L'oeuf, source de Protéines et de Micronutriments

Francoise Nau

Productions Animales : durabilité des systèmes et conséquences pour le consommateur

Quoi de neuf dans l'œuf ?

L'œuf, source de Protéines et de Micronutriments

Françoise NAU

Prof. *Sciences des Aliments*

UMR1253 Science et Technologie du Lait et de l'Œuf

l'institut Agro
agriculture • alimentation • environnement

AGRO CAMPUS OUEST

INRAE

Journées Francophones de Nutrition

JFN Live Connectons nos savoirs

25-27 novembre 2020

DECLARATION DE LIEN D'INTERÊT

JFN Live
Connectons nos savoirs

- **Activités de conseil, fonctions de gouvernance, rédaction de rapports**
  *Non ~~/ Oui *~~* *Société(s) : ……*

- **Essais cliniques, autres travaux, communications de promotion**
  *Non ~~/ Oui *~~* *Société(s) : ……*

- **Intérêts financiers (actions, obligations)**
  *Non ~~/ Oui *~~* *Société(s) : ……*

- **Liens avec des personnes ayant des intérêts financiers ou impliquées dans la gouvernance**
  *Non ~~/ Oui *~~* *Société(s) : ……*

- **Réception de dons sur une association dont je suis responsable**
  *Non ~~/ Oui *~~* *Société(s) : ……*

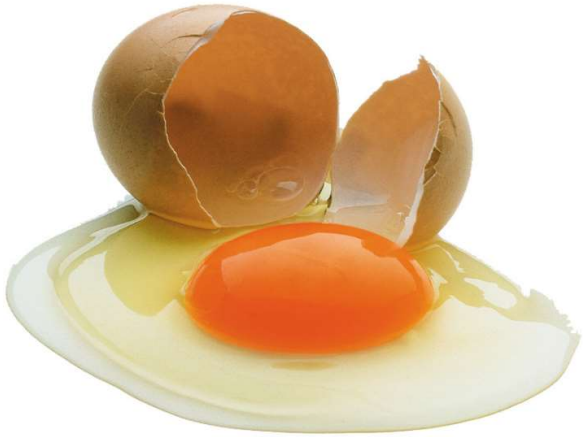
- **Perception de fonds d'une association dont je suis responsable et qui a reçu un don**
  *Non ~~/ Oui *~~* *Société(s) : ……*

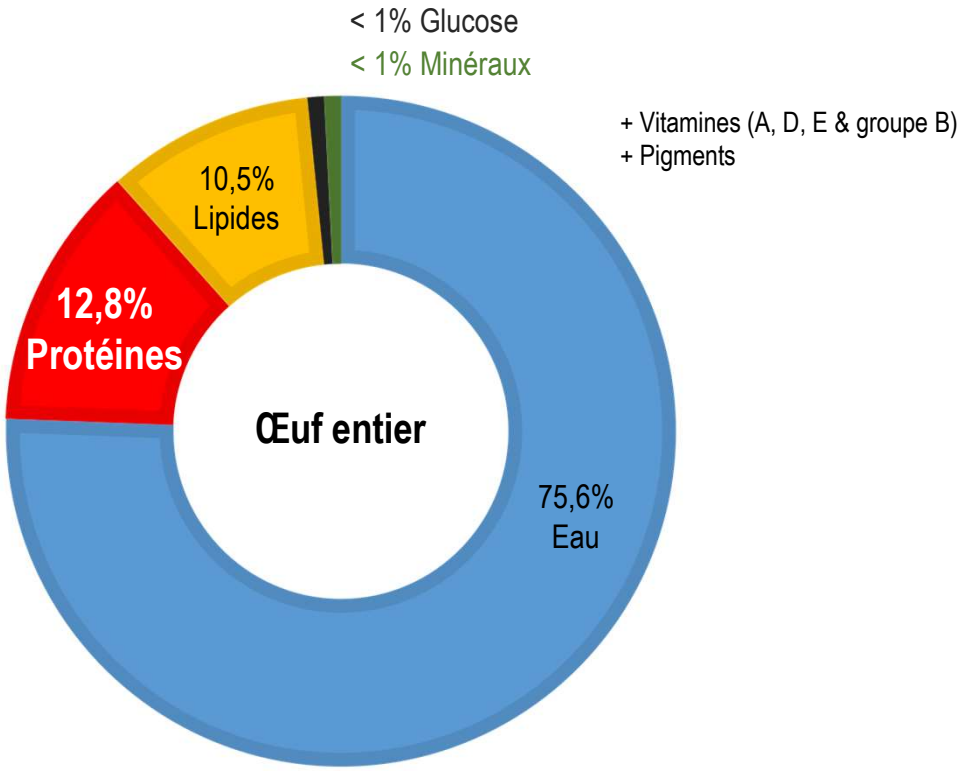
- **Détention d'un brevet, rédaction d'un ouvrage utilisé par l'industrie**
  *Non ~~/ Oui *~~* *Société(s) : ……*

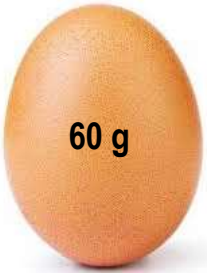
** Rayer la mention inutile*

Œuf et PROTÉINES

Un aliment riche en protéines







= 10% des ANC (RNP) en protéines d'un homme adulte
(~ 30 à 35 g de viande de boeuf ou de poisson pour l'apport protéique)

