Qualité des protéines et sécurité nutritionnelle

UMR Physiologie de la Nutrition et du Comportement alimentaire

Team "Protein Intake and metabolic regulations" (APReM)

UMR PNCA
Physiologie de la Nutrition et du Comportement Alimentaire

AgroParisTech — Département SVS

université PARIS-SACLAY — Département « Sciences de la Vie»

INRAE — Département « AlimH »

General scientific objectives

UMR PNCA
Physiologie de la Nutrition et du Comportement Alimentaire

To produce knowledge on the impact of **protein and amino acids as well as food sources of proteins on physiology, metabolism and dietary behavior,** in order:

- to **ensure nutritional security**,
- to **prevent dysfunctions and nutritional pathologies**
- to **contribute to improve health**

while considering **societal and environmental** questions (ethics, sustainability of foods, …).

Elaboration of nutritional strategies

✓ To orientate public policies in the establishment of recommandations
✓ To help industries in their product developpment strategies

PCNA Organization

KIM Food & Health

Team 2 :
Dalila AZZOUT-MARNICHE
Protein Intake and metabolic regulations

- *Bioavailability*
- *Satisfaction of AA requirements*
- *Protein and energy pathways*

- *Bacterial metabolites*
- *Epithelial mucosa*

Team 1 :
François BLACHIER
Protein Intake and Intestinal Adaptations

✓Low protein level
✓Substitution plant/animal proteins

Team 3 :
François MARIOTTI
Protein Intake, Nutritional Security and Cardiometabolic Risk

- *External and internal factors of food decision*
- *Mechanisms of control of protein intake*

Team 4 :
Isabelle DENIS
Protein Intake and Neurosciences of Dietary Behavior

- *Nutrient adequacy*
- *Prevention of cardiometabolic disorders*

Transversal Group:

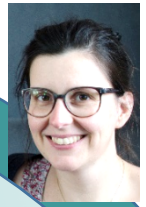
Clinicians (Robert Benamouzig)

CHAIRE ANCA: Mediation to general public

APReM












Assessing the consequences of variations in protein-energy intake on metabolism and physiology, in different physiological and pathological situations

to establish criteria and reference data on the satisfaction of protein, amino acid and energy requirements, tacking into acount individual characteristics of metabolic sensitivity to diets

- **The bioavailability of proteins and amino acids.**
- **Protein and energy metabolic orientations and regulations.**
- **The search for biomarkers of protein and amino acid requirements.**

5 EC/CR et ingénieurs, 2 IR, 1 post-doctorant, 1 AI, 1 TR et 2 PhD students

Evaluation of protein quality

- **Amino acid score** :comparison of the content of the limiting amino acid in the protein or diet with its content in the reference protein:

> Amino acid score = mg of amino acid in 1 g test protein/ mg of amino acid in requirement pattern

- le **PD-CAAS (*Protein Digestibility Corrected Amino Acid Score*)** . Amino acid scorre corrected by the protein digestibility

> PDCAAS = protein digestibility × amino acid score

- le **DIAAS (*Digestible Indispensable Amino Acid Score*) :** digestibility of each IAA for a test protein in comparison to reference protein

> DIAAS % = 100 x [(mg of digestible dietary indispensable amino acid in 1 g of the dietary protein) / (mg of the same dietary indispensable amino acid in 1 g of the reference protein)].

Score < 100% at least 1 IAA is limiting
Score > 100% No limiting IAA .

IAA concentration, Profile of the protein reference and PD-CAAS

$$\textbf{PD-CAAS} = \frac{\text{AA protéine (mg/g)}}{\text{AA profil de référence (mg/g)}} \times \text{Digestibilité \%}$$

mg/g Protein	Reference profile	Wheat Digestibility of 85%	PD-CAAS %	Milk Digestibility of 95%	PD-CAAS %
Histidine	15	*21*	>100	*28*	>100
Isoleucine	30	*34*	>100	*64*	>100
Leucine	59	*69*	>100	*93*	>100
Lysine	**45**	***23*** *(23/45)x85*	**43**	***83***	**>100**
Met+Cys	22	*36*	>100	*32*	>100
Phe+Tyr	38	*77*	>100	*105*	>100
Thréonine	23	*28*	>100	***51***	>100
Tryptophane	6	*10*	>100	*14*	>100
Valine	39	*38*	>100	*68*	>100
		PD-CAAS = 43%		PD-CAAS = 100%	

