Improving animal and ecosystem health benefits human health.

Measurable markers of global health (one Health).

(An example)

Effects of feeding concentrate including fat to dairy cows fed maize silage

PH. BRUNSCHWIG (1), PH. AUGEARD (2), P. WEILL (3), Y. CHILLIARD (4)
(1) Institut de l'Elevage, 14 avenue J. Joxé, 49006 Angers Cédex 01

1995

1995 - 2021 : From cows' health to human health

26 years in search for « One Health »

May omega-3 fatty acid dietary supplementation help reduce severe complications in Covid-19 patients ?

Pierre Weill [a], Claire Plissonneau [b, c], Philippe Legrand [d, e], Vincent Rioux [d, e], Ronan Thibault [e, f, *]

2021

FAO-WHO-PNUE «*The health of humans, animals, plants and the environment in general (including ecosystems) is closely linked and interdependent*". *(2021)*

One Health: « When we protect one, we help protect all.. »

Are you sure about this ?

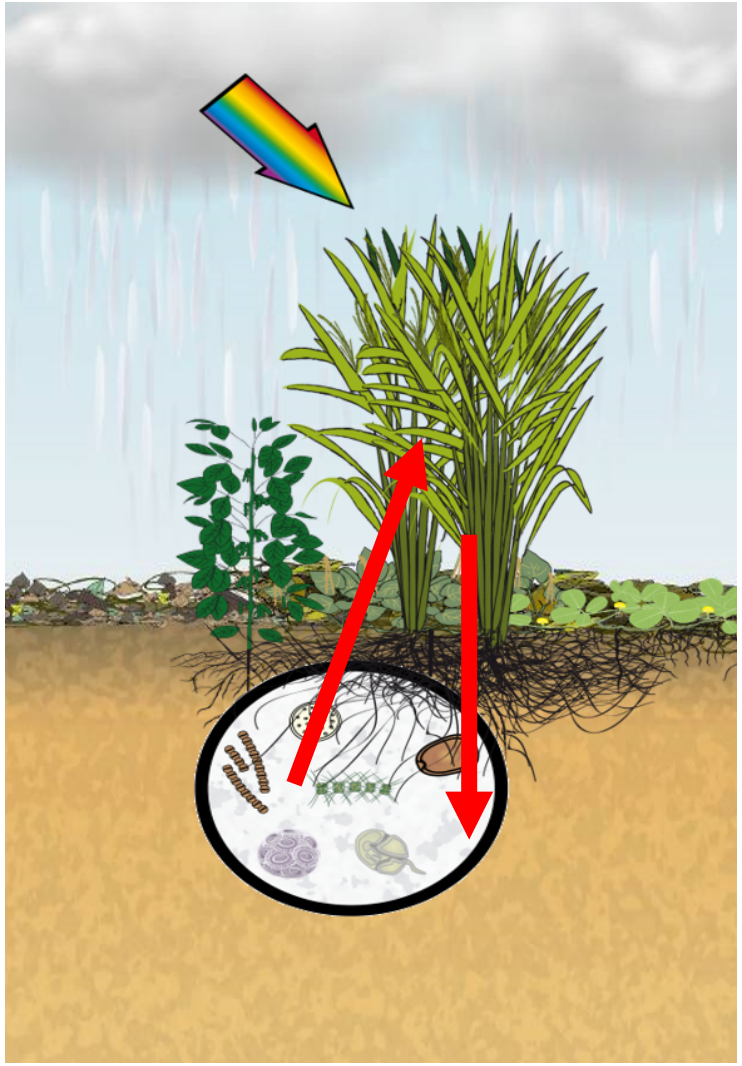
One Health requires delicate balances and many compromises... from soil to blood

I am a healthy plant on healthy soil **and I produce a lot of toxic substances** for humans and animals that want to eat me.

I am a healthy cow who ruminates a lot. **I produce a lot of methane**, a powerful greenhouse gas, **and a lot of atherogenic saturated fats.**

Balance and Compromises:

1- Soil, sun and plants



It all begins when plants convert the sun's light energy into "organic matter".
About 20% of this solar energy is “given” to soil populations.

Then, with the help of soil microbiome, plant synthetize

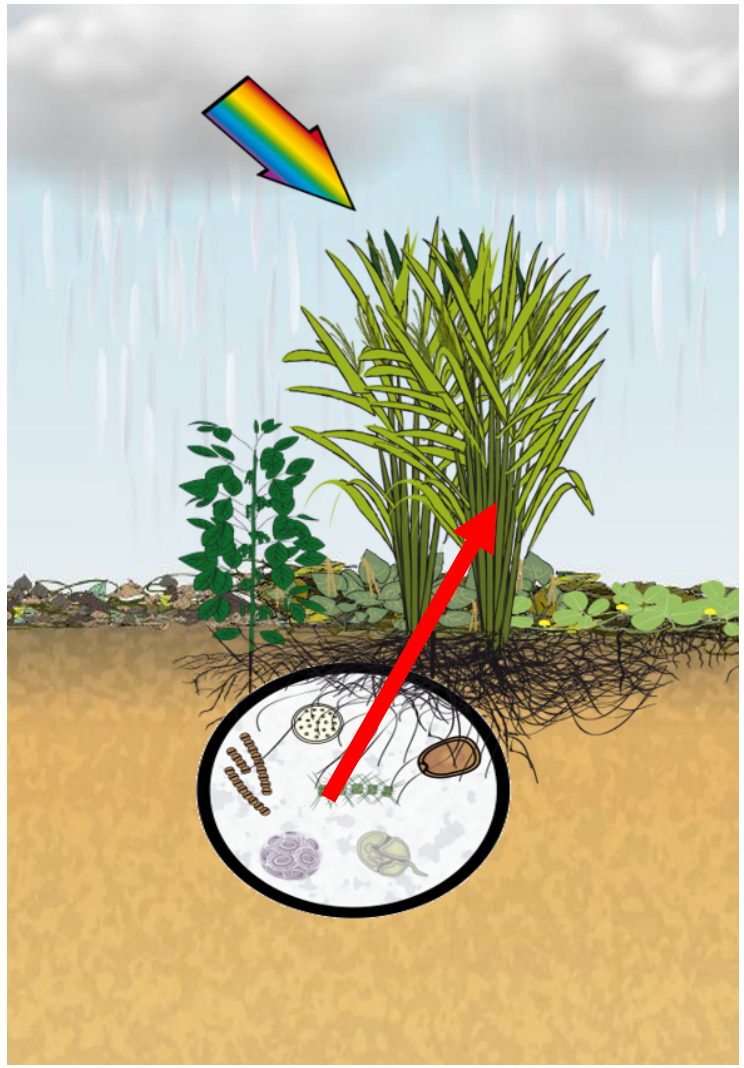
Antioxydant nutrients for the plant
They need it to fight against excess oxidation and free radicals.