Des protéines de haute qualité

- Aucun acide aminé limitant

Acides aminés essentiels	Quantité apportée par 100 g d'œuf entier (mg)(1)	% de couverture des besoins quotidiens(2) par 100 g d'œuf
Histidine	290	33
Isoleucine	660	46
Leucine	1040	33
Lysine	820	34
Méthionine + cystéine	640	53
Phénylalanine + tyrosine	1150	53
Thréonine	590	46
Tryptophane	190	59
Valine	790	55

(1) D'après Seuss-Baum et al (2011) In Improving the safety and quality of eggs and egg products, vol 2, Woodhead Publishing Ltd, pp 201-236
(2) Calculés pour un homme adulte de 80 kg d'après les propositions de l'AFSSA 2007

- 91-97% de digestibilité vraie chez l'Homme

(Young et al, 1973; Bodwell et al, 1980; Evenepoel et al, 1998)

Food	PDCAAS	DIAAS	Limiting AA
MPC[a]	1.00	1.18	
WPI[a]	1.00	1.09	
SPI[a]	0.98	0.90	Met + Cys
PPC[a]	0.89	0.82	Met + Cys
RPC[a]	0.42	0.37	Lys
Whole milk[b]	1.00	1.14	Met + Cys
Chicken breast[b]	1.00	1.08	Trp
Egg (hard boiled)[b]	1.00	1.13	
Cooked peas[a]	0.60	0.58	Met + Cys
Cooked rice[a]	0.62	0.59	Lys
Almonds[b]	0.39	0.40	Lys
Chickpeas[b]	0.74	0.83	Met + Cys
Tofu[b]	0.56	0.52	Met + Cys
Corn-based cereal[a]	0.08	0.01	Lys
Hydrolyzed collagen[c]	0.0	0.0	Trp

PDCAAS, protein digestibility-corrected amino acid score; DIAAS, digestible indispensable amino acid score; MPC, milk protein concentrate; WPI, whey protein isolate; SPI, soy protein isolate; PPC, pea protein concentrate; RPC, rice protein concentrate; Trp, tryptophan.
[a]Values from Ref. (26).
[b]Values from Ref. (24). FAO 2013
[c]Hydrolyzed collagen has a PDCAAS and DIAAS of 0 since it contains no Trp and is very low in methionine (27).

Phillips, 2017

Œuf et MICRONUTRIMENTS

Nutrition Bulletin

ORIGINAL ARTICLE

DOI: 10.1111/nbu.12462

Evaluating current egg consumption patterns: Associations with diet quality, nutrition and health status in the UK National Diet and Nutrition Survey

S. Gibson* and **J. Gray**†

*Registered Nutritionist, Sig-Nurture Ltd., Southampton, UK;
†Registered Nutritionist, London, UK

		Male ♂			Female ♀		
		Egg non-consumer	Egg consumer	P value	Egg non-consumer	Egg consumer	P value
	N	114	159		150	224	
Eggs and egg dishes (g/day)†	Mean	0	54	<0.001	0	46	<0.001
	SE	0	3		0	3	

~6 eggs/ week

~5 eggs / week

Table 5 Micronutrient status of egg consumers and non-consumers (means)

		Male			Female		
	N	Egg non-consumer	Egg consumer	*P* value	Egg non-consumer	Egg consumer	*P* value
N (max)	*295*	*54*	*73*		*59*	*109*	
25-hydroxy vitamin D (nmol/l)	*295*	47	50	ns	48	57	0.031
Total carotenoids[†] (μmol/l)	*290*	1.85	1.84	ns	1.9	2.38	0.005
Lutein (μmol/l)	*290*	0.25	0.25	ns	0.23	0.27	0.033
Holotranscobalamin (pmol/l)	*289*	71	72	ns	78	79	ns
Vitamin B2 Status (EGRAC)	*288*	1.37	1.33	ns	1.37	1.36	ns
Vitamin B1 Status (ETKAC)	*288*	1.12	1.12	ns	1.12	1.11	ns
Vitamin B6 Pyridoxal-5-Phosphate (PLP) (nmol/l)	*290*	51	52	ns	45	50	ns
Red cell folate (nmol/l)	*267*	579	604	ns	594	591	ns
Total serum folate (nmol/l)	*295*	18.1	17.9	ns	16.4	19.0	ns
Selenium (μmol/l)	*290*	1.0	1.03	ns	0.97	1.04	0.011
Zinc (μmol/l)	*290*	13.2	13.2	ns	12.3	12.5	ns
Haemoglobin (g/l)	*283*	147	148	ns	130	133	ns
Ferritin (μg/l)[‡]	*286*	118	130	ns	49	72	0.003
Low iron status							
Hb < 120 g/l	*283*	0%	2.7%	ns	18.2%	5.0%	0.007
Ferritin < 15 μg/l[‡]	*286*	0%	1.4%	ns	17.9%	8.4%	0.074

ns, non-significant. *P* values for T-test, except for carotenoids, lutein and ferritin (Mann–Whitney). Categorical analysis using chi-square.

