RFL #2
RENCONTRES FRANCOPHONES LÉGUMINEUSES

cirad
LA RECHERCHE AGRONOMIQUE POUR LE DÉVELOPPEMENT

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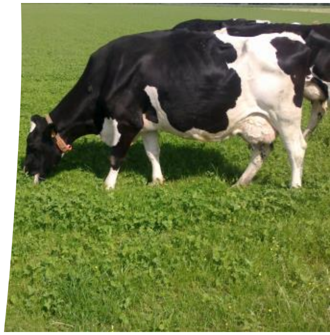
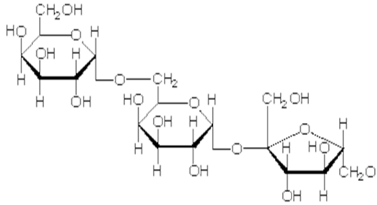


Modélisation du comportement des α-galactosides/folates au cours du trempage-cuisson du niébé / Réduction de son pouvoir antinutritionnel

Fanny Coffigniez / Aurélien Briffaz,
CIRAD (UMR QualiSud)

Toulouse, France – 17 & 18 octobre 2018

Présentation du modèle graine



raffinose

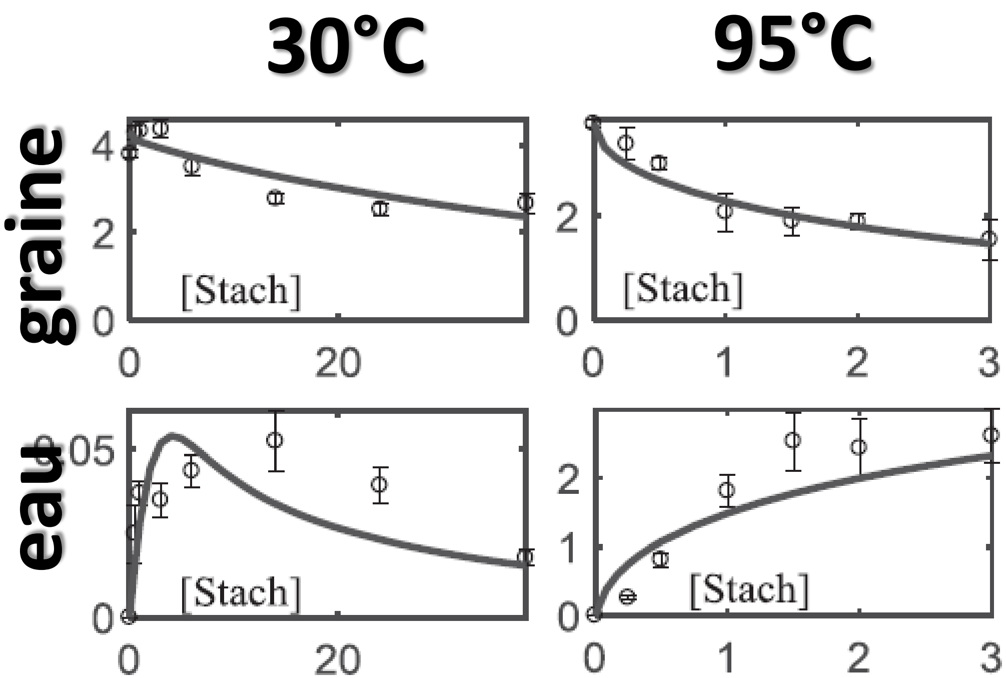
- Niébé (*Wankoun*) = légumineuse d'Afrique de l'Ouest
- α-galactosides (verbascose, stachyose, raffinose) = oligo-saccharides fermentescibles dans le côlon **=> flatulences**

- **Optimisation trempage-cuisson** permettrait de **réduire la teneur en α-galactosides de la graine**
- **2 compartiments considérés dans le modèle:**
  - Graine supposée symétrique / composition homogène
  - Eau de trempage *V*(*t*) avec ratio eau-graine de 4:1 (m/m)

