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L'INSTITUT
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EAAP

European Federation of Animal Science

Meat vegetable analogues: real competitors of animal foods?

Are the nutritional and sensory services identical between meat foods and vegetable analogues of meat?

PORTO (PORTUGAL)

4-9 Sep. 2022

L'INSTITUT NATIONAL D'ENSEIGNEMENT SUPÉRIEUR POUR L'AGRICULTURE, L'ALIMENTATION ET L'ENVIRONNEMENT

MEMBRE DE

UBFC

UNIVERSITÉ
BOURGOGNE-FRANCHE-COMTE



Session 59. Flexitarianism, plant-based products, cultured meat: pros and cons of these new solutions

Who is your speaker?

PR Philippe CAYOT

- Teacher (Institut Agro Dijon, France) in:
 - Food Chemistry and Food Process Chemistry
 - **specialist in Food Formulation**

- Research (UMR PAM, UBFC) about:
 - **Iron: bioavailability in vegetable food**
 - **Iron: radical initiator ; lipid oxidation**
 - **Antioxidant: fast detection (electrochemistry)**
 - **In the past: protein gelation & emulsifying activity of protein**



1. Competitive environment

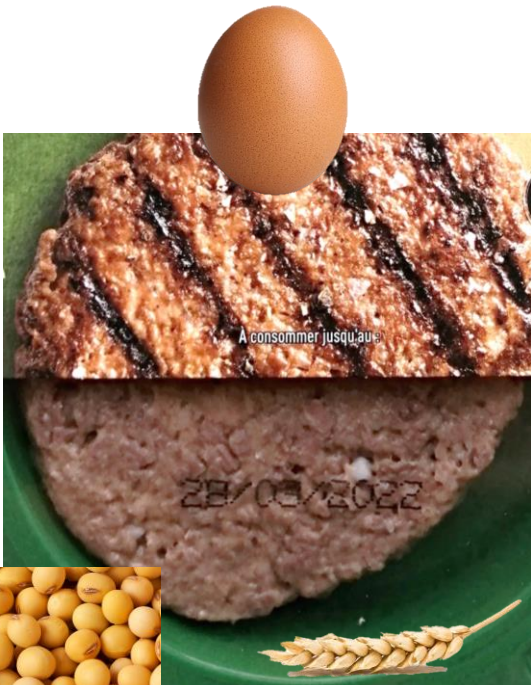
How meat analogues mimic meat products?

Hamburger meat versus “wheat and soy garden delicacy”

Chopped meat

Ingredients:

pure ground beef



PR Philippe CAYOT Meat vegetable analogues: real competitors?

Major European charcuterie brand

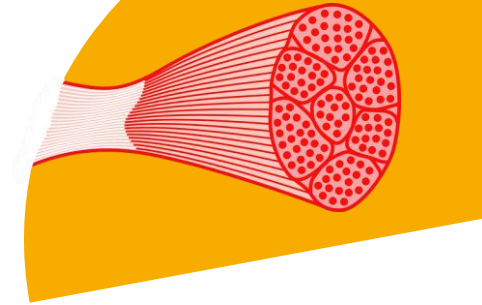


Ingredients: rehydrated **SOY PROTEINS** 51% (water, soy protein 16%), rehydrated **wheat protein** 15% (water, wheat gluten 6%), rapeseed and sunflower oil, onions, mayonnaise, **EGG WHITE POWDER** 4,1%, **yeast extract**, onions powder & flakes, vinegar, apple purée, **MAIZE STARCH**, salt, spices & aromatic herbs (& extracts), **barley malt extract**, potassium hydroxide (acidity corrector)