Italics indicate number of subjects.

[†]Composite of lutein, alpha-cryptoxanthin, beta-cryptoxanthin, lycopene, alpha-carotene and beta-carotene.

[‡]Ferritin excludes values > 400 μg/l.

Œuf et MINÉRAUX

Une forte variabilité

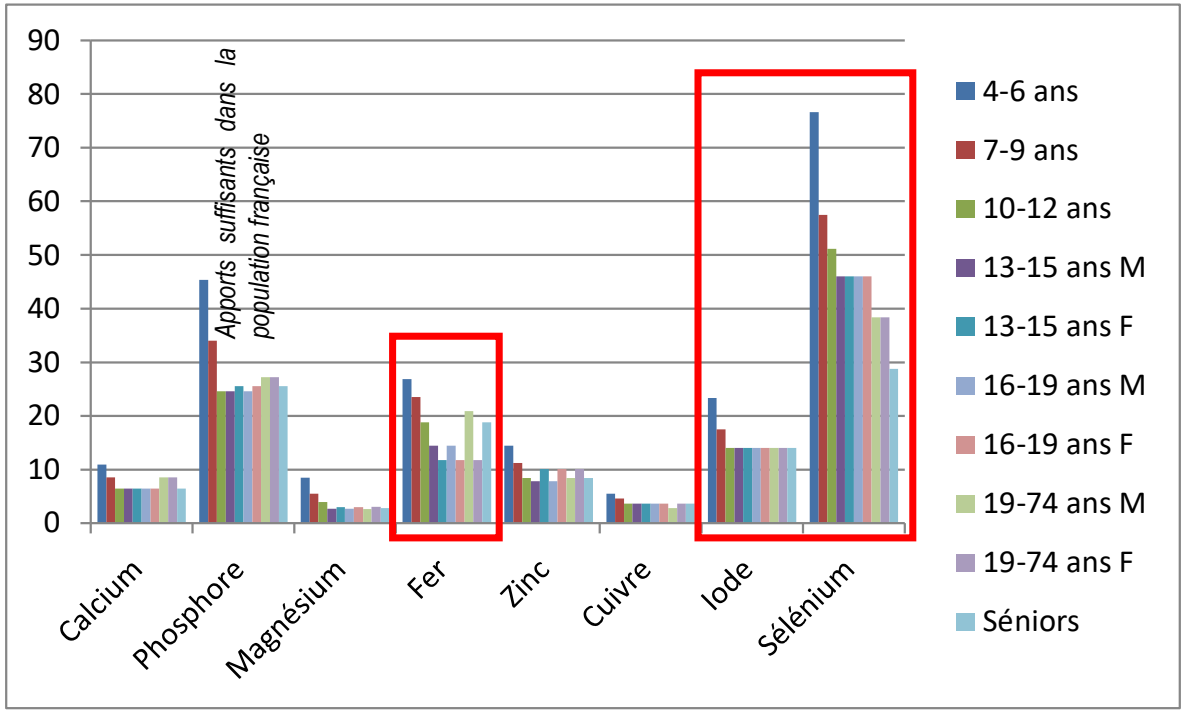
Composition minérale de l'œuf (pour 100 g de produit)

	CIQUAL 2020			Gammes de variation observées dans les tables nationales de l'UE[1]	
Minéraux (mg/100 g)	**Œuf entier cru**	Blanc cuit	Jaune cru	Œuf entier	Valeur max / Valeur min
Potassium	134	163	43	104-147	1,4
Sodium	124	166	19.1	110-144	1,3
Calcium	76.8	6	50.2	40-91	**2,3**
Phosphore	204	15	141	179-312	1,7
Magnésium	11	11	1.5	9-13,0	1,4
Fer	1.88	0.05	0.7	1,5-2,9	1,9
Zinc	1.01	0.03	1,1	1,01-2,3	**2,3**
Cuivre	0,055	0,023	<0,1	0,06-0,14	**2,3**
Iode	0,021	0,002	0,175	0,01-0,053	**5,3**
Sélénium	0,023[2]	0,006	0,084	0,006-0,032	**5,3**
Manganèse	0,027	0,011	<0,1	nd	nd

(1) Extrait de Seuss-Baum, Nau, Guérin-Dubiard (2011) The nutritional quality of eggs, In Imrpoving the safety and quality of eggs and egg products, vol2, Woodhead Publishing

(2) Valeur de la table Ciqual 2013

Des apports intéressants en selenium, iode et fer



Pourcentage des ANC couverts par 100 g d'œuf entier

(calculs effectués à partir des teneurs moyennes des tables CIQUAL et des ANC rapportées dans l'étude INCA2).

foods

MDPI

Un enrichissement possible en **sélénium**

Article

Effect of Selenium Source and Level on Performance, Egg Quality, Egg Selenium Content, and Serum Biochemical Parameters in Laying Hens

Hu Liu [1,2], Qifang Yu [1,2], Chengkun Fang [1,2], Sijia Chen [1,2], Xiaopeng Tang [1,2], Kolapo M. Ajuwon [3] and Rejun Fang [1,2,*]

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2 Hunan Co-Innovation Center of Animal Production Safety, Changsha 410128, China
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* Correspondence: fangrj63@126.com

Received: 4 December 2019; Accepted: 7 January 2020; Published: 8 January 2020

Table 4. Effects of dietary supplementation of different selenium sources and levels on egg selenium content of laying hens.