- **Phénomènes modélisés impliquant les α-galactosides :**
  - Absorption (D, $m^2.s^{-1}$) d'eau de la graine
  - Diffusion (D, $m^2.s^{-1}$) de la graine vers l'eau trempage
  - Dégradabilité (k, s^{-1}) par voie enzymatique endogène (α-galactosidase)
- **Températures de trempage étudiées:** 30 / 60 / 95°C

Transport *vs* Réactivité

- Comportement contrasté en fonction de la température: (ex; stachyose):



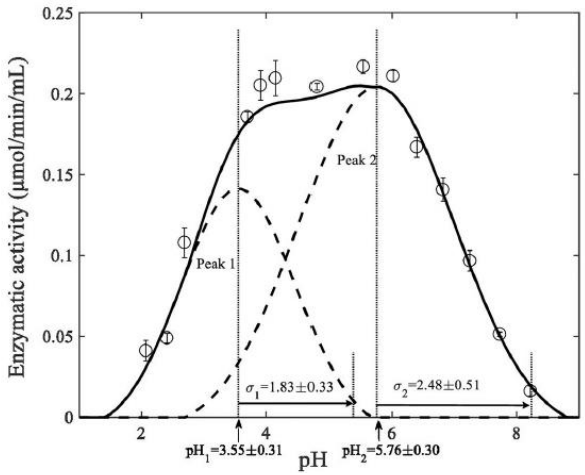
Stachyose:	30°C	95°C
Diffusivité *D* ($m^2.s^{-1}$)	$2x10^{-13}$	**$4.3x10^{-11}$**
Dégradabilité k (s^{-1})	**$2.9x10^{-6}$**	$0.0x10^{-6}$

- À 30°C: activité enzymatique observée aussi bien dans graine que eau de trempage => **caractérisation α-galactosidase endogène**

Coffigniez, F., Briffaz, A., Mestres, C., Alter, P., Durand, N., Bohuon, P., (2018). Multi-response modeling of reaction-diffusion to explain alpha-galactoside behavior during the soaking-cooking process in cowpea. Food Chemistry 242, 279-287.

Modélisation du comportement enzymatique

- Identification des affinités et pH/T°C optimaux pour l'α-galactosidase endogène extraite du niébé:



Substrate	Michaelian parameters		RMSE[§] (mM)
	v_{max}(µmol.min^{-1}.mL^{-1})	K_m(mM)	
Verbascose	0.01 ± 0.01	0.25 ± 0.06 [a]	0.01
	0.21	15.9 ± 0.1[b]	0.01
Stachyose	0.22 ± 0.06	4.1 ± 1.8[a]	0.20
	0.21	3.6 ± 0.6[b]	0.23
Raffinose	0.19 ± 0.01	1.2 ± 0.3[a]	0.51
	0.21	1.7 ± 0.3[b]	0.84

- Caractérisation (par ajouts dosés) des effets inhibiteurs de certains micro-constituants de la graine :

$$v = \frac{v_{max}[S]}{K_m^{app1} + [S]}$$

$$K_m^{app1} = K_m\left(1 + \frac{[I]}{K_I}\right)$$

Michaelian parameters	Values	RMSE
$v_{max}$for PNP (µmol.min^{-1}.mL^{-1})	0.21 ± 0.01	0.005[a] µmol min^{-1} mL^{-1}
K_m for PNP (mM)	0.40 ± 0.05	
K_I galactose (mM)	0.28 ± 0.03	
K_I galactinol (mM)	0.88 ± 0.02	0.06[b] mM
K_I myo-inositol (mM)	11.90 ± 0.20	0.06[b] mM

Coffigniez, F., Briffaz, A., Mestres, C., Ricci, J., Alter, P., Durand, N., Bohuon, P., (2018). Kinetic study of enzymatic alpha-galactoside hydrolysis in cowpea seeds. Food research international (Ottawa, Ont.) 113, 443-451.

agropolis fondation

VITAMICOWPEA

VITAMIn B9 (folate) study to Increase COwpea value chain sustainability in West Africa through Product and procEss innovAtion