Polyphenols – Flavonoïds – Vitamines - Etc..

Anti-inflammatory nutrients for the plant
Promoting plant immunity mechanisms

Alpha linolenic Acid Omega 3

2- Soil's health and plants' antioxydant and vitamines density



PeerJ

Soil health and nutrient density: preliminary comparison of regenerative and conventional farming

David R. Montgomery[1], Anne Biklé[2], Ray Archuleta[3], Paul Brown[4] and Jazmin Jordan[4]

[1] Department of Earth and Space Sciences, University of Washington, Seattle, WA, United States
[2] Dig2Grow.com, Seattle, WA, USA
[3] Unaffiliated, Seymour, MO, USA
[4] Brown's Ranch, Bismarck, ND, USA

Minimum Tillage

Crop Diversity

Organic fertiliser

Soil cover and max organic matter (carbon) in soil

Regenerative to Conventional Comparison

(average values, neighboring farms, same soil and crop variety)

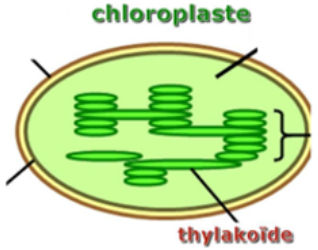
Average values for peas, sorghum, corn, soy and cabbage

Carotenoids	+15%
Phenolics	+20%
Phytosterols	+22%
Vitamin K	+34%
Vitamin C	+17%
Vitamin E	+15%
Vitamin B1	+14%

Montgomery, D. R., et al., Soil health and nutrient density: A preliminary comparison of regenerative and conventional farms, *PEERJ*, 10:e12848, 2022.

3- Alpha Linolenic Acid Omega 3

(Anti-inflammatory nutrient)



carbonyarate substrates
Acétyl-Co- A

Photosynthesis

CO2 – H2O

C16:0

C18:0

C18:1 n-9

Δ12

Δ15

C18:3 n-3 ALA

LOX: Lipoxygénase

AOS: Allène Oxyde Synthétase

AOC: Allène Oxyde Cyclase

Jasmonic Acid

Plant health and defense
Micronutrient synthesis

Human Nutrition

Agriculture and "One Health"

Adapted from Legrand & al, 2011

Pro-inflammatory

LA
Omega 6

Balance
LA / ALA = 5

Anti-inflammatory

ALA
Omega 3

20:4 n-6

20:5 n-3; 22:6 n-3

Prostaglandines
Thromboxanes

Prostaglandines
Thromboxanes

- CV diseases
- Brain composition and functionment
- Cancer & Tumoral Growth
- Diabetes
- Obesity

Animal provide from 55% to 75% of total lipids in human western diets and the composition of these lipids in FA change with animal diets composition

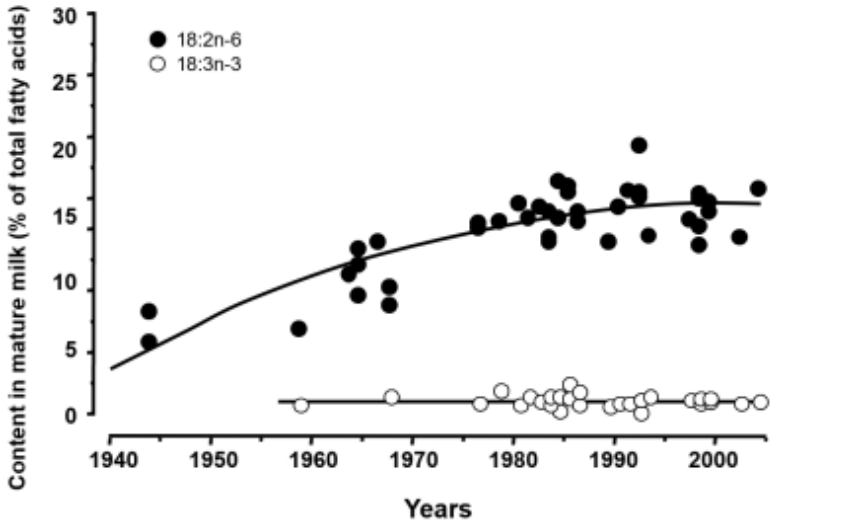
Temporal changes in dietary fats: Role of *n*−6 polyunsaturated fatty acids in excessive adipose tissue development and relationship to obesity

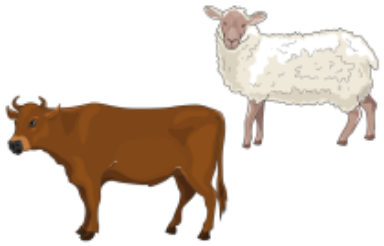
Gérard Ailhaud [a,*], Florence Massiera [a], Pierre Weill [b], Philippe Legrand [c], Jean-Marc Alessandri [d], Philippe Guesnet [d]

[a] *ISDBC, Centre de Biochimie UMR 6543 CNRS, Faculté des Sciences, Parc Valrose, 06108 Nice cedex 2, France*
[b] *Société Valorex, La Messayais, 35210 Combourtille, France*
[c] *Laboratoire de Biochimie, ENSA-INRA, 35042 Rennes cedex, France*
[d] *Unité de Nutrition et Régulation Lipidique des Fonctions Cérébrales, INRA, 78352 Jouy-en-Josas, France*

Received 9 November 2005; received in revised form 22 December 2005; accepted 10 January 2006

LA / ALA in human Breast milk





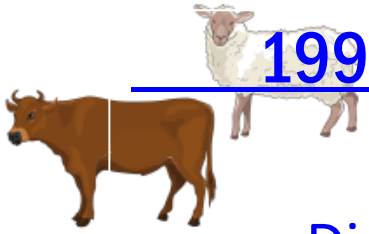
4- Ruminant provide (in France) more than a third of our lipids, and the Fatty Acids (FA) composition of their diets varies greatly according to animal diet.

	Lipids (% DM)	FA content (% lipids)	LA (% FA)	ALA (% FA)	LA /ALA
Grass	**6 à 10%**	**50%**	**12%**	**60%**	**1/5**
Corn	**4 à 6%**	**80%**	**57%**	**1%**	**57/1**
Corn silage	**3 à 4%**	**70%**	**50%**	**5%**	**50/1**
Linseed	**40%**	**90%**	**15%**	**60%**	**1/4**

From Morand-Fehr et al, 2001.

