g	3.86
			DCAD meQ	321
Alfalfa silage	12.00	3.84	DM %	47%
			Conc. %	34%
			fat g	30.1
			Sugar g	24
			Starch g	288
SBM	3.00	2.64	Lys/Met	3.20
SBM ROBOT	0.94	0.83		
			ADF g	206
Corn	4.00	3.45	NDF g	333
Protected Lysine + Methionine	0.12	0.11	NDF f %	27.4
			CF g	187
				99
Concentrate feed robot	2.50	2.19		
			Ration cost € / D	3.86
			Milk basic price €/kl	0.330
			Milk price paid €/kl	0.354
Mineral premix	0.60	0.60	Income milk € /VL/J	12.7
Soda	0.15	0.15	milk 7% in kg	40.5
			€/KL	95.1
SALT	0.05	0.05	Feed efficiency	1.51
Total ration kg	**57.4**	**26.8**	IOFC / VL	8.89

Gaec Alliance Holstein

Average ration
37.2 kg
42.5 Fat rate
33.8 Protein rate
230 Urea
110 SCC
175DIM

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Formulation on amino acids

LACTATION

Lys Di = 7-7.2% of PDI
Met Di = 2.2- 2.5 % of PDI
His Di = 2 - 2.5% of PDI

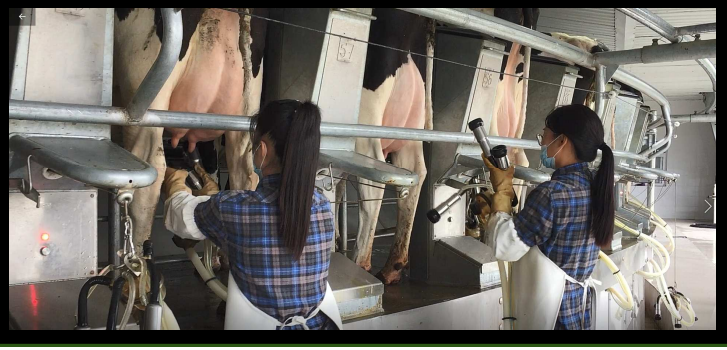
Ratio LYS/MET
2.8 - 3 = Optimisation of the protein rate
3 - 3.2 = Optimisation of the production

CP between 15 and 16%
Adjust the PDI at 98-100% of the needs
RDP between 9 and 11% DM
BPR between 10 and 15

Objective = NO ENERGY DEFICIT
Milk allowed by UF > Milk produced PDI

CLOSE UPS

10 UFL / d
1000-1100 g PDI / d
> 80 g LYS Di /d
> 25 g MET Di / d
BPR > 0



Effects of Lysine + Methionine fed together on transition cows (Osorio et al 2014)

- Dosage on close up cows **=**

  80 g LYS di + 27 g MET di (lys/met=3)

- Dosage of beginning of lactation = LYSdi/ METdi = 3

Effects =

- Increase the appetite before and after calving + 2 kg DM
- Increase the milk production at 28 DIM = + 4 kg ECM
- Provide a better antioxydant status (Gluthation)
- Better liver parameters
- Less ketone bodies
- Better reproduction = reduction of the embryo mortality (19 to 6 %)

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EXEMPLE	prepa vel		15/08/19	
PREPA - close up Race laitière - dairy breed HOLSTEIN Poids kg 700				
feedstuff	kg as fed	kg DM	Nutrients	/kg DM
straw	3.00	2.64	CP g	135
			UFL	0.81
			PDI g	79
			BPR	8
corn silage	19.50	6.77	Ca g	14.79
			P g	3.64
			DCAD meQ	**-112**
			DM %	48%
wheat	0.30	0.26	Conc. %	21%
			Fat g	25.2
Sunflower meal	0.25	0.22	Sugar g	31
Rapeseed meal	1.00	0.89	Starch g	186
SBM	1.20	1.06	Lys/Mét	2.81
Sugar cane molasses	0.10	0.07		
			ADF g	243
			NDF g	427
LYS + MET supplement	0.10	0.09	NDF f %	38.1
			CFg	217
Ammonium chloride	0.04	0.04	Needs waterL	40
			Ration cost € / D	2.03
Mineral premix dry	0.35	0.35		
Calcium chloride	0.04	0.04	LYS DI g	**75**
Magnesium chloride	0.03	0.02	MET DI g	**27**
Calcium carbonate	0.20	0.20	PDI g	**1005**
			UFL total	**10.25**
			Mg g	**4.4**
Total ration kg	**26.1**	**12.6**		

Example of a close-up TMR

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5 steps to respect in order to formulate on Amino Acids

- Prepare a TMR containing a mix of fermentescible glucids and efficient fibers in order to maximize the DMI, the microbial protein and the milk production. The microbial protein has the best profile with Lys 7.9% and Met 2.6%

- Bring enough degradable nitrogen in order to optimize the needs of the microbial flora in amino acids and ammonia.
  - RDP between 9 and 11%. 10 < BPR < 15 . Milk urea around 220 mg / L
  - A lack of RDP reduces the carbohydrates digestion, the VFA production, the synthesis of the microbial protein, the DMI and the milk production.

- Select the meals rich in lysin (soya, colza) and add protected lysin to reach the optimum level of 7-7.2 LYS di %PDI

- Supplement in protected methionin in order to get close to the ratio LYS/MET = 3:1

(Note : A bad choice in sources of protected lysine and methionine can lead to failures)

- Don’t overload in PDIA = when the balance LYS/MET is good, PDIA supplies can be decreased and be replaced by carbohydrates to keep supporting the bacteria

Conclusion :

→ Dairy cows don't need PDI but need amino acids
→ The first step is to work on LYSINE and METHIONINE
→ Then, other amino acids will have to be taken in consideration (HIS, LEU,…)

Benefits brought by AA ratio optimization :

- Increase of milk production
- Increase of milk fat and protein
- Allows the reduction of PDIA supplies of 1 to 2 % / DM
- Reduces nitrogen excretion = N urines / N milk / N faecal
- Can work on milk urea around 200 mg / L
- Improves health and reproduction
- Reduces weight loss at the beginning of lactation
- Increases farm profitability = + 0.30 € of income over feed cost/ cow / d (+ 100 € / cow / year)

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