RFL2 / 10 October 2018
Toulouse

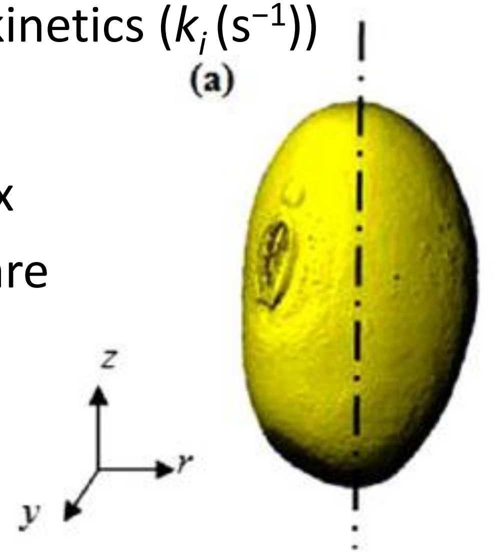
Dr Fanny Coffigniez (CIRAD/ QualiSud research unit, Montpellier (France)) PhD student
Prof. Michael Rychlik (Technical University of Munich), Fanny Supervisor
Dr Aurelien Briffaz (CIRAD/ QualiSud research unit, Montpellier (France)) Project Coordinator

Project objectives

- Investigate folate vitamer behaviour during cowpea soaking-cooking process and germination at 30°C/60°C/95°C.
- Develop a mathematical model describing transport and reactivity properties of folate vitamers during processing.
- Identify optimized processing pathways that could maximize folate retention in cowpea seeds.