Parameters.	Basal Diet	Se yeast SY-L 0,3mg/kg	Se yeast SY-H 0,5mg/kg	Sodium Se SS-L 0,3mg/kg	Sodium Se SS-H 0,5mg/kg	*P*-Values S	*P*-Values L	*P*-Values S × L
Se content, mg/kg	0.2683 ± 0.0593 ^{A}	0.4920 ± 0.0171 ^{B}	0.6491 ± 0.0142 ^{C}	0.4780 ± 0.0257 ^{B}	0.5107 ± 0.0120 ^{B}	0.009	<0.001	<0.001

Note: SY-L, 0.3 mg/kg selenium yeast; SY-H, 0.5 mg/kg selenium yeast; SS-L, 0.3 mg/kg sodium selenium; SS-H, 0.5 mg/kg sodium selenium; S, selenium sources; L, selenium levels; S × L, the interaction of selenium sources and levels. In the same row, means without letters or with the same superscripts are not significantly different ($P > 0.05$), while means with different superscripts mean significantly different ($P < 0.05$).

X 1,8

X 2,4

X 1,8

X 1,9

100 g d'OE = 100 % des ANC de l'adulte

*Un enrichissement également possible en **iode***

Sumaiya S et al. (2016)
Effect of dietary iodine on production of iodine enriched eggs,
Veterinary World, 9(6): 554-558

Protocole expérimental :
135 pondeuses (White Leghorn), 55 semaines d'âge
T_1 : régime de base sans enrichissement
T_2 à T_5 : enrichissement avec $Ca(IO_3)_2$

Table-3: Concentration of iodine in eggs of laying hens fed on various levels of iodine after 10th week of supplementation (before and after boiling).

Treatments	Iodine level (ppm)	Yolk iodine (µg/g)		Albumen iodine (µg/g)	
		Before boiling	After boiling	Before boiling	After boiling
T_1	0.45	$0.20^{e}\pm0.014$	$0.18^{e}\pm0.017$	$0.02^{e}\pm0.001$	$0.02^{e}\pm0.001$
T_2	03.25	$0.28^{d}\pm0.014$	$0.23^{d}\pm0.020$	$0.05^{d}\pm0.001$	$0.04^{d}\pm0.002$
T_3	06.50	$0.60^{c}\pm0.014$	$0.51^{c}\pm0.014$	$0.07^{c}\pm0.001$	$0.06^{c}\pm0.002$
T_4	09.75	$0.84^{b}\pm0.023$	$0.72^{b}\pm0.020$	$0.09^{b}\pm0.002$	$0.08^{b}\pm0.002$
T_5	13.00	$1.20^{a}\pm0.021$	$1.03^{a}\pm0.002$	$0.12^{a}\pm0.002$	$0.11^{a}\pm0.002$

x 29 (Iodine level) ; x 6 (Yolk iodine) ; x 6 (Albumen iodine)

Mean values bearing different superscript differ significantly ($p<0.05$)

Charoensiriwatana *et al. Nutrition Journal* 2010, **9**:68
http://www.nutritionj.com/content/9/1/68

NUTRITION JOURNAL

RESEARCH Open Access

Consuming iodine enriched eggs to solve the iodine deficiency endemic for remote areas in Thailand

Wiyada Charoensiriwatana[1*], Pongsant Srijantr[2], Punthip Teeyapant[1], Jintana Wongvilairattana[1]

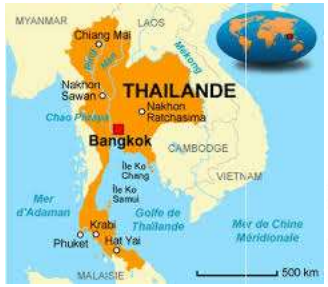


Table 2 Iodine content in eggs from the experimental farm before and after the iodine enriched feeding

Aliment pondeuses enrichi à 4 mg I / kg

	Average iodine content in eggs	
	µg per egg	µg per 100 g.wt
Eggs from regular feeding (#4; 50-55 g)	25.31	75.96
Iodine enriched eggs (#3; 55-60 g)	93.57	182.67
Iodine enriched eggs (#2; 60-65 g)	97.76	184.58

X 2,4

Table 5 Comparison of urine iodine contents of women volunteers (as the same volunteers) with treatment before and after consuming iodine enriched eggs in Ban Nong Nok Kean village and Ban Kew village

N = 110 volontaires
1 œuf / j pendant 5 j

	Median urine iodine contents (µg/dL)	
	Ban Kew village	Ban Nong Nok Kean village
Before consuming iodine enriched eggs	6.87	7.11
After consuming iodine enriched eggs	20.76	13.09
F-test	P < 0.001	P < 0.001
Statistical signification	**	**
Number of volunteers	57	53

X 2,4

** highly statistical significant as P value < 0.001

Note: There were 14 volunteers (12 in Ban Nong Nok Kean village and 2 in Ban Kew village) that dropped out during the study.