Bioavailability and nutritional quality of protein

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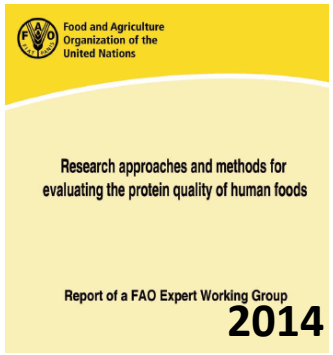


PD-CAAS → **DIAAS**

Protein digestibility is a proxy

Fecal digestibility

Amino acid digestibility is not relevant

Ileal digestibility

No validated method

Ileal canula

Intestinal tube

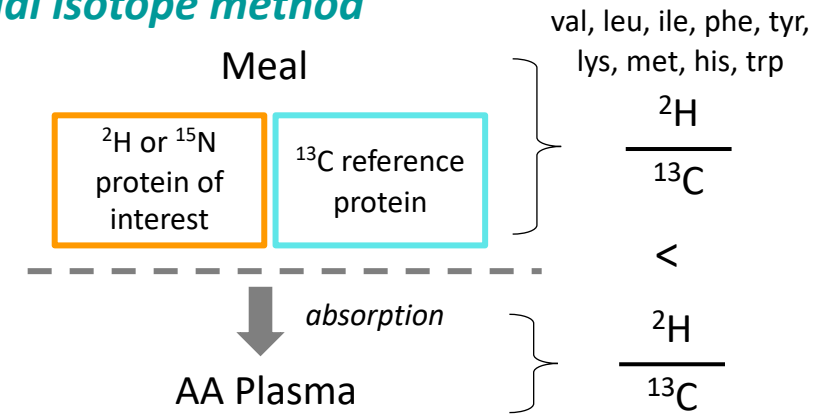
- Standard method
- Very invasive

Dual isotope method

- New method to develop
- Minimally invasive

Bioavailability/quality of protein sources

The dual isotope method



- Intrinsic labeling of protein sources with ^{2}H and ^{15}N

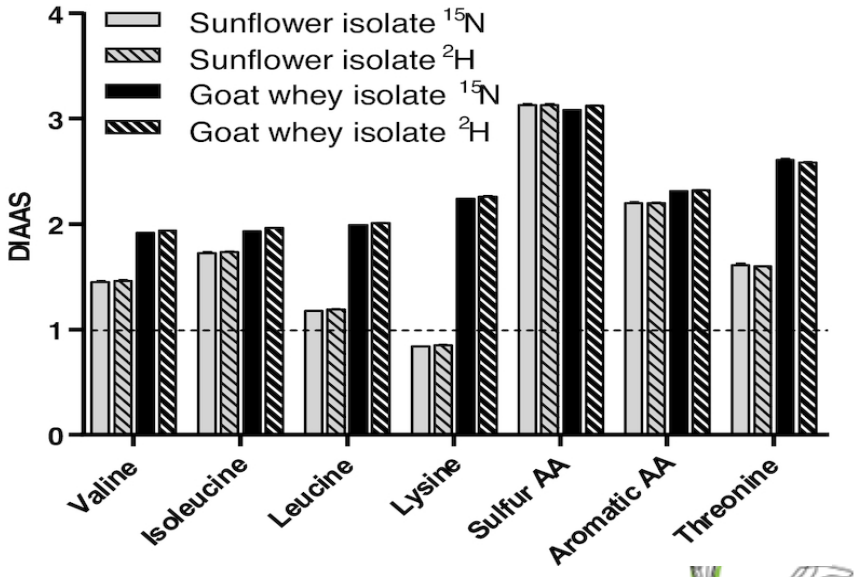



- To develop the dual isotope method in rats
- To Implement the method in Humans and challenge against the standard method

$\Rightarrow$ ^{2}H leu is more bioavailable than ^{13}C leu

Objective: to develop multiple isotope methods(^{13}C, ^{15}N, ^{2}H).

FIGURE 2 DIAAS of sunflower protein isolate and goat whey protein using ^{15}N and ^{2}H labeling.
Tessier et al. 2020



Dietary protein quality evaluation in human nutrition

FAO FOOD AND NUTRITION PAPER 92

Report of an FAO Expert Consultation

2011

Explore **new approaches** for determining **amino acid requirements satisfaction**, including the use of gene expression studies (including nutrigenomics), **metabolomics and/or specific biomarkers**.