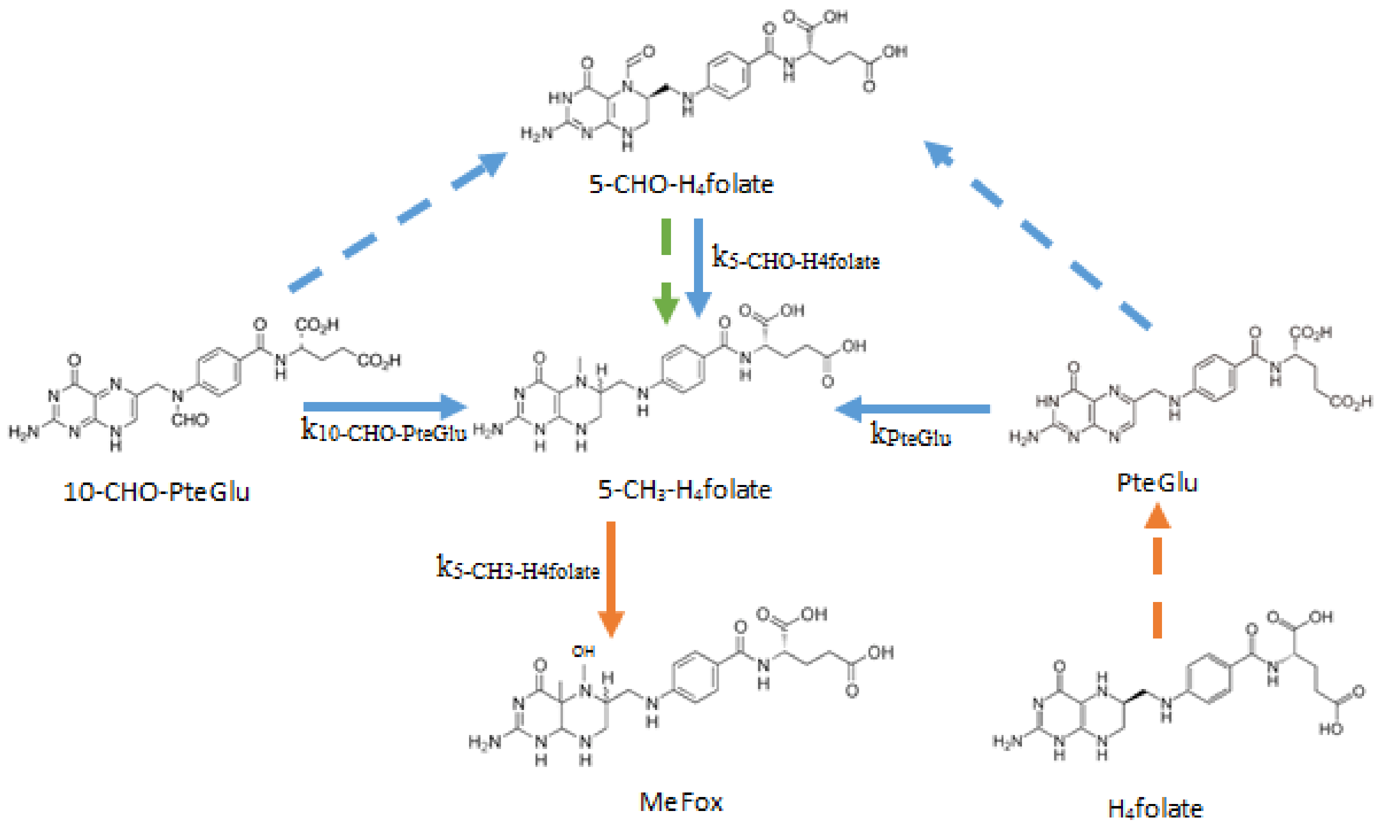
Model presentation

- One single cowpea seed considered and being surrounded by a limited amount of water:
  - With a water-to-seed ratio of 4:1 (w/w) in the case of soaking
  - With a water-to-seed ratio of 1:1 (w/w) in the case of germination
- Investigated temperature: 30°C.
- Model assumptions:
  - Transport by means of molecular diffusion (D_i ($m^2.s^{-1}$), Fick's law)
  - Folate production/degradation assuming first-order kinetics (k_i (s^{-1}))
- Model adjustments:
  - Minimization of the determinant of covariance matrix
  - Coupling of COMSOL Multiphysics and Matlab software