Milk (some) FA composition plasticity (Moate et al, 2007)

% total FA	**Mean**	**Min**	**Max**
C16:0	29	15	46
C18:0	12	3	27
C18:1 n-9	21	7	37
LA C18:2 n-6	**3**	**0,5**	**13**
ALA C18:3 n-3	**0,6**	**0,02**	**2**
LA / ALA	**7**	**1**	**100**



1995-2022: We measured the impact of dietary ALA intake on milk & meat FA composition and also:

Diet digestibility, GHG ouput, Fertility or Metabolic diseases in cows, goats, etc.

- Akraim et al,. (2006). Effects of preconditioning and extrusion of **linseed** on the **ruminal biohydrogenation of fatty acids**.. In vivo studies. Animal Research
- Moallem, U. (2009). The effects of **extruded flaxseed** supplementation to high-yielding dairy cows on **milk production and milk fatty acid composition**. Animal Feed Science and Technology
- Moallem et al. (2020). The effects of **omega 3 from flaxseed oil suppllemented to high yielding cows** on **production, health and fertility.** Livestock science
- Zachut et al, U. (2010). Effects of dietary fats **differing in n-6:n-3 ratio** fed to high-yielding dairy cows on fatty acid composition **of ovarian compartments, follicular status, and oocyte quality**. Journal Dairy Science
- Duvaux-Ponter et al. (2008). Effect of a supplement **rich in linolenic acid**, added to the diet of gestating and lactating goats, on the **sensitivity to stress and learning ability of their offspring**. Applied Animal Behaviour Science
- Laurain et al. (2011). Improving **milk nutritional and environmental value** with **flaxseed**-supplemented diets. World Rev Nutr Diet,

- …… & lot of others with a lot of partners




5- In monogastric animals, increase of dietary ALA has a direct impact on FA composition of eggs, meats....and

Lipogenesis, Peroxidation, Production performance, Piglet health, C footprint and sensory quality,

(Tran 2000 et Weill 2002)

	Lipids (% DM)	LA (% FA)	ALA (% FAt)	LA/ALA
Wheat	2,0%	60%	5%	**12**
Barley	2,5%	56%	6%	**9**
Corn	4,5%	60%	1%	**60**
Soybean Meal	2%	57%	7%	**8**
Rapeseed Meal	3,50%	20%	7%	**3**
Sunflower Meal	2,50%	68%	0,30%	**227**
Linseed	40%	15%	60%	**0,25**

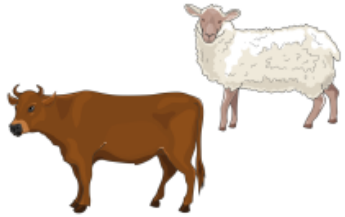
Eggs, meats and cured meats (excluding ruminants) account for 25% of lipid consumption in France.

The n-6 and n-3 fat content of these animals' lipids reflects their n-6 and n-3 fat intake.

The n-6 / n-3 ratio of monogastric animals' usual rations is usually between 7 and 25.

1. Guillevic, M. et al (2009). Effect of a linseed diet on lipid composition, lipid peroxidation and consumer evaluation of French fresh and cooked pork meats. Meat Science,
2. Baeza, E., et al (2015a). Is it possible to increase **n-3 fatty acid** content of meat without affecting its technological and/or sensory quality and the growing performance of chickens? British Poultry Science.
3. Shapira, et al. (2008). Egg fortification with n-3 polyunsaturated fatty acids (PUFA): nutritional benefits versus high n-6 PUFA Western diets, and consumer acceptance. The Israel Medical Association Journal.
4. Guillevic, et al (2009). Effect of a linseed diet or a sunflower diet on performances, fatty acid composition, lipogenic enzyme activities and stearoyl-CoA-desaturase activity in the pig. Livestock Science,
5. de Quelen, et al. (2011). N-3 polyunsaturated fatty acids in the maternal diet **modify the** post-natal development of nervous regulation of intestinal permeability in piglets. The Journal of Physiology, & lot of others

1995-2022. When ALA is the dominant PUFA in animal diets, (in the form of grass or extruded linseed) :



- **Milk lipids contain less C16:0 and more ALA (and also more MUFA & CLA c9 t11).**
- **Greenhouse gas emissions (CH4) are reduced by 10 to 30% for the same milk production level.**
- **Fewer metabolic diseases. The health and fertility of animals (and their offspring) are improved.**
- **Milk and meat production are maintained with lower intake levels.**
- **Butter is softer, and meats are preferred in sensory analyses.**

Animal product lipids contain:

More n-3 : ALA (in TG), **EPA, DHA** (in PL) **as % of total FA**

Lower n-6 / n-3 ratio

Less C16:0 in % & less total fat

With improved technological and sensory quality of raw animal products

With improved (some) measurable animal health parameters, notably piglet health when sows are fed this way.

With reduced "global warming" footprint of eggs, pigs and chickens meat.

So, ALA is interesting for plant & animal health. ALA is interesting for environment & climate change.

6- And for man's health ?

Consumption of n-3 PUFAs (in France and..) **is far from recommended levels**

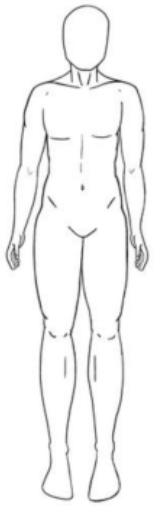
	Minimal requirement	**ANC 2010**	Consumption(1)	conso / ANC	**% People consuming ANC (2)**
Total lipids	30% AE	35-40% AE	31-36% AE	=	
LA C18:2n-6	2% AE	4% AE	4% AE	=	
ALA C18:3 n-3	0,8% AE	**1% AE**	0,4% AE	**50%**	**2,3%**
DHA C22:6 n-3	250 mg	**250 mg**	180 mg	**72%**	**14,6%**
EPA C20:5 n-3		**250 mg**	140 mg	**56%**	**7,8%**
C12:0+C14:0+C16:0		≤ 8% AE	8-9% AE	113%	
SFA		≤12% AE	13-15% AE	125%	
Oleic Acid C18:1n-9		15-20% AE			
Other FA					