Œuf et VITAMINES

Une forte variabilité

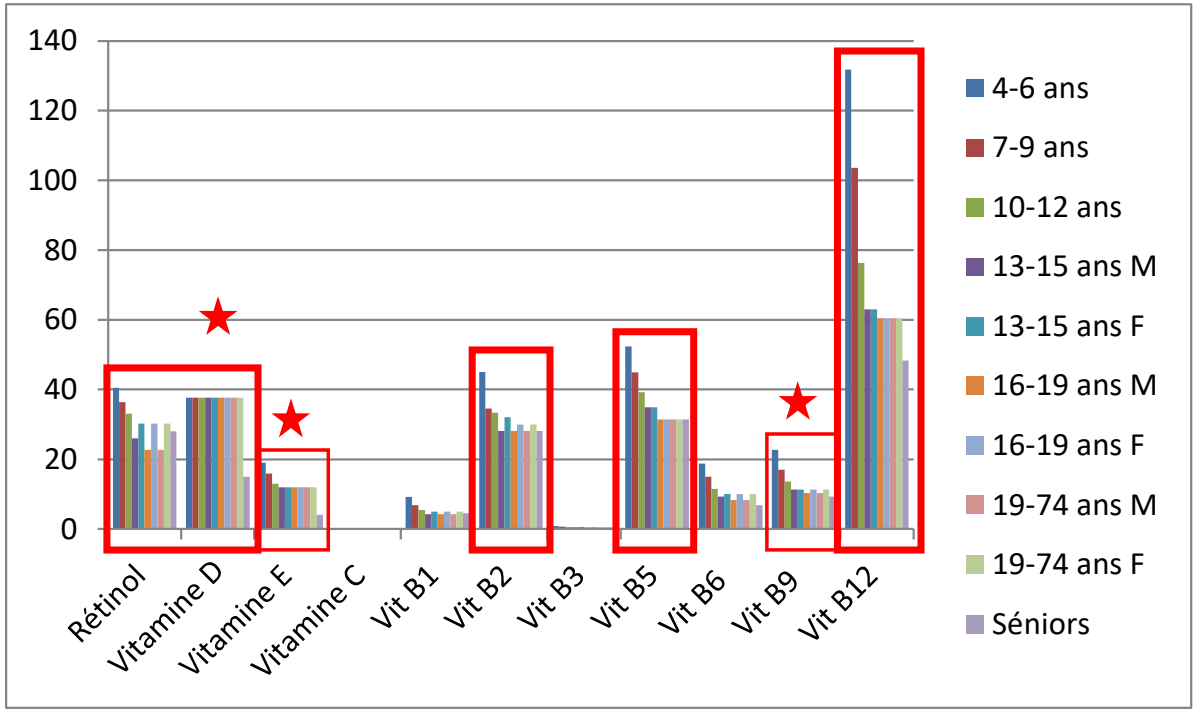
Composition en vitamines de l'œuf (pour 100 g de produit)

Vitamines (/100 g)	CIQUAL 2020			Gammes de variation observées dans les tables nationales de l'UE[1]	Valeur max / Valeur min
	Œuf entier cru	Blanc cuit	Jaune cru	Œuf entier	
Rétinol en µg	182	0	336	140-278	**2,0**
Vitamine D en µg	1.88	0	2	1,2-2,9	**2,4**
Vitamine E en mg	1.43	0	3.89	1,1-2,8	**2,5**
Vitamine K1 en µg	0,3	0	0.7	0,3-8,9	**29,7**
Vitamine C en mg	0	0	0	-	
Vit B1 en mg	0.055	0.004	0.17	0,07-0,12	1,7
Vit B2 en mg	0,45	0.44	0.38	0,3-0,5	1,7
Vit B3 en mg	0,063	0.093	<0.16	0,05-3,8	**76**
Vit B5 en mg	1,57	0.2	2.87	1,44-1,8	1,25
Vit B6 en mg	0,15	0.0035	0.29	0,12-0,17	1,4
Vit B9 en µg	34	5.5	159	21-65	**3,1**
Vit B12 en µg	1.45	0.09	3.03	1,29-2,5	1,9

(1) Extrait de Seuss-Baum, Nau, Guérin-Dubiard (2011) The nutritional quality of eggs, In Imrpoving the safety and quality of eggs and egg products, vol2, Woodhead Publishing

Des apports intéressants en Vitamines B12, B5, B2, D et A, mais aussi en Vitamines E et B9