Fanny Coffigniez, PhD
(Dec 2017 – Fev 2018)
Vitamicowpea project,
TUM Munich

Folate reaction scheme



Enzymatic conversion

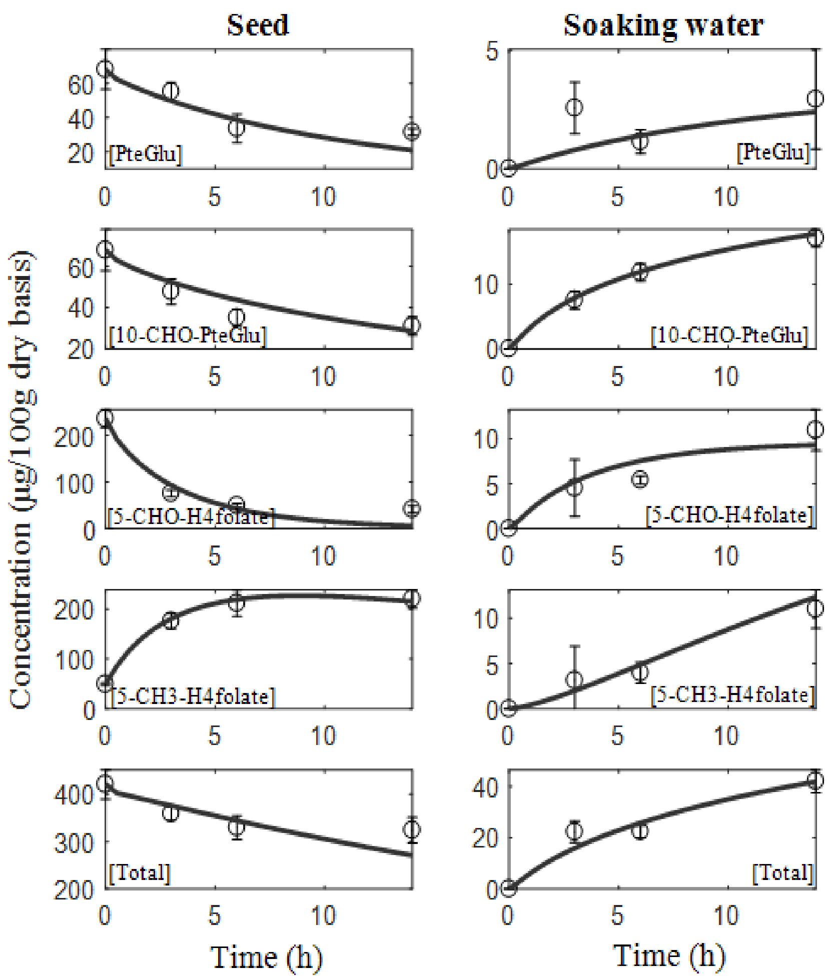
Chemical conversion

Themal oxidation

Solid lines : modeled

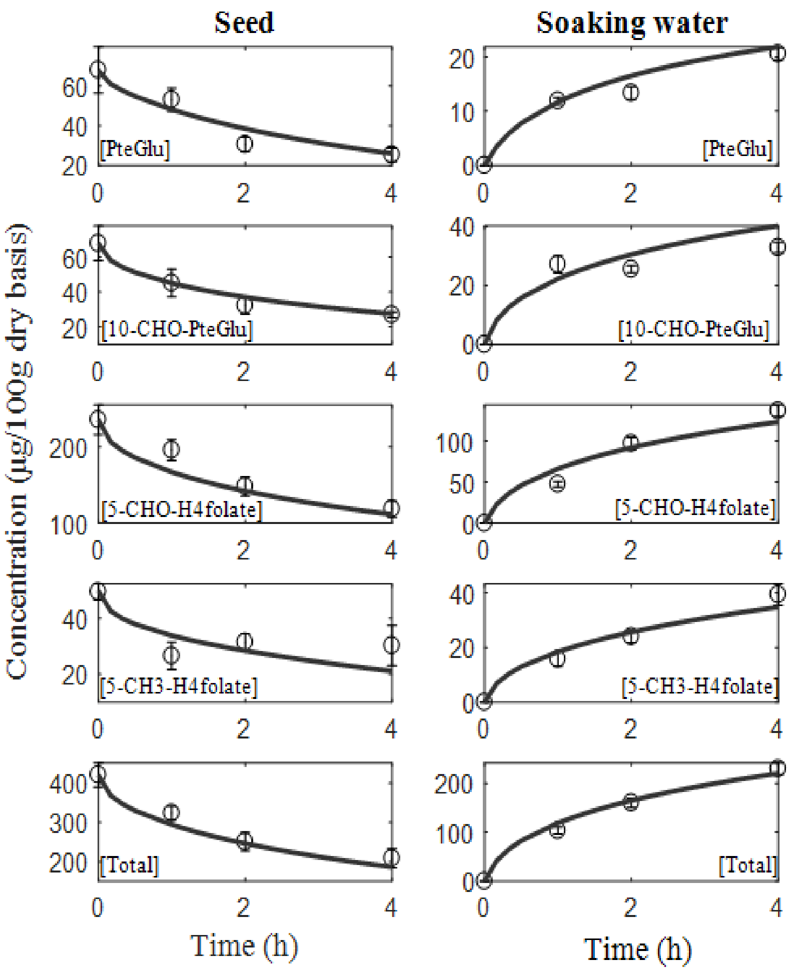
Dashed lines : Not modeled

Soaking-cooking results 30°C (paper 1)