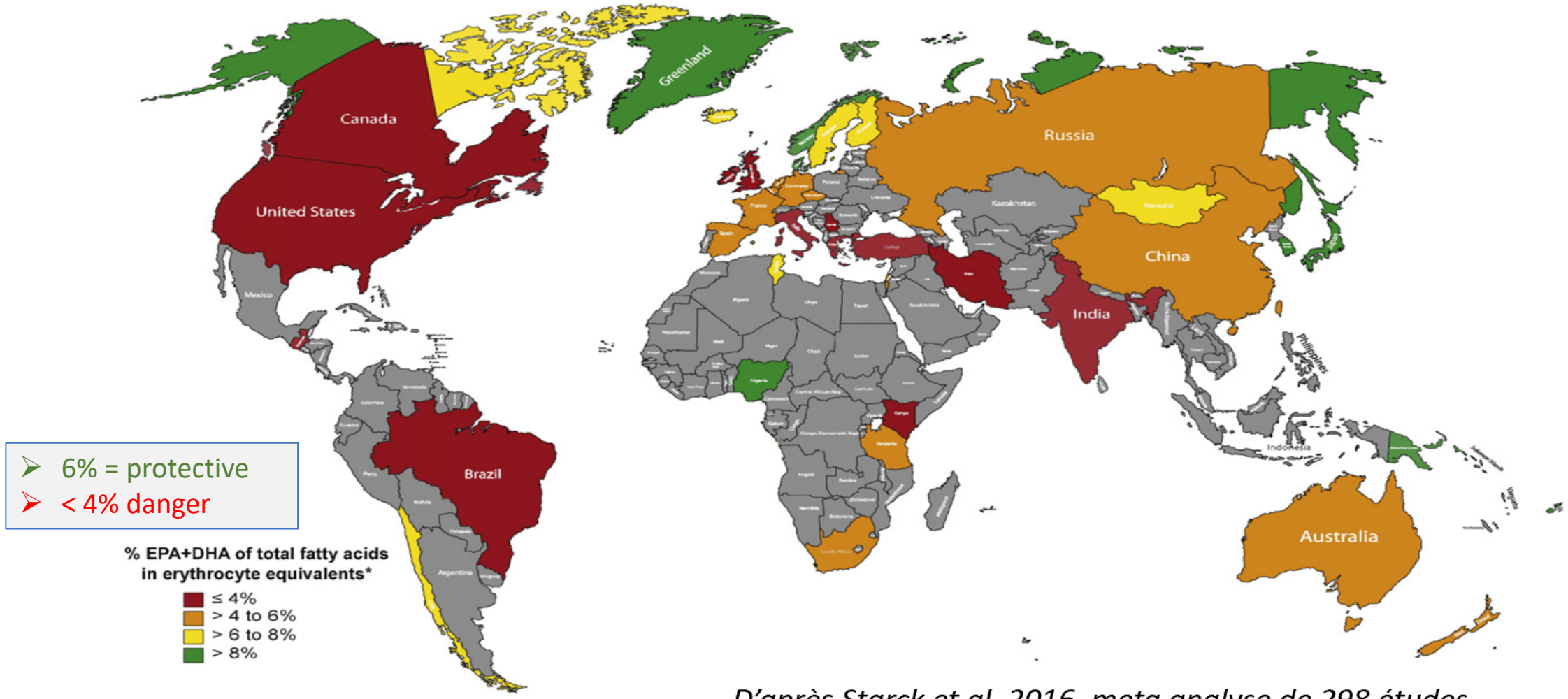
Official French Guidelines (ANC) for FA consumption
Apports Nutritionnels Conseillés (ANC) de l'ANSES, 2011

AE: Total Calorie intake without alcohol *(1) INCA 3 study* *(2) Tressou & al 2018 INCA 2*

Animal lipids account for 60% to 65% of lipids consumed in France *(Lafay & al, 2017 INCA 2, INCA 3)*

- **EPA and DHA, described as "marine" omega 3s, are most often derived from non-renewable fish resources.**

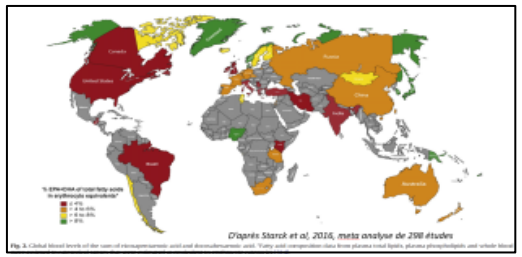




- 6% = protective
- < 4% danger

D'après Starck et al, 2016, meta analyse de 298 études

Fig. 2. Global blood levels of the sum of eicosapentaenoic acid and docosahexaenoic acid. *Fatty acid composition data from plasma total lipids, plasma phospholipids and whole blood were assigned to categorical ranges that were estimated as equivalent to erythrocyte categories [314].



Can adding ALA to land animal diets reduce the global n-3 fat deficit in humans ?

- **In order to raise the world's population into the green range**, … a total of **3.12 million metric tons of EPA+DHA would be needed every year**. …the present production **would only support about 6% of the population**.

- **One suggestion has been to increase the consumption of ALA,** the precursor of EPA and DHA as there is an abundant supply of this fatty acid in vegetable oils. However, the human conversion to EPA is limited and conversion to DHA is very low such that **supplementation studies with ALA in humans have shown little increases in EPA and DHA**.

- **The "fish" resource is insufficient**
- **The "vegetable oils" resource is inefficient (***for conversion to EPA, DPA, DHA)***)**

- **Terrestrial animals are rarely (never) considered as a potential source**

2000:
Validation of the hypothesis

Original Paper

Annals of Nutrition & Metabolism

Ann Nutr Metab 2002;46:182–191
DOI: 10.1159/000065405

Received: September 12, 2001
Accepted: March 20, 2002

Effects of Introducing Linseed in Livestock Diet on Blood Fatty Acid Composition of Consumers of Animal Products

Pierre Weill[a] Bernard Schmitt[b] Guillaume Chesneau[a] Norohanta Daniel[b]
Faouzi Safraou[b] Philippe Legrand[c]

[a]Valorex, Combourtillé, [b]Centre d'Enseignement en Nutrition, Centre hospitalier de Bretagne sud, Lorient, et
[c]Laboratoire de Biochimie ENSA/INRA, Rennes, France

With the addition of 5% extruded flax to animal rations, all other things being equal, we measure a significant improvement in lipid composition in the plate, serum and red blood cells of consumers of animal products after only 35 days. (LA/ALA: -50% in serum & OI : + 10% in RBC)

2000 - 2023...