★ Forte prévalence d'apports insuffisants dans la population française



Pourcentage des ANC couverts par 100 g d'œuf entier

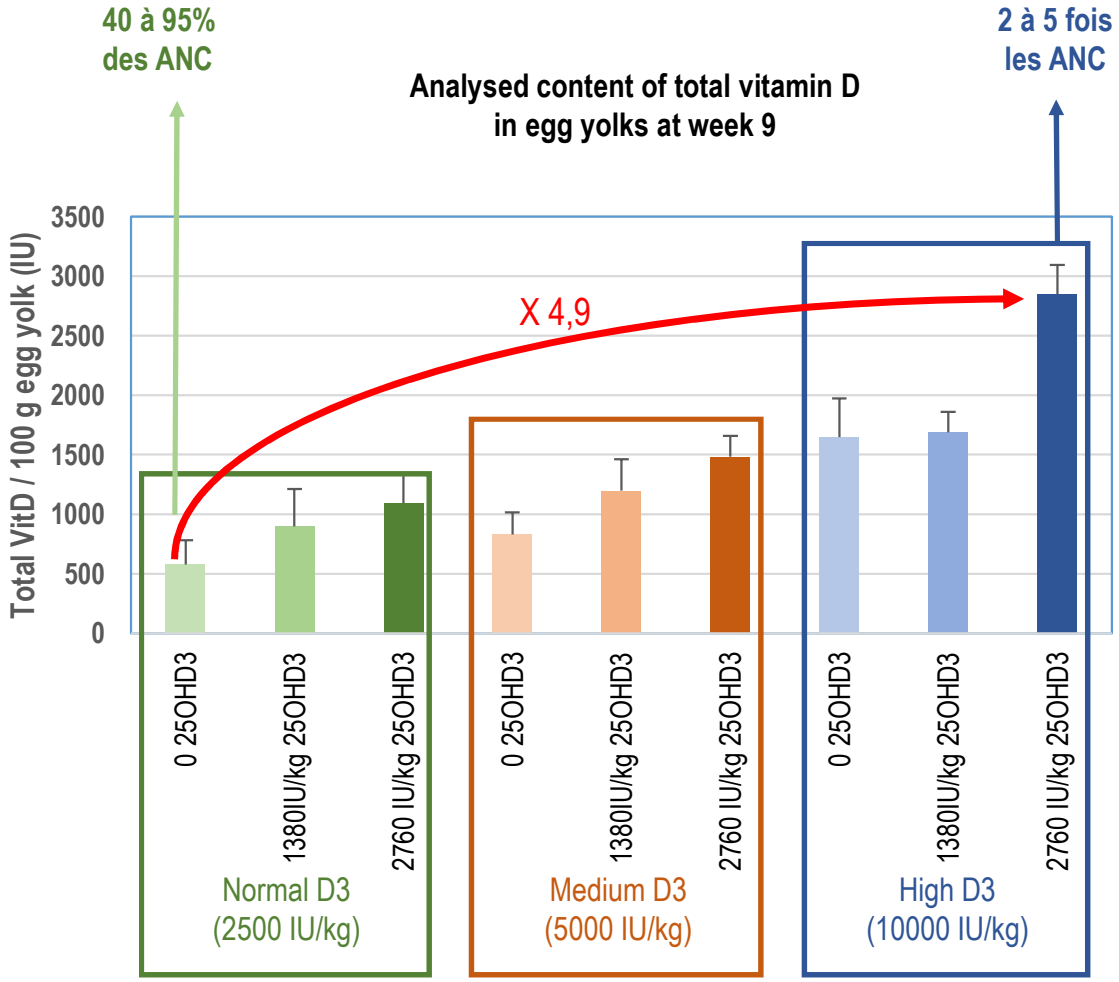
(calculs effectués à partir des teneurs moyennes des tables CIQUAL et des ANC rapportées dans l'étude INCA2).

*Un enrichissement possible en **Vitamine D***

Vitamin D fortification of eggs for human health

Linda C Browning[a,b*] and Aaron J Cowieson[a]

J Sci Food Agric 2014; **94**: 1389–1396



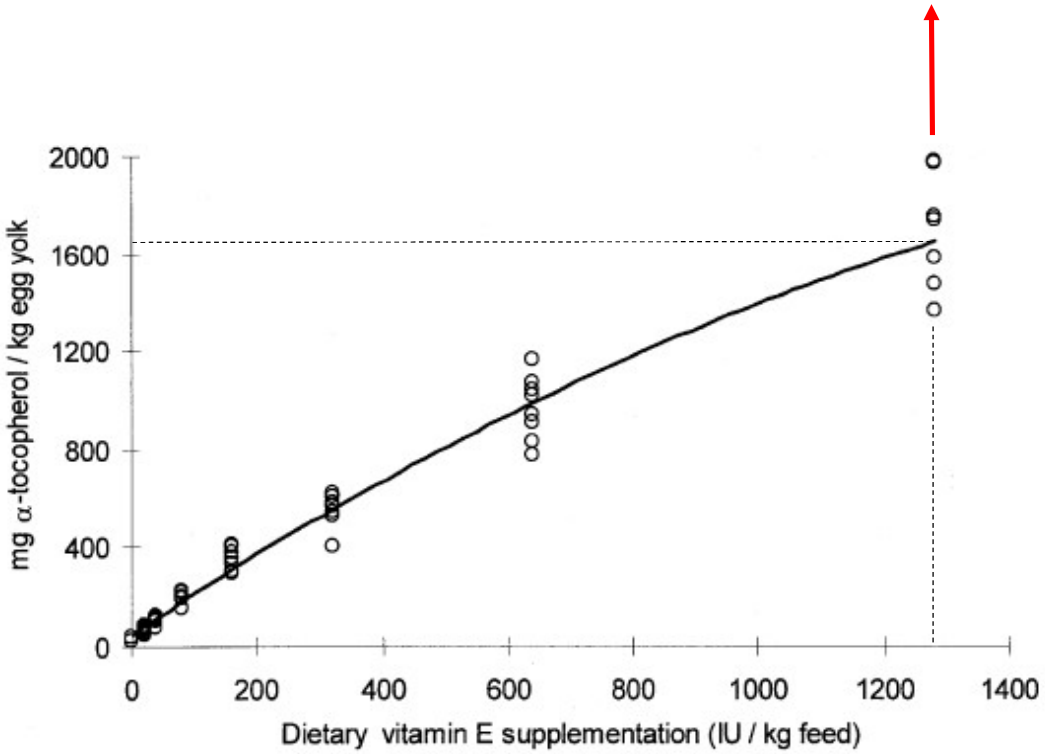
*Un enrichissement possible en **Vitamine E***