Amino acid requirements in adults (mg/Kg/d)

	Nitrogen balance	isotope method	Mean Requirements WHO/FAO/UNU report
Histidine	8-12		10
Isoleucine	10	55	20
Leucine	14	24.5; 38; 40 - 55	39
Valine	10	19-55	26
Lysine	**12**	**27 - 35; 37; 38; 45**	**30**
Sulfur amino acid	13	13	15
Aromatic amino acids	14	39 - 15	25
Threonine	7	13.5 - 19	15
Tryptophane	3,5	4	4

Signature of AA and protein status

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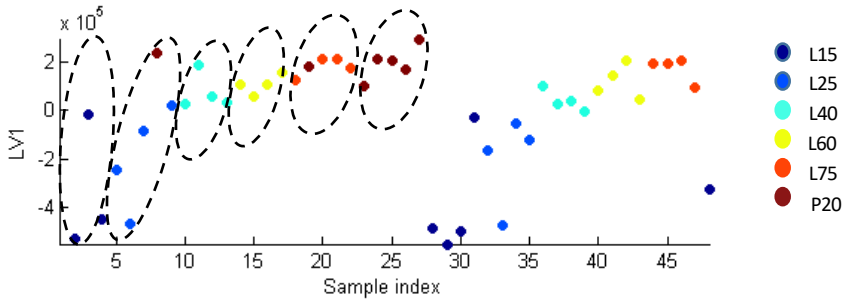
Hypothesis

Physiologic, metabolic and cellular signals could provide suitable biomarkers of AA requirement satisfaction

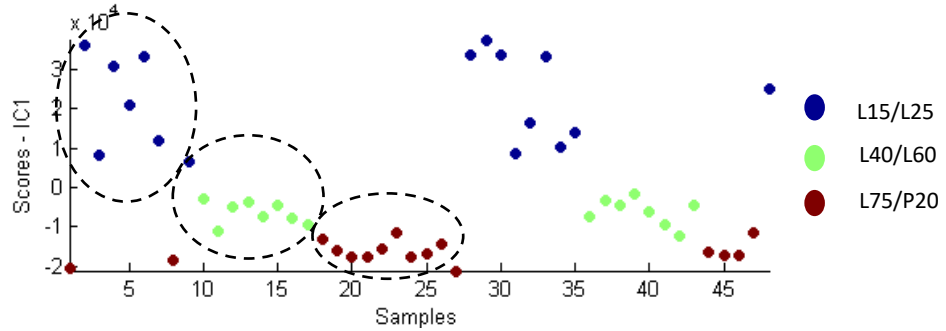
Objectives:

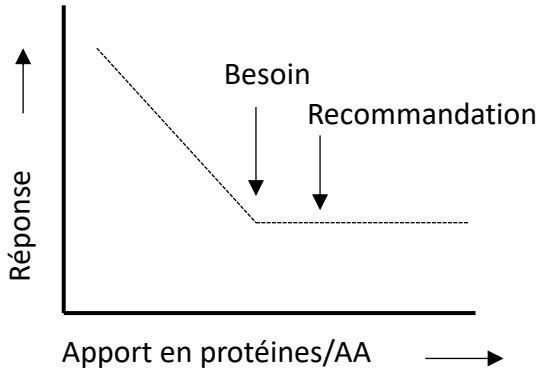
- To develop new methods using metabolomics to identify **biomarkers of AA requirements**
- To **identify signatures** of adequate/inadequate intake of AA

Lysine PLS

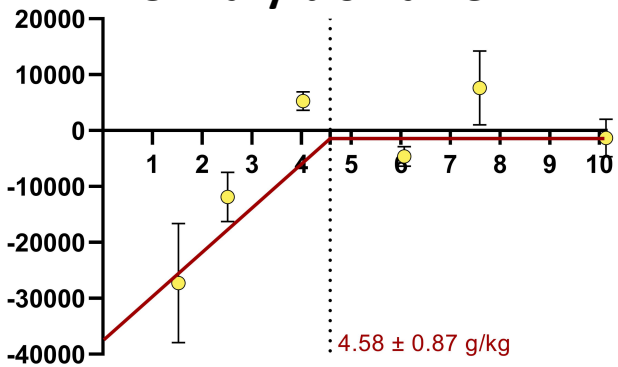


Lysine ICDA





Urinary biomarker



PLS = Partial Least Square

ICDA = Independent Component Discriminant Analysis

Projet VAMP

Analyses de la composition en acides aminés de différentes variétés d'arachides

GROUPE nutriset

AgroParisTech
Talents d'une planète soutenable

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Physiologie de la Nutrition et du Comportement Alimentaire

INSTITUT DE RECHERCHE AGRONOMIQUE DE GUINÉE
I.R.A.G.