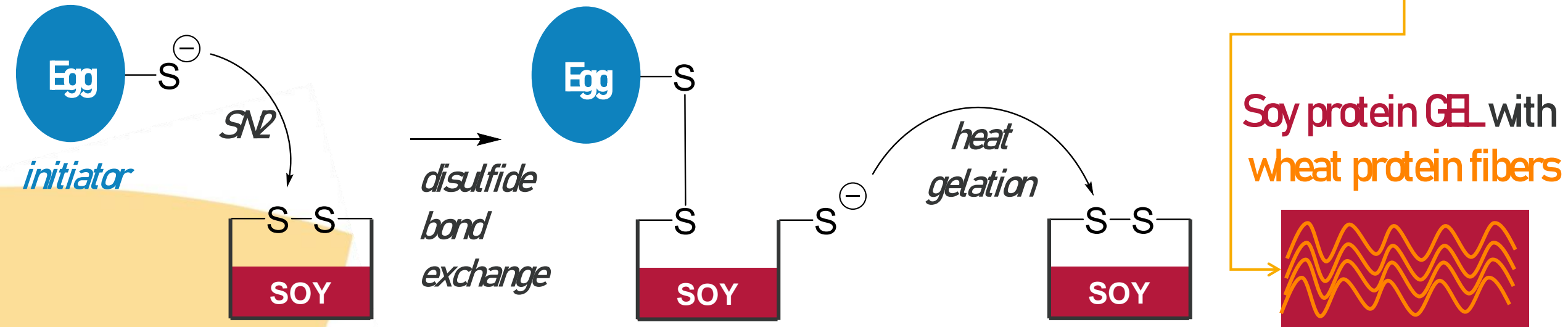
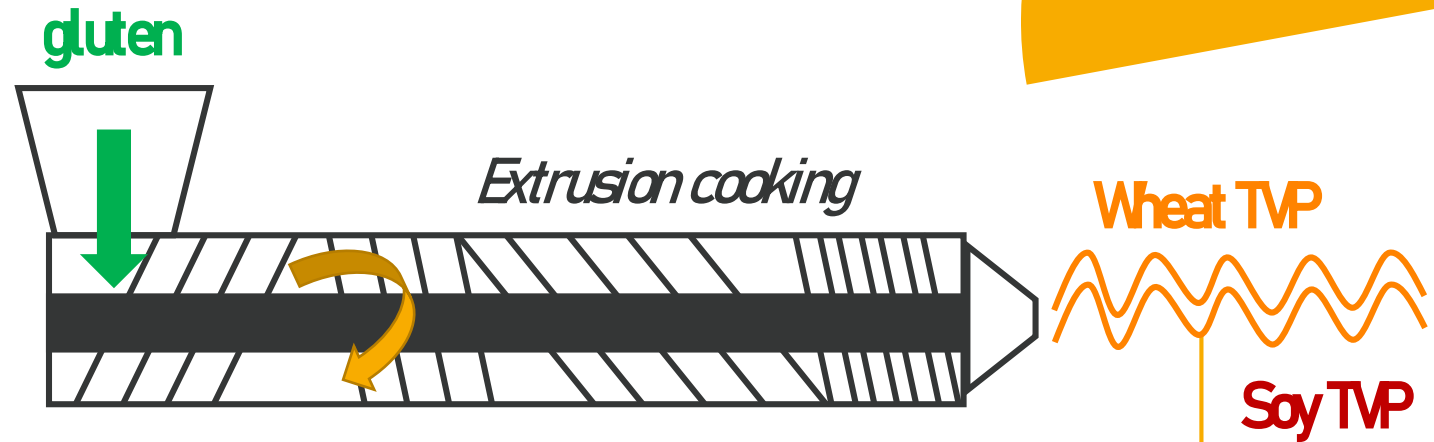
GEL - **fibrous texture**
taste - **color**



How is the meat analogue designed & formulated?