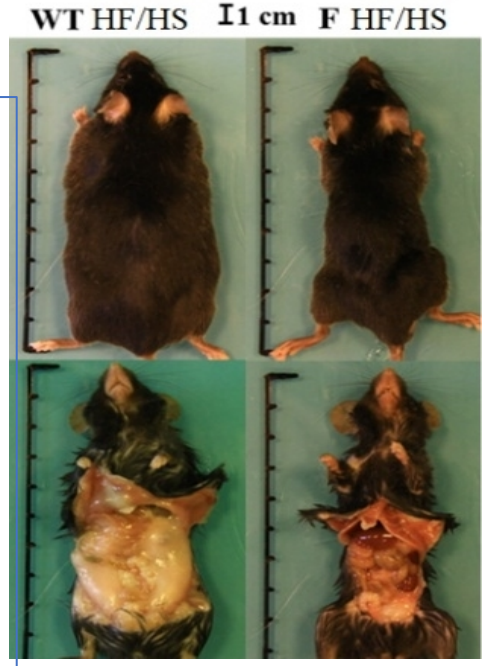
From Blood FA composition to Health Markers

Strengthening the scientific basis

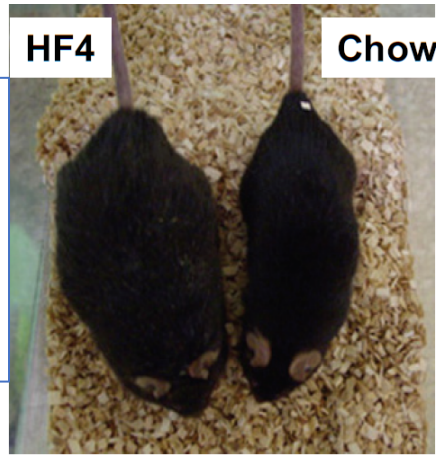
(Human Health is the endpoint)

Dedicated Animal studies (some examples)

FAT 1 or WT Mice
N-3 PUFA: An innovative strategy against obesity and related metabolic disorders, intestinal alteration and gut microbiota dysbiosis
(Bellenger & al)



A Western-like fat diet is sufficient to induce a gradual enhancement in fat mass over generations
((Massiera et al,)



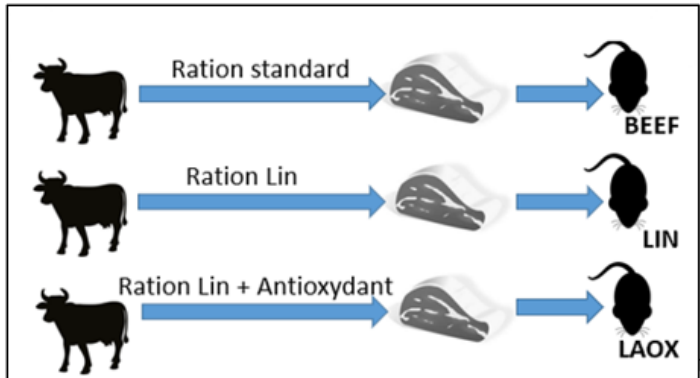
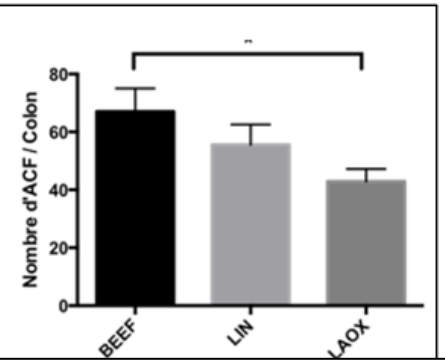


Figure 1: Logigramme de l'étude : production des viandes bovine et expérimentation nutritionnelle chez le rat F344.



Modulation of **early biomarkers of carcinogenesis** in rats by consumption of red meat **from cattle fed rations rich or not in omega 3 and antioxidants** (*Pierre et al*)

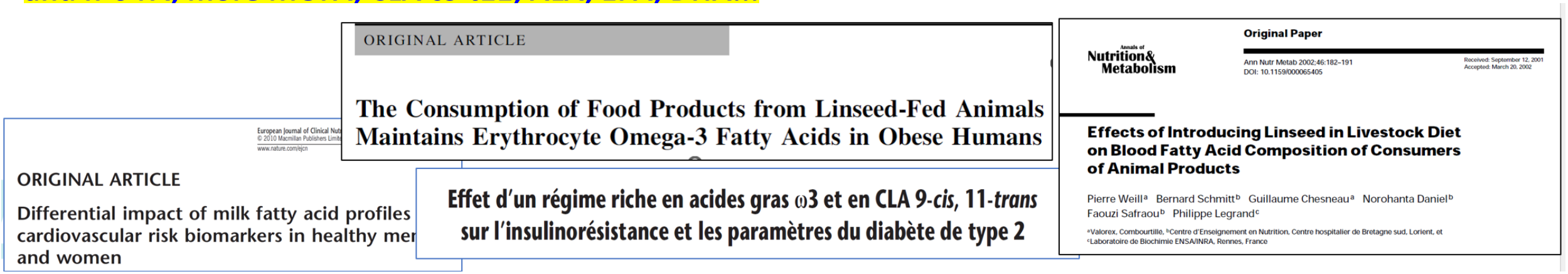
Human trials results

NB: The experimental variable is ALA in the animal's diet

- With the same study design (changing animal diets, but not human regimens), we measure **"modest" but significant changes:**

- Significative improvement for **red blood cell FA composition** in healthy and obese volunteers
- Significative improvement for **Insulinemia** (tendency for IR) in diabetics volunteers
- Significative improvement for **cardiovascular markers** in healthy volunteers (10% less predicted stroke)
- Significative improvement for **weight regain & BMI** (4 times less) after a low-calorie diet in obese volunteers .

- **It's impossible to say whether these positive effects in humans are linked to a particular FA, since :Less C16:0 and n-6 FA, more MUFA, CLA c9 t11, ALA, EPA, DHA…**



- **NB: a trial measured the impact of more "direct" ALA (5% Extruded flax in bread): More ALA & EPA in blood…**

7- And Environment ?