Effect of Vitamin E and A Supplementation on Egg Yolk α-Tocopherol Concentration

S. Grobas,* J. Méndez,† C. Lopez Bote,‡ C. De Blas,* and G. G. Mateos*,[1]

2002 Poultry Science 81:376–381

5 à 7,5 g de jaune couvrent les ANC (22 g pour les séniors)



Vitamine B9 dans l'œuf :

(1) particulièrement biodisponible

Folate availability index of foods[1]

Food	Availability index
	%
Egg yolk	72.2 ± 9.8
Cow's liver	55.7 ± 19.3
Orange juice	21.3 ± 0.4
Cabbage	6.0 ± 1.2
Lima beans	4.5 ± 1.2
Lettuce	2.9 ± 0.02
Baker's yeast	0.3 ± 0.02

[1] Values are means ± SEM for 2–3 trials.

Seyoum & Selhub (1998) J Nutr 128: 1956-1998

(2) avec possibilité d'enrichissement des œufs

Effect of Dietary Folic Acid Supplementation on Egg Folate Content and the Performance and Folate Status of Two Strains of Laying Hens

K. Hebert,* J. D. House,*†·[1] and W. Guenter*

2005 Poultry Science 84:1533–1538

Dietary folic acid level, mg/kg	Egg folate, µg/egg	
	W36	W98
0	16.6[b]	16.8[b]
2	32.8[ab]	42.2[ab]
4	48.2[a]	31.0[ab]
8	31.6[ab]	49.5[a]
16	29.5[ab]	47.1[a]
32	45.8[a]	42.2[a]
64	35.8[ab]	46.7[a]
128	34.5[ab]	42.8[a]
SEM[2]	4.5	
P-value	0.008	

Effet seuil

~ 46 µg / œuf
soit
~ 85 µg / 100 g d'œuf
=
27% des ANC
de l'adulte

(3) Stable au stockage…

Validation of Folate-Enriched Eggs as a Functional Food for Improving Folate Intake in Consumers

Leslie Altic, Helene McNulty, Leane Hoey, Liadhan McAnena and Kristina Pentieva *

Nutrients 2016, *8*, 777; doi:10.3390/nu8120777

~ 130 µg / 100 g =
40% des ANC
de l'adulte

	Folate Concentration (µg/100 g)						
	Un-Enriched Barn		Un-Enriched Free-Range		Folate-Enriched [2]		*p*-Value [3]
	4–7 °C	18–20 °C	4–7 °C	18–20 °C	4–7 °C	18–20 °C	
Day 1	41.4 (2.8) [a]		65.6 (18.5) [b]		123.2 (12.4) [c]		<0.001
Day 7	N/A		N/A		107.9 (9.6)	127.0 (26.9)	0.17
Day 14	N/A		N/A		134.0 (16.9)	115.1 (24.3)	0.21
Day 21	N/A		N/A		119.5 (19.7)	108.2 (14.7)	0.28
Day 27	36.6 (11.3) [a]	43.9 (5.9) [a]	70.0 (16.4) [b]	65.9 (7.2) [b]	122.0 (27.7) [c]	123.7 (18.3) [c]	<0.001

…et à la cuisson

Cooking Method	Folate Concentration (µg/100 g)			*p*-Value [2]
	Raw (n = 6)	Time 1 [3] (n = 6) [4]	Time 2 [3] (n = 6) [4]	
Boiled	135.7 (22.5)	125.2 (28.6)	145.4 (20.5)	0.402
Fried	135.7 (22.5)	137.2 (11.7)	139.1 (12.1)	0.730
Scrambled	135.7 (22.5)	133.9 (23.0)	132.5 (35.1)	0.616
Poached	135.7 (22.5)	126.9 (10.8)	132.7 (19.1)	0.597