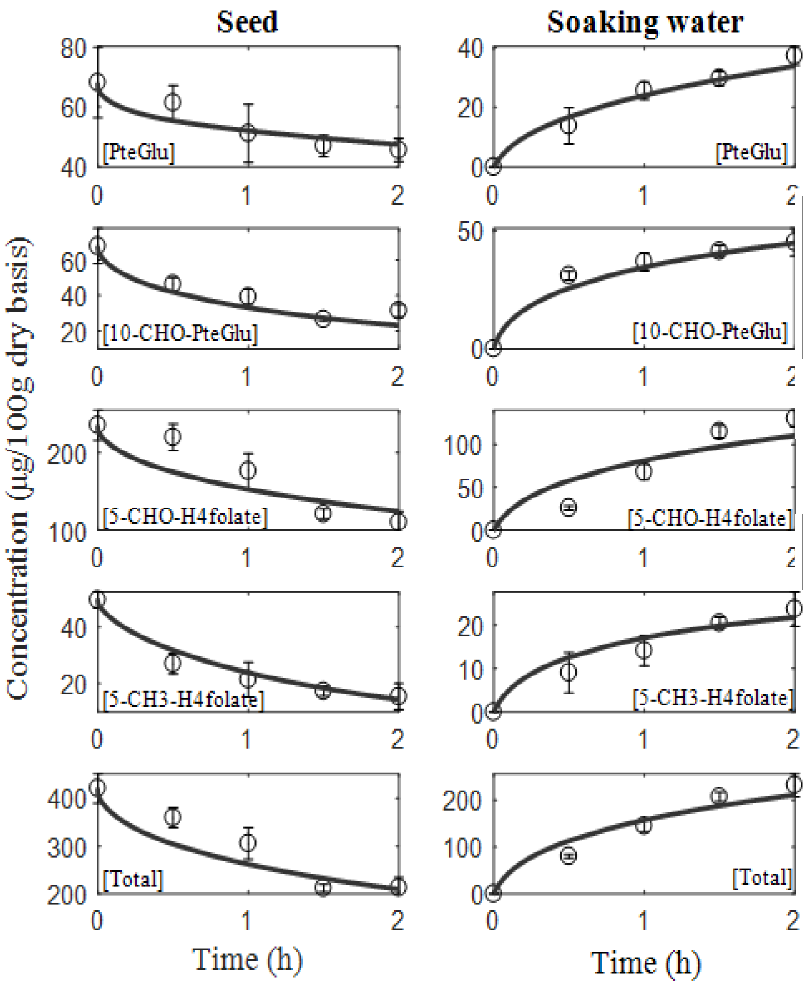
Vitamers X	T(°C)	$D_X \times 10^{11} (m^2 s^{-1})$	$k_{X,\Omega_S} \times 10^5 (s^{-1})$	RMSE*	
				In seed (S)	In soaking water (SW)
Folic acid	30	0.010 ± 0.001	2.21 ± 0.04	8.9	1.3
10-formyl-folic acid	30	0.181 ± 0.003	0.81 ± 0.01	8.3	1.3
5-formyl-H4folate	30	0.026 ± 0.001	8.0 ± 0.12	23.0	2.4
5-methyl-H4folate	30	0.014 ± 0.002	1.11 ± 0.02	17.1	1.4

Soaking-cooking results 60°C (paper 1)



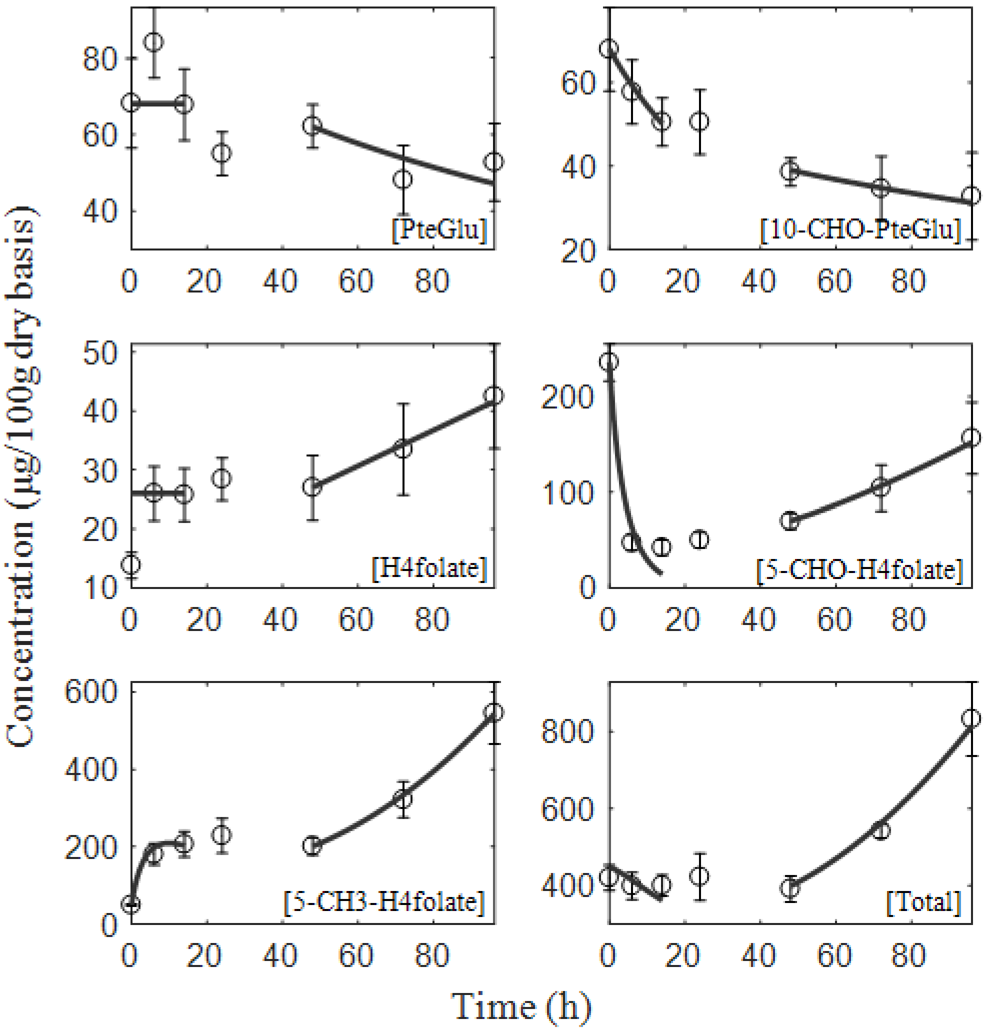
Vitamers X	T(°C)	$D_X \times 10^{11} (m^2 s^{-1})$	$k_{X,\Omega_S} \times 10^5 (s^{-1})$	RMSE* In seed (S)	RMSE* In soaking water (SW)
Folic acid	60	0.81 ± 0.02	3.73 ± 0.06	7.2	1.4
10-formyl-folic acid	60	2.93 ± 0.05	0	6.3	5.2
5-formyl-H_4folate	60	2.12 ± 0.04	0	20.1	12.4
5-methyl-H_4folate	60	3.52 ± 0.07	3.39 ± 0.06	7.1	3.3