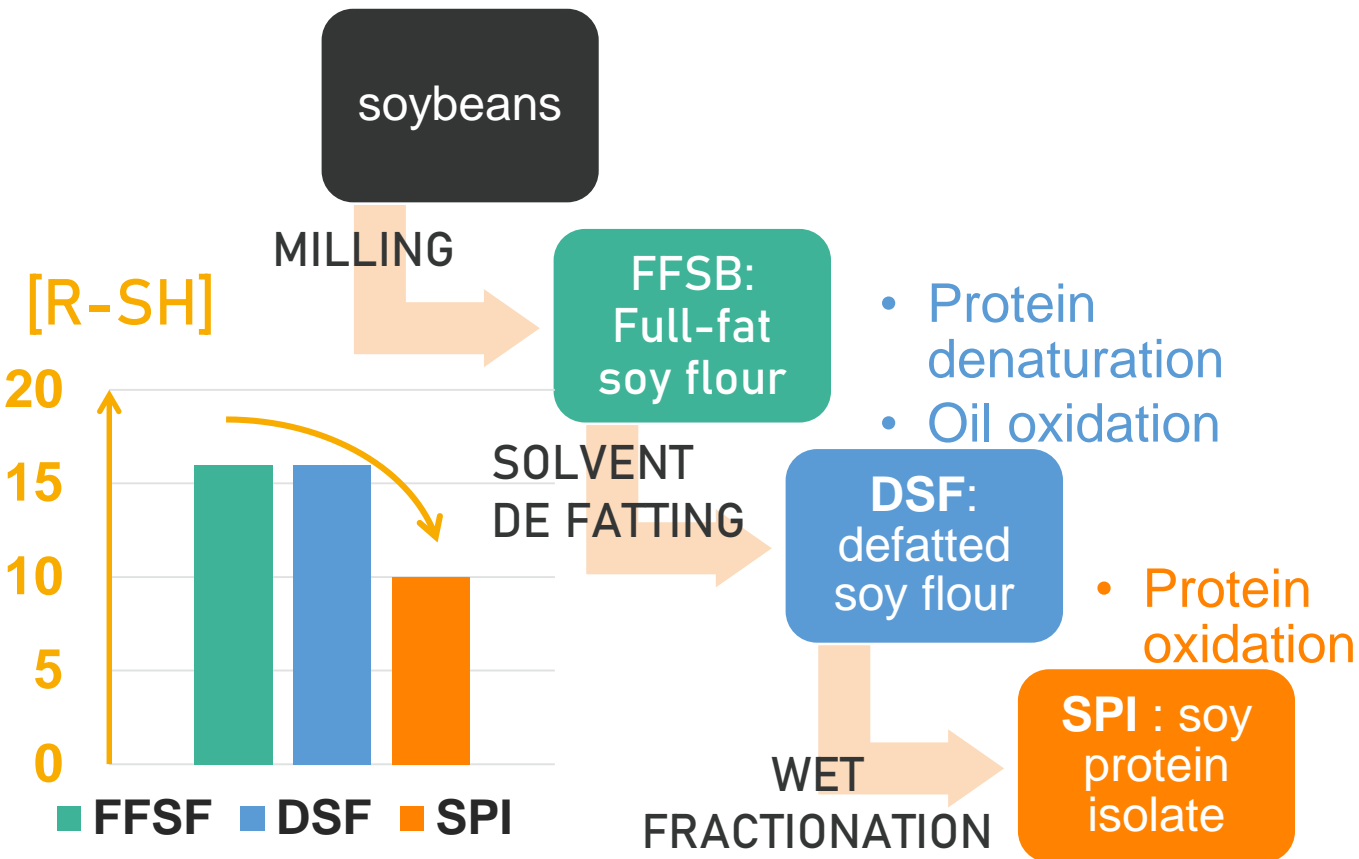
- ❖ To simulate meat fibers = **gluten** → wheat "texturized vegetable protein"
- ❖ Egg proteins = gel initiator
- ❖ To associate meat-like fibers = Soy + Egg protein's **GEL**
- ❖ To retain water = starch