VAMP: Varietal selection based on nutritional quality of Peanuts

<u>Objectif :</u> Selection of the local varieties of peanuts with high quality protein to develop a high nutritional quality food

The novelty and the originality of the project is to select variety of peanuts based on protein quality. To our knowledge, this approach has not been used to characterise the nutritional quality of seed for developing high nutritional quality food. Thus, rather than adding free AAs in the food to reach a high protein quality, the ScreenPeanuts project will promote the wealth found in nature biodiversity to conserve and promote sustainable use of biological resources

→ 6 varieties: Fleur AA, Numex 01, AK11, AK12, AK13, AK15

→ Sowing by IRAG (Institut de Recherche Agronomique de Guinée) (Guinea) on june 2021 and harvesting in september 2021 en Guinée

	Fleur 11			Numex 01		AK11			AK12			AK13			AK15		
Number of seed lines	1	2	2	1	2	1	2	2	1	2	2	1	2	2	1	2	2
Sowing date	25/06	25/06	16 /06	25/06	25/06	25/06	25/06	16/06	25/06	25/06	16/06	25/06	25/06	16/06	25/06	25/06	16/06
Harvesting date	24/09	24/09	14/09	24/09	25/09	24/09	24/09	14/09	24/09	24/09	14/09	24/09	24/09	14/09	24/09	24/09	18/09

Protein and lysine content of peanuts varieties

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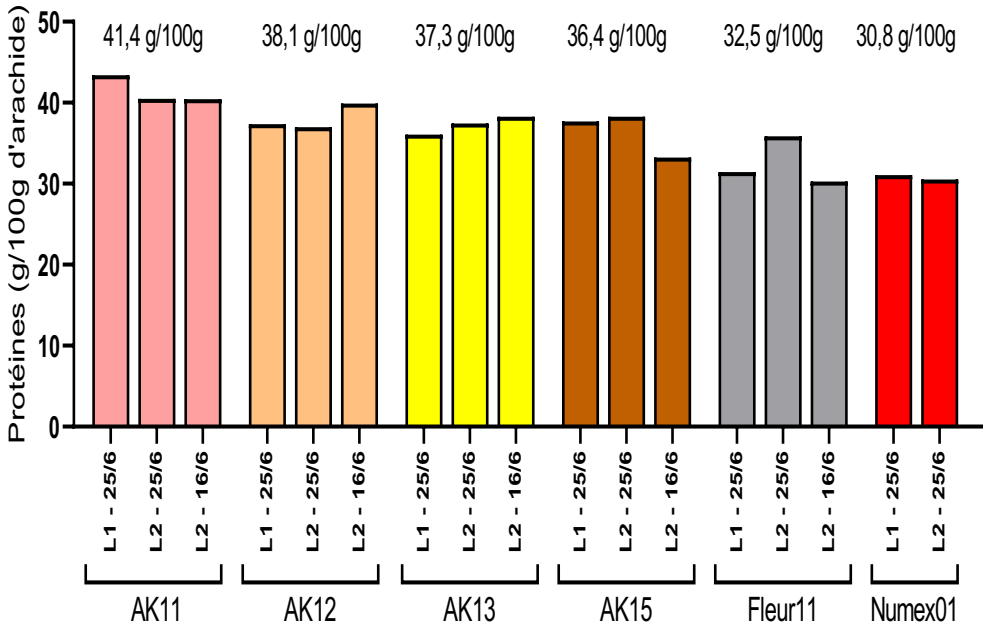
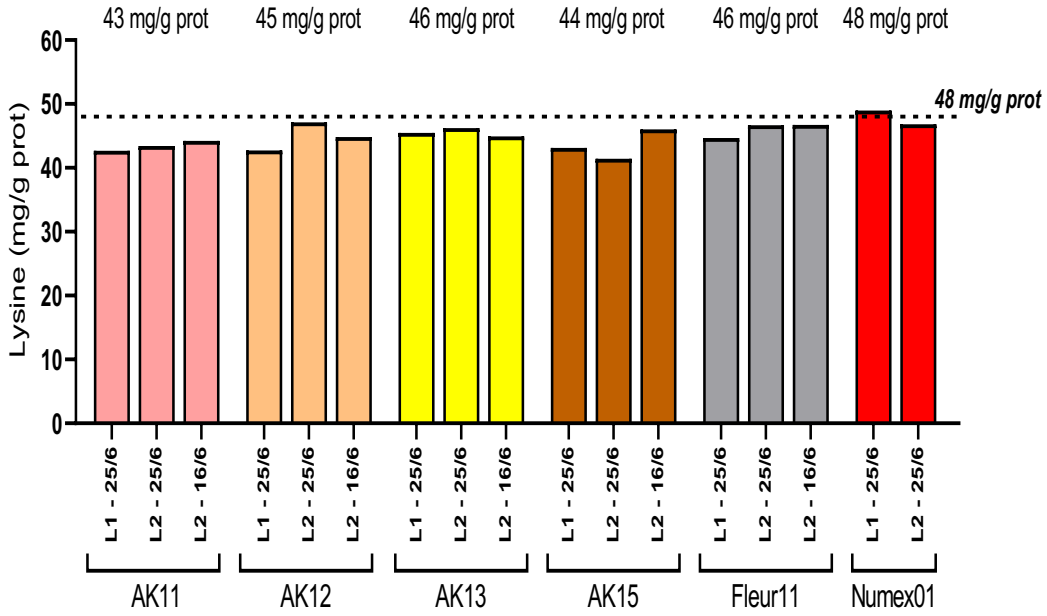
Protein content