Œuf et XANTHOPHYLLES

nutrients

Nutrients **2020**, *12*, 1721; doi:10.3390/nu12061721

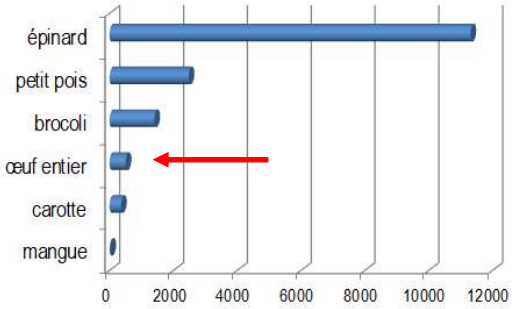
Review

Lutein Supplementation for Eye Diseases

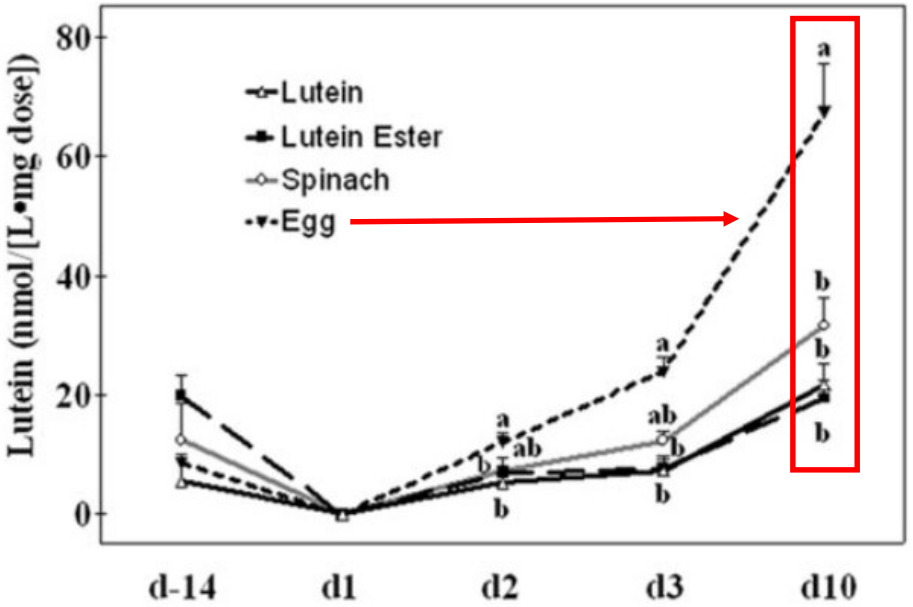
Long Hin Li [1], Jetty Chung-Yung Lee [2], Ho Hang Leung [2], Wai Ching Lam [1], Zhongjie Fu [3,4,*] and Amy Cheuk Yin Lo [1,*]

Abstract: Lutein is one of the few xanthophyll carotenoids that is found in high concentration in the macula of human retina. As *de novo* synthesis of lutein within the human body is impossible, lutein can only be obtained from diet. It is a natural substance abundant in egg yolk and dark green leafy vegetables. Many basic and clinical studies have reported lutein's anti-oxidative and anti-inflammatory properties in the eye, suggesting its beneficial effects on protection and alleviation of ocular diseases such as age-related macular degeneration, diabetic retinopathy, retinopathy of prematurity, myopia, and cataract. Most importantly, lutein is categorized as Generally Regarded as Safe (GRAS), posing minimal side-effects upon long term consumption. In this review, we will

L'oeuf, à la charnière entre le végétal et l'animal pour les teneurs en lutéine et zéaxanthine



Teneurs en lutéine + zéaxanthine de quelques aliments (µg / 100 g)
(D'après tables USDA 1998)



Changes in serum lutein concentration after ingestion of 6 mg/d lutein from lutein, lutein ester, spinach, and egg in n=10 healthy men. All values are subtracted from the baseline value of each treatment and adjusted for dose.

Lutein Bioavailability Is Higher from Lutein-Enriched Eggs than from Supplements and Spinach in Men[1,2]

J. Nutr. 134: 1887–1893, 2004.

Hae-Yun Chung, Helen M. Rasmussen, and Elizabeth J. Johnson[3]

Enrichment of Eggs with Lutein

2004 Poultry Science 83:1709–1712

S. Leeson[1] and L. Caston

TABLE 3. Lutein and zeaxanthin content of eggs (experiment 1)

Dietary lutein (ppm)		Lutein	Zeaxanthin	Lutein + zeaxanthin
Expected	Assayed	mg/60 g of egg		
0	4.9	0.16^{d}	0.16^{a}	0.32^{c}
125	126	1.17^{c}	0.16^{a}	1.33^{b}
250	250	1.25^{bc}	0.14^{ab}	1.39^{b}
375	318	1.37^{abc}	0.14^{abc}	1.50^{ab}
500	451	1.49^{ab}	0.13^{bc}	1.62^{ab}
625	588	1.45^{ab}	0.12^{bc}	1.57^{ab}
750	733	1.49^{ab}	0.11^{c}	1.60^{ab}
1,000	1,091	1.62^{a}	0.12^{bc}	1.74^{a}
SD		0.15	0.02	0.16
Significance		**	**	**

X 223

X 5,4

[a–c]Means within columns with different superscripts are significantly different.

**$P < 0.01$.

Multi-enrichissement des œufs :

Techniquement possible. Nutritionnellement pertinent ?

J Nutr Health Aging. Sep-Oct 2006;10(5):371-6.

An important source of omega-3 fatty acids, vitamins D and E, carotenoids, iodine and selenium: a new natural multi-enriched egg

J M Bourre [1], F Galea

Micronutriment	Enrichissement (facteur multiplicateur)	% couverture des ANC par 100 g d'œuf entier
ALA	x 6	15%
DHA	x 3	100%
Vitamine D	x 3	30%
Vitamine B9	x 4	70%
Vitamine E	x 6	66%
Lutéine + Zéaxanthine	x 6	70% (1)
Iode	x 2,5	100%
Sélenium	x 4	45%

(1) *Recommandations internationales*

Merci de votre attention