Methods to simplify diet and food life cycle inventories: accuracy versus data-collection resources

Franck Pernollet, Carla R.V. Coelho, Hayo M.G. van der Werf

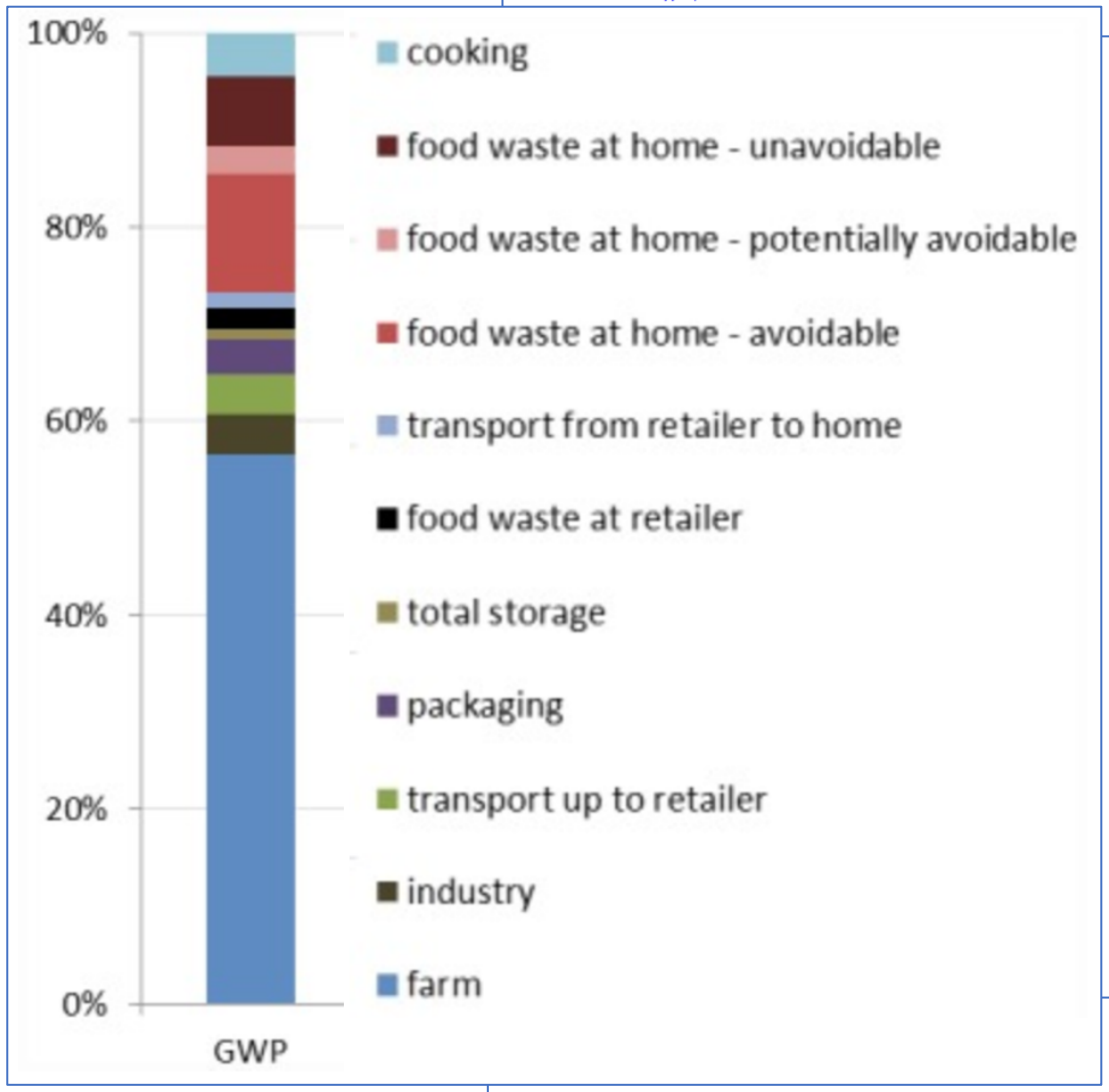
PII: S0959-6526(16)30788-0

DOI: 10.1016/j.jclepro.2016.06.111

Climate Change: 60% of our meals GHG are emitted at farm door (the "agricultural " stage of food production).
(And 25% "at home")

At farm door, GHG emission are reduced by 15 to 30% (CH_4, N_2O, CO_2) when animal diets contain more ALA, less LA.

Less… but better
(Lower footprint & higher nutrient density)



Coelho et al, 2016 (AGRAID)

FAO-WHO-PNUE One health definition:

The health of humans ✓, animals ✓, plants ✓, and the environment ✓, in general (including ecosystems) is closely linked and interdependent". (2021)

Good Proof of concept …

So, we have a lot of scientific data

What to do with all this ?

For Earth, Animals and Men

The "Bleu-Blanc-Coeur" NPA was created in August 2000 (after the first clinical trial) to organize a: HEALTH ORIENTED AGRICULTURE based on:

1- Measures (health, climate, mainly)=obligation of results

2- Scientific consensus =

Basis of 420 peer-review articles including 7 human trials

3- Large Accessibility

BLEU-BLANC-CŒUR : LARGE ACCESSIBILITY

PREMIUM PRICE + 5% (64% of French consumers are familiar with the brand and trust is very high)

Today (2022): The largest quality approach in the animal sector.

From 5 to 15% by sectors :

6% of all French eggs

8% of all French pigs

4% of all French chicken

4% of all French milk

Etc. (25% for rabbit ☺)

> 2 bs € for the BBC products

GOVERNANCE AND ORGANIZATION (ALL THE FOOD CHAIN)

950 members from the economic sectors from farmers to retailers.

Administration Council

INRAE

Conseil d'administration

30 Researchers from public institutes

Scientific board

8 collèges
représentés par un maximum de 4 représentants élus :
1- Production Végétale (2)
2- Nutrition Animale (2)
3- Producteurs Fermiers (2)
4- Production Animale (2)
5- Transformateurs (4)
6- Distributeurs (3 – deviendra 4 à l'AG)
7- Associations et Collectifs de Consommateurs (2)
8- Interprofessions et Représentants Filières (2)

4 communautés
représentés par 1 à 2 représentants élus :
1- Professionnels de la Santé (2)
2- Eleveurs Engagés (1)
3- Consommateurs Individuels (1)
4- Métiers de Bouche (1)

1 Conseil Scientifique

1 représentant nommé par le PDG de l'INRAE
+ 2 représentants nommés par le conseil scientifique

27.000 members
Chefs, Health prof. Farmers, Consumers

FOR INSTANCE:
EGGS SPECIFICATION


Obligation of means:

A minimum of vegetal Omega 3 in hen's feed: 0,66% Omega 3 from linseed, grass, alafafa..

No imported protein linked to deforestation (Palm, Soybean..)

Usage of growth factors is prohibited

A mInimum of 6 different seeds in feed

Free range

Maximum CO2 in feed: 420 g/ kg feed

Obligation of results:

Omega 3 > 4 (versus 1,5% of FA)

DHA: > **1,5 (versus 0,7% of FA)**

SFA / Omega 3 < 7 (versus 23)

Omega 6 / Omega 3 **< 4 (versus 15)**

The difference (nutritional superiority) can be measured analytically.