→ Between 30,8 et 41,4 g of proteins/ 100 g of Peanuts

→ No effect of sowing date and number of seed lines

Lysine content



→ Between 43 et 48 mg of lysine per g proteins

→ Low variability

Nutritional quality of peanuts proteins

Amino acid score and PDCAAS for Peanuts varieties

	AK11			AK12			AK13			AK15			Fleur 11			Numex 01	
	25-juin 1	25-juin 2	16-juin 2	25-juin 1	25-juin 2	16-juin 2	25-juin 1	25-juin 2	16-juin 2	25-juin 1	25-juin 2	16-juin 2	25-juin 1	25-juin 2	16-juin 2	25-juin 1	25-juin 2
His	1,32	1,47	1,31	1,21	1,22	1,24	1,22	1,20	1,43	1,25	1,23	1,73	1,52	1,20	1,45	1,25	1,50
Ile	1,16	1,25	1,23	1,25	1,25	1,23	1,24	1,25	1,26	1,21	1,21	1,18	1,21	1,20	1,23	1,25	1,22
Leu	1,12	1,14	1,13	1,13	1,15	1,13	1,14	1,13	1,13	1,10	1,10	1,12	1,11	1,11	1,12	1,13	1,10
Lys	**0,89**	**0,91**	**0,92**	**0,89**	**0,98**	**0,93**	**0,95**	**0,96**	**0,94**	**0,90**	**0,86**	**0,96**	**0,93**	**0,97**	**0,97**	**1,02**	**0,98**
SAA	2,25	1,85	1,68	1,31	1,25	1,35	1,25	1,10	1,33	2,26	2,07	2,04	2,30	1,91	1,64	1,68	1,69
AAA	2,44	2,49	2,39	2,46	2,46	2,42	2,43	2,42	2,41	2,32	2,38	2,32	2,34	2,28	2,30	2,35	2,48
Thr	1,22	1,23	1,19	1,22	1,24	1,22	1,25	1,21	1,25	1,21	1,21	1,22	1,26	1,25	1,29	1,29	1,06
Trp	1,05	1,02	1,10	1,17	1,14	1,09	0,95	1,36	1,04	1,22	1,06	1,04	1,09	1,23	1,14	1,19	1,29
Val	0,99	1,15	1,13	1,15	1,13	1,13	1,14	1,14	1,16	1,09	1,09	1,05	1,12	1,12	1,16	1,15	1,10
SC	**0,89**	**0,91**	**0,92**	**0,89**	**0,98**	**0,93**	**0,95**	**0,96**	**0,94**	**0,90**	**0,86**	**0,96**	**0,93**	**0,97**	**0,97**	**1,02**	**0,98**
moy		**0,91**			**0,93**			**0,95**			**0,91**			**0,96**			**1,00**

PDCAAS	**0,84**	**0,86**	**0,88**	**0,85**	**0,93**	**0,89**	**0,90**	**0,92**	**0,89**	**0,85**	**0,82**	**0,91**	**0,88**	**0,92**	**0,92**	**0,97**	**0,93**
moy		**0,86**			**0,89**			**0,90**			**0,86**			**0,91**			**0,95**

→ Amino acid score <1 for lysine for all the varieties except for Numex 01

→ Amino acid score = 1 for Numex 01

→ **PDCAAS <1 for all the varieties but >0,85**

Next steps: Varietal selection of nutritional quality peanuts

Varietal selection of nutritional quality peanuts adapting to the multiple environments of the Great Green Wall