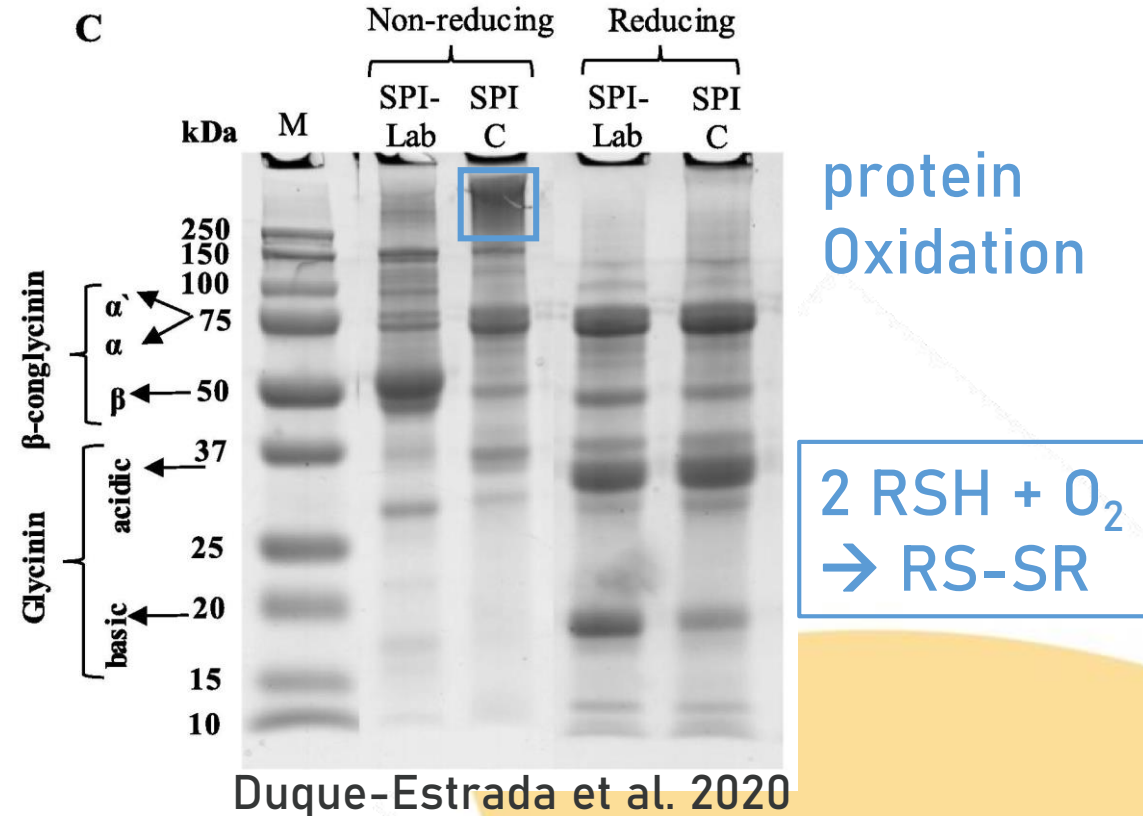
Soy protein isolation: oxidation of proteins

Duque-Estrada et al. *Food Chemistry* 318 (2020) 126499

Thiol group concentration ($\mu\text{mol} / \text{g}$ of protein) by DTNB determination



SDS-PAGE non-reducing & reducing (2-mercaptoethanol) conditions



Chicken aiguillettes versus “grilled wheat and soy strips”

Chicken aiguillettes



Ingredients: chicken

TVP

texturized vegetable protein

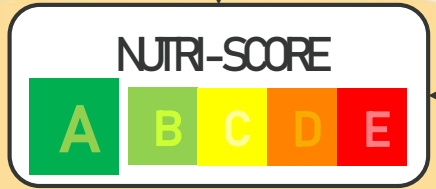


Major European charcuterie brand



Ingredients: rehydrated **SOY PROTEINS** 49% (water 37%, soy protein 13%), rehydrated **wheat protein** 22% (water 14%, wheat gluten 8%), rapeseed and sunflower oil, apple purée, **EGG WHITE POWDER** 3,7%, **yeast extract**, vinegar, onions powder, citrus fibers, **MAIZE STARCH**, salt, spices, **egg yolk**, iodized salt, sucrose, mustard, water

GEL = soy + egg + starch
fibrous texture - **color** - unami taste



2. Nutritional services

Is meat analogues a real meat replacer?



Hamburger meat versus “wheat and soy garden delicacy”: analogy up to the same protein concentration

Minced meat