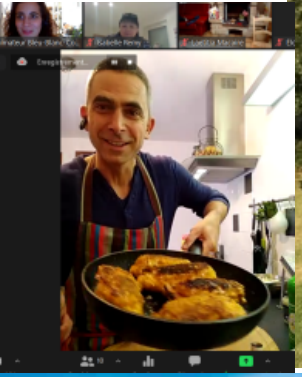
The Obligation of Results consists of 5 analitical criteria:

(in % of total FA)	Standart egg	Bleu-Blanc-Coeur egg			
	Standart value	Compliant		Non compliant	
		Target value	Tolerance area	Out of limit	Remarks
Omega 3	1.5	**≥4.5**	**≥4**	<4	Rich in "good fat"
DHA	0.7	**≥1.5**	**≥1.2**	<1.2	Rich in "good fat"
ALA	0.8	**≥2.8**	**≥2.4**	<2.4	Balanced
Omega 6/ Omega 3	15	**≤4.5**	**≤5**	>5	Balanced
SFA/ Omega 3	23	**≤7**	**≤10**	>10	Balanced

[1]This table relates only to eggs. For other finished products, incorporating fats of different origins in their composition (e.g. omelets with bacon), refer to the specifications in section 17 "Caterers, prepared meals and other elaborated products".

Each sector(Eggs, Milk, Honey, Spinach leaves, Chicken, Trout… has its own specification)

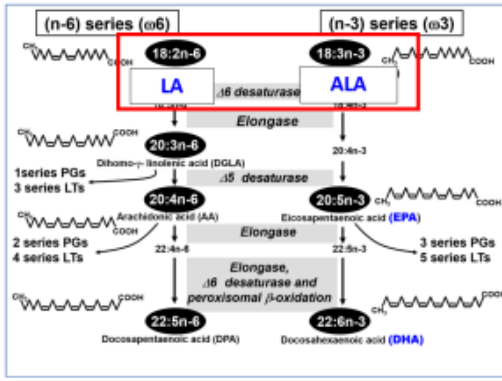
Always linked with nutrient density (obligation of results)






When animals are well fed, man is healthier

Communication ≠ Information



Bleu-Blanc-Cœur communities: 26 851 voluntary members (physicians, dieticians, chefs, farmers, consumers)


Valérie Pons
(Chef)


Josiane Sablé
(éleveuse)

OUT OF FRANCE...

8-Ongoing human studies

2 * 40 **pregnant** then lactating **women**

Recruited at the 6th month visit at the hospital

Endpoint = Milk FA composition at 21d
+ Baby microbiote

Started 2023

Till 2027

Elderly People

MAIA: Study en EHPAD (nursing home)

Endpoint = risk of bacterial infection
+ **muscle and brain**

Iso Human Regimen
Differences in animal diets only
Commercial products

Temporal changes in dietary fats: Role of $n-6$ polyunsaturated fatty acids in excessive adipose tissue development and relationship to obesity

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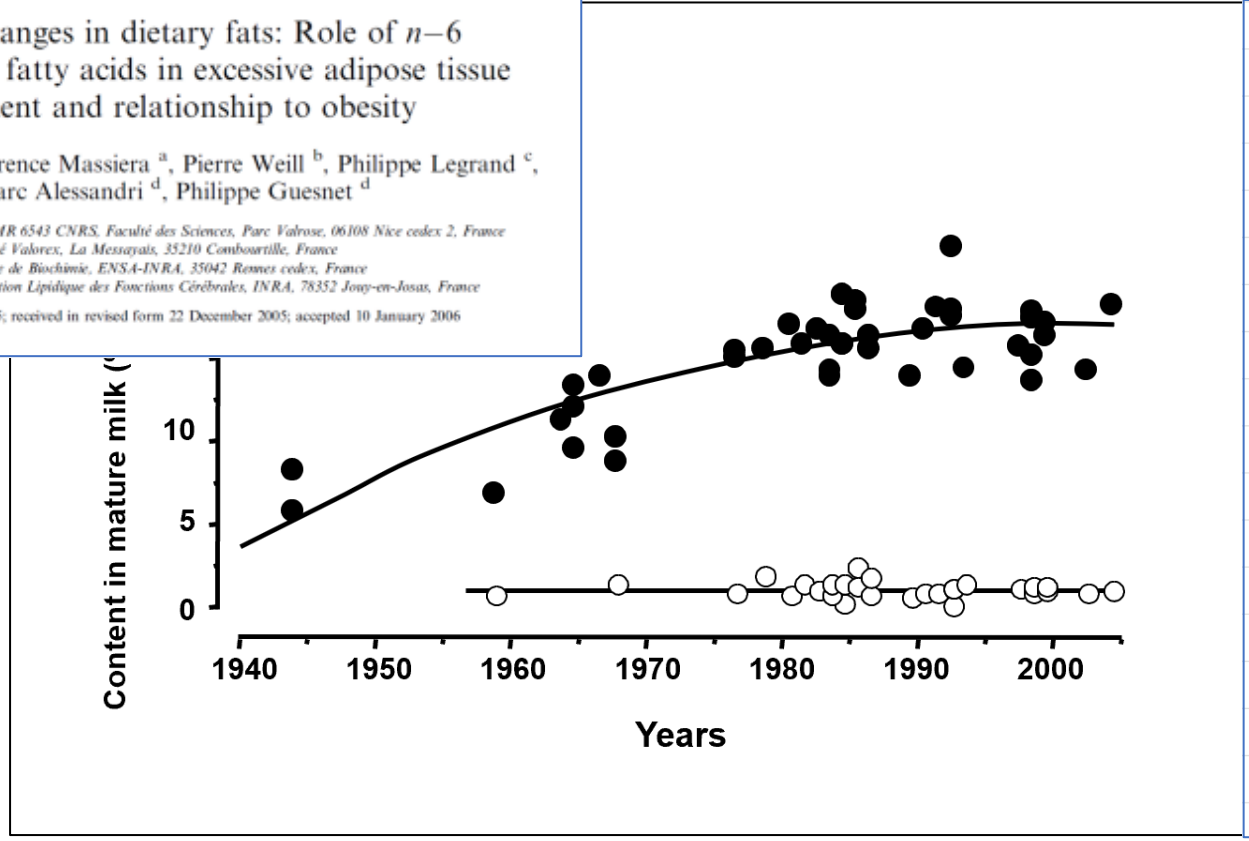
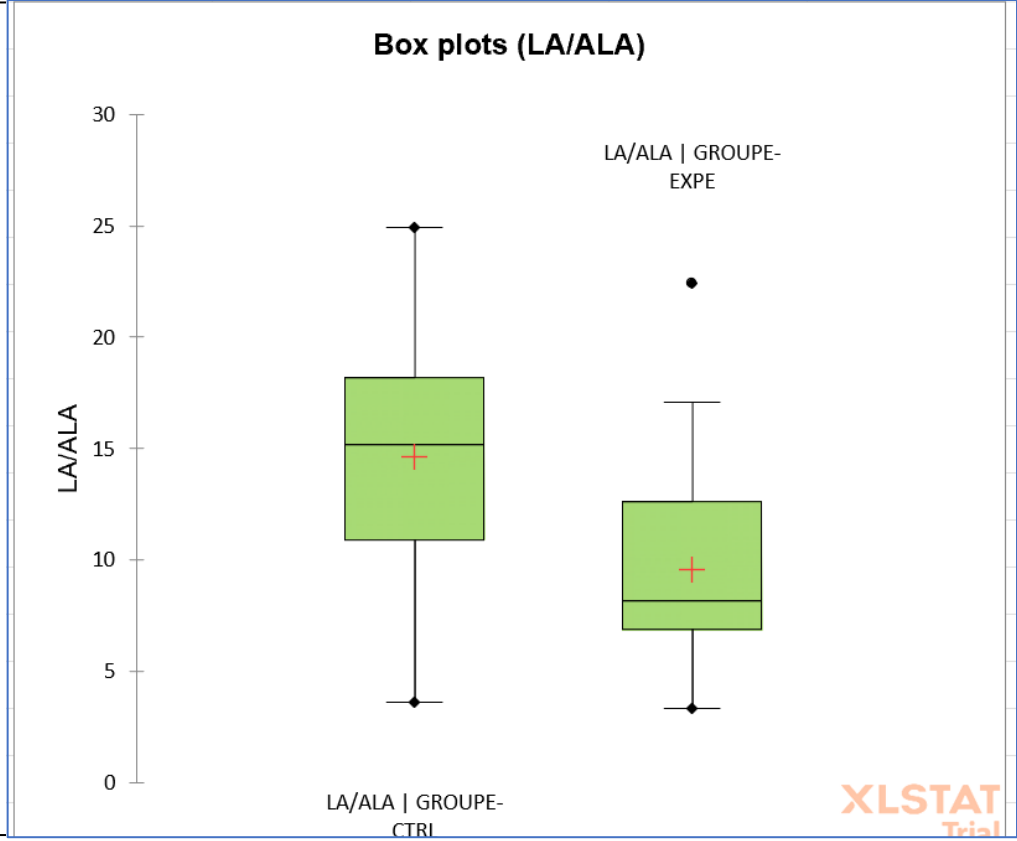