Societal impact

Start from 300 peanut lines

↓

Filter by genetic screening depending on **agronomic, environmental, nutritional properties**
→ select 3-4 varieties/region

↓

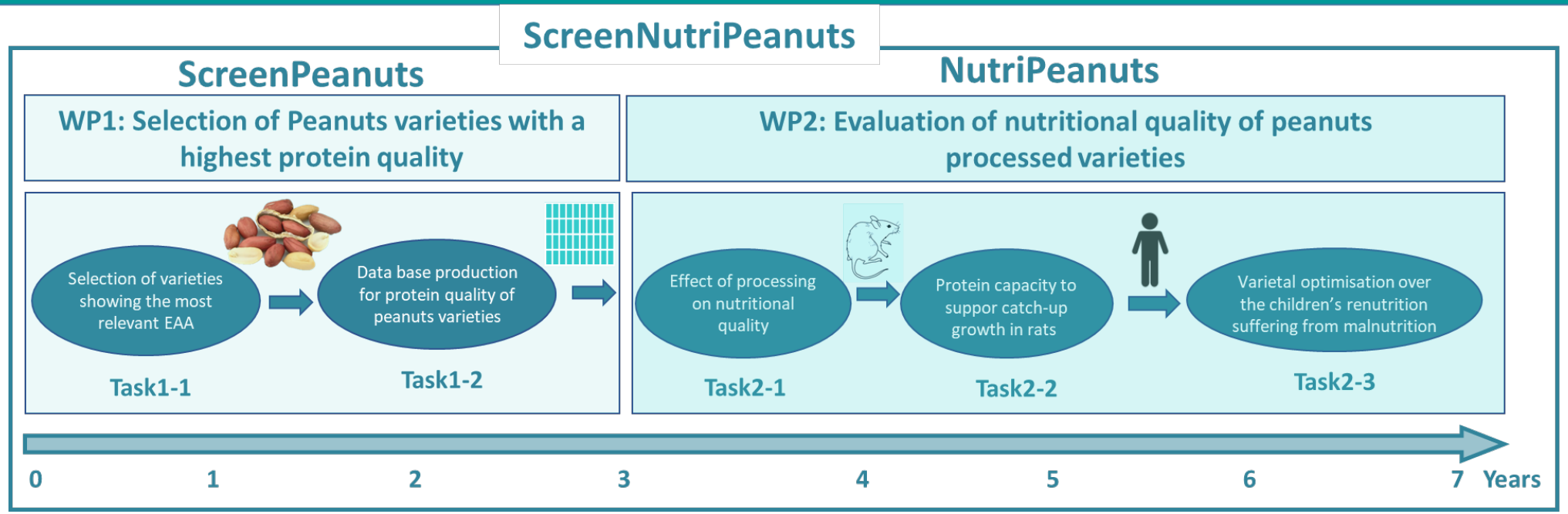
Industrial applicability on ready-to-use therapeutic food in 6 countries

↓

Clinical study on the digestibility (1 variety)

- Sommet France Afrique, Montpellier , Vendredi 8 Octobre 2022, séquence Enseignement supérieur, la recherche et l'innovation (ESRI) dans les champs interconnectés Nourrir-Soigner-Protéger (l'être humain et la planète), modératrice Amanda Harding
- Sommet France Afrique, Montpellier , Vendredi 8 Octobre 2022, séquence présidentielle
- Side-Event Salon International de l'Agriculture/ PROTEINES VEGETALES DANS LE CADRE DE LA GRANDE MURAILLE VERTE : ENJEUX ET PERSPECTIVES, 2 mars 2022

Next steps: Varietal selection of nutritional quality peanuts



WP1: ScreenPranuts

- select peanut variety with the best nutritional quality based on EAA profile from 300 lines already collected by the CIRAD in Senegal,
- produce a database for peanuts protein quality.

WP2: NutriPeanuts

- Impact of technological treatments on peanut EAA profile and nutritional quality of selected peanut varieties
- Effect of high nutritional quality peanut variety in pre-clinical and clinical study in children.