Soaking-cooking results 95°C (paper 1)



Vitamers X	T(°C)	$D_X \times 10^{11} (m^2 s^{-1})$	$k_{X,\Omega_S} \times 10^5 (s^{-1})$	RMSE*	
				In seed (S)	In soaking water (SW)
Folic acid	95	3.12 ± 0.06	0	7.3	3.5
10-formyl-folic acid	95	7.94 ± 0.16	0	6.6	4.4
5-formyl-H4folate	95	3.23 ± 0.05	0	29.3	19.9
5-methyl-H4folate	95	3.63 ± 0.06	7.73 ± 0.14	4.2	3.4

Germination results 30°C (paper 2)



Species X	Process	$k_{X,\Omega_S} \times 10^5 (s^{-1})$	$k_{pX,\Omega_S} \times 10^5 (s^{-1})$	RMSE* In seed (S)
Folic acid	S	2.21 ± 0.04	0	8.9
	G1	0	0	12.5
	G2	0.16 ± 0.01	0	8.8
10formyl-folic acid	S	0.81 ± 0.01	0	8.3
	G1	0.63 ± 0.02	0	7.6
	G2	0.13 ± 0.01	0	6.7
5formyl-H_4folate	S	7.95 ± 0.12	0	23.0
	G1	6.18 ± 0.23	0	22.6
	G2	0.11 ± 0.01	1.72 ± 0.04	21.4
5methyl-H_4folate	S	1.11 ± 0.02	0	17.1
	G1	1.02 ± 0.03	0	21.5
	G2	0	4.53 ± 0.09	12.7

*RMSE: Root mean square error between experimental and predicted concentrations ($mg/100\,kg\,db$).

S: soaking, G1: germination < 14 h; and G2: germination > 48 h

Fondazione CARIPLO

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sous l'égide de la fondation de france

Projet de recherche 2017 – 2019

ICOWPEA

L'innovation participative pour le développement de produits à base de niébé au Bénin

https://niebe-icowpea.cirad.fr/

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UNIVERSITE D'ABOMEY-CALAVI

IRD

cirad
LA RECHERCHE AGRONOMIQUE POUR LE DÉVELOPPEMENT

MERCI POUR VOTRE ATTENTION

fanny.coffigniez@hotmail.fr
aurelien.briffaz@cirad.fr