BBC:

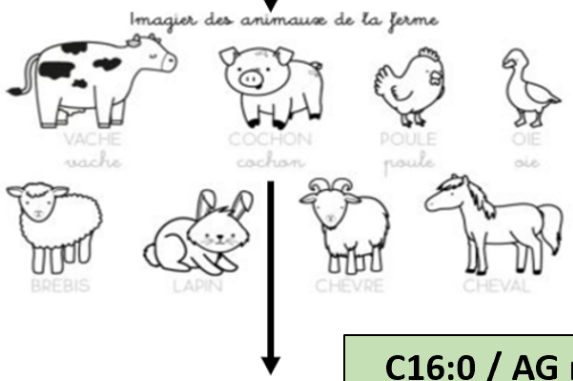
- **0,3 t of CO2 /an (-3% total footprint**
- **& -13 &% food footprint (Agribalyse)**

ALA : + 42% in breastmilk at d21

From 6th month inclusion to D21 = 100 d

Take home messages from these 26 years experience

LA / ALA < 3



C16:0 / AG n-3

ALA + EPA +
DPA n-3 + DHA

- ALA is a component of plant health (JA)
- ALA-rich crops contribute to a better environmental footprint of food
- ALA in animal diets helps animal health and fertility
- ALA fed animal products have better nutritional and sensorial quality
- These terrestrial products contribute to ALA, EPA, DHA needs in humans.
- They help improvement of some human health markers
- The consumer acceptance of these products is good
- **PUFA Biosynthesis is a good documented example of One Health Concept**
- Enrichment of the human diet with “well fed” animals appears to be effective for nutrition-health prevention .....
- *(As a complement to direct intake of plant ALA and consumption of fish (although the design of the human studies prohibited consumption of fish and rapeseed oil).*
- **In our example: Human health is the ultimate goal of “One Health”**

Thank you

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Cultivons vos différences

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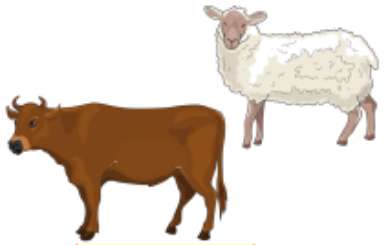
Pour la Terre, les animaux et les hommes



Lipids (Long PUFA)

Concentrate

Forage

Carbohydrates

Concentrate (starch)

Forage (cellulose)

Diet

By-Pass

C18:3 n-3, C18:2 n-6, C18:1 n-9

Bio-hydrogenation

C18:0, C18:1 tr10, C18:1 tr11, C18:2 c9tr11

C18:0, C18:1 tr10, C18:1 tr11, C18:2 c9tr11

De novo synthesis

Odd and branched FA

Degradation

Propionate

Acetate

Rumen

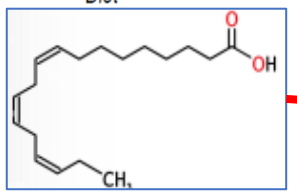
ALA: C18:3 cis 9 cis 12 cis 15

C18:3 cis 9 trans 11 cis 15

C18:2 cis 9 trans 11

C18:1 trans 11

C18:0



CH4

poproteine lipase

EFA

Glut 1

3-Glycerol-P

Glycerol

(C14-C18)

Δ-9 desaturase

(>C16) Glycerophospholipids

(C12-C22)

Acyl-coA

(C4-C22) Triglycerides

De novo FA synthesis

Fatty acid synthase

(C4-C16)

Ceramide

Sphingosine

(>C16) Sphingolipides

Fat globule

AcetylCoA carboxylase

Cholesterol

Acetate

De novo synthesis

Specific hydrolase

Cholesterol esters

Pigments and vitamines

Lactocyte