Database creation for amino acids profile in different protein sources

Database creation for amino acids profile in different protein sources

Source	Wheat	Rice	Maize	Wheat var.	Buckwheat	Amaranth	Quinoa	Millet	Oat	Barley	Sorgo
N=	165	68	64	2	42	4	50	33	20	19	76

Source	Bean	Beans	Soybean	Peanut	Pea	Peas	Chickpea	Cowpea	Lupin	Lentils	Cassava
N=	41	95	77	108	31	12	36	38	40	33	56

Source	Yam	Potato	Rapeseed	Sunflower	Human milk	Animal Milk	Chicks	Calf	Pork	Rabbit	Egg
N=	4	16	34	3	3	28	77	11	14	7	37

Source	Bovin	Sheep	Lamb	Goat	Black meat	Fishs Oth.	Sturgeon	Salmon	Tuna	Anchovie	Channa s.
N=	50	3	17	4	8	175	11	10	8	11	30

Source	Tilapia	Tassergal	Sardines	Surmulet	Hareng	Mollus.	Trout			Total	Unclas.
N=	11	8	3	8	6	9	18			**1734**	466

Cereals, Pseudo-cereals, Legumes, Oilseed, Root, Egg, Milk, White milk, Red meet, Fish

Lysine content of different sources of proteins

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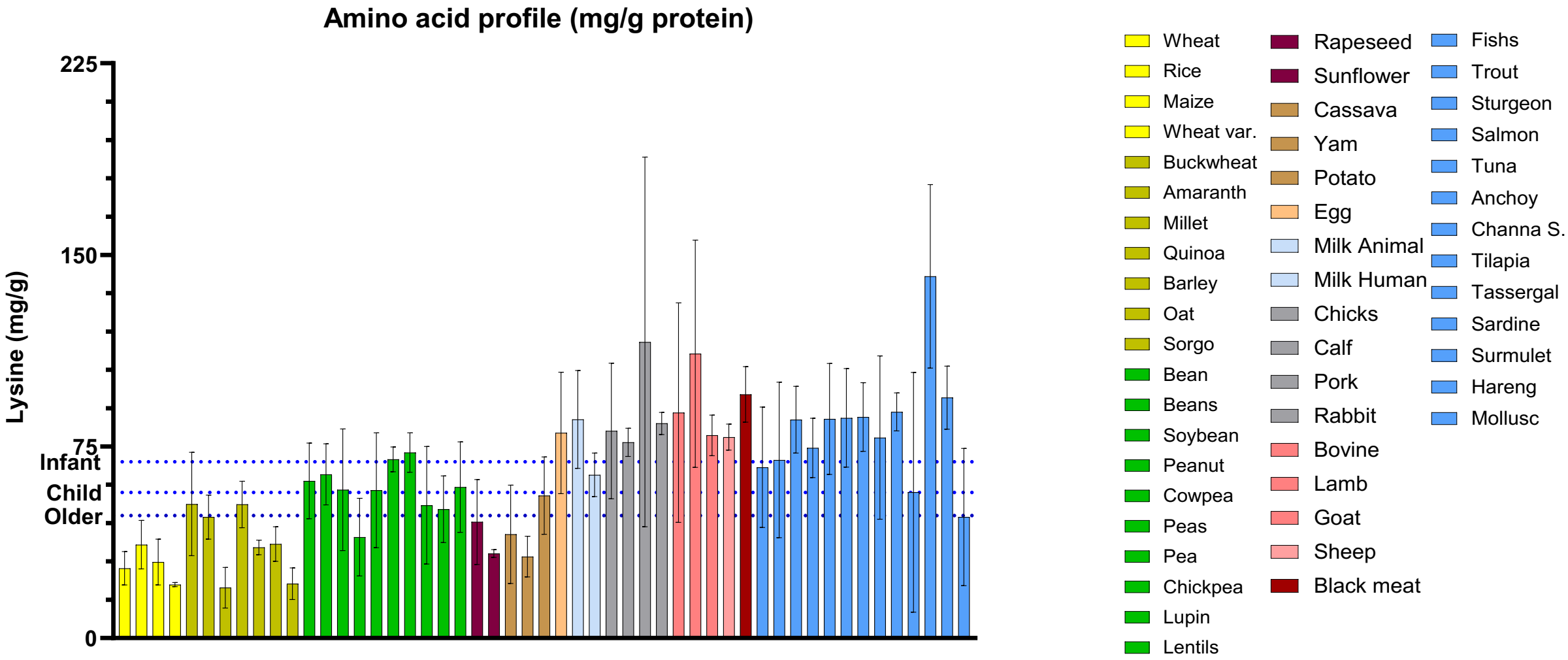

Cereals, Pseudo-cereals, Legumes, Oilseed, Root, Egg, Milk, White milk, Red meet, Fish

Variability of lysine content peanuts varieties

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Cultivar effect

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Anova Table (Type II tests)

Response: Lys
           Sum Sq Df F value Pr(>F)
Cultivar    15593 70   29.67 0.0022 **
MethodeAA      80  2    5.34 0.0743 .
Residuals      30  4
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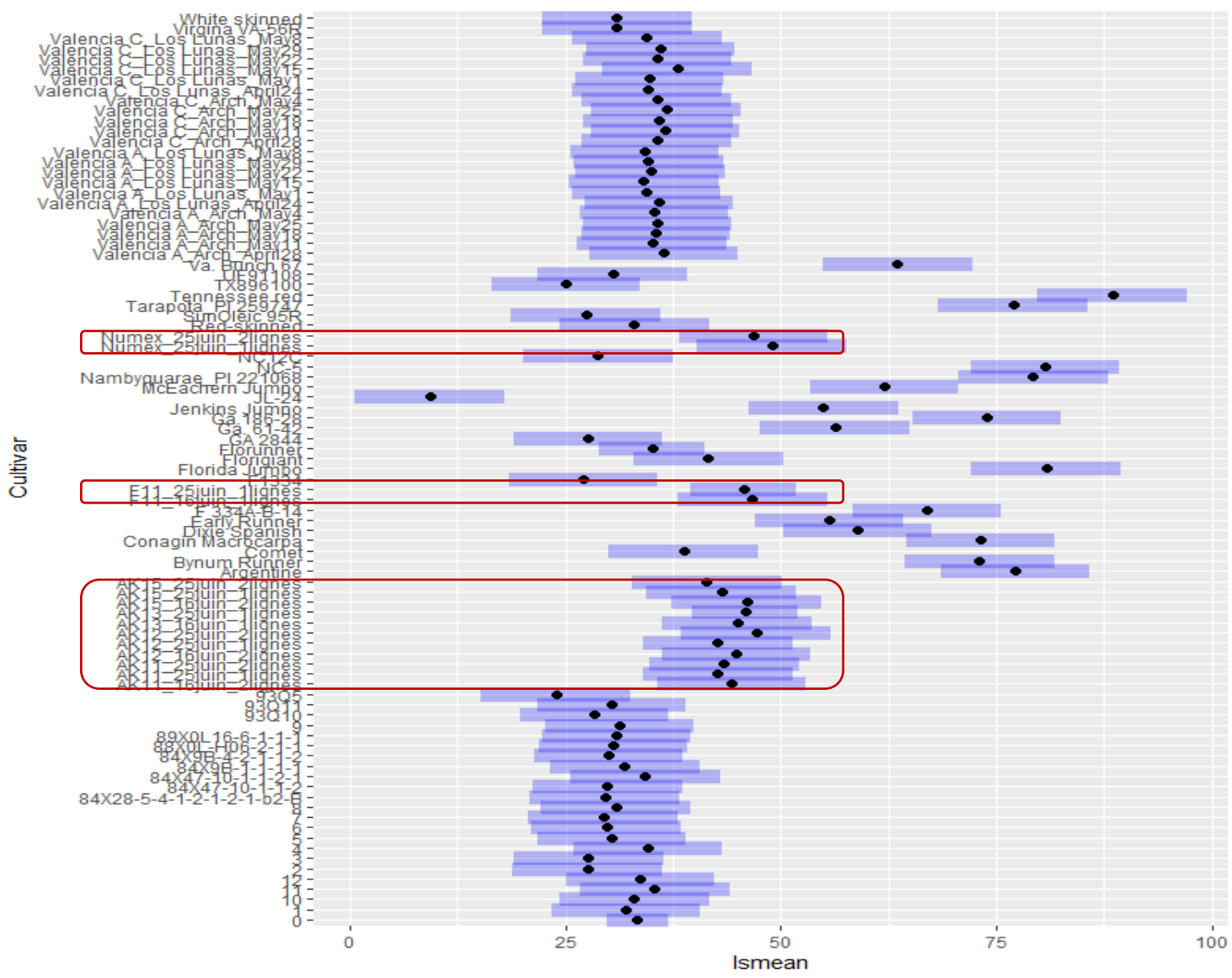

Conclusion

- There is not only on amino acid profile for one specie, but many, depending of the variety
- Knowing indispensable amino acid profile of proteins allow the calculate amino acid score, first step to evaluate protein quality
- to select variety based on protein quality for developing high nutritional quality food will promote nature biodiversity to conserve and promote sustainable use of biological resources, adapted to local environmental conditions.
- Identification of non invasive biomarkers of amino acid requirement allow to measure the ability of protein to cover amino acid requirements
- The developpement of new mathods to measure digestibilty will allow to provide reference data fot the bioavailability of amino acids for differentes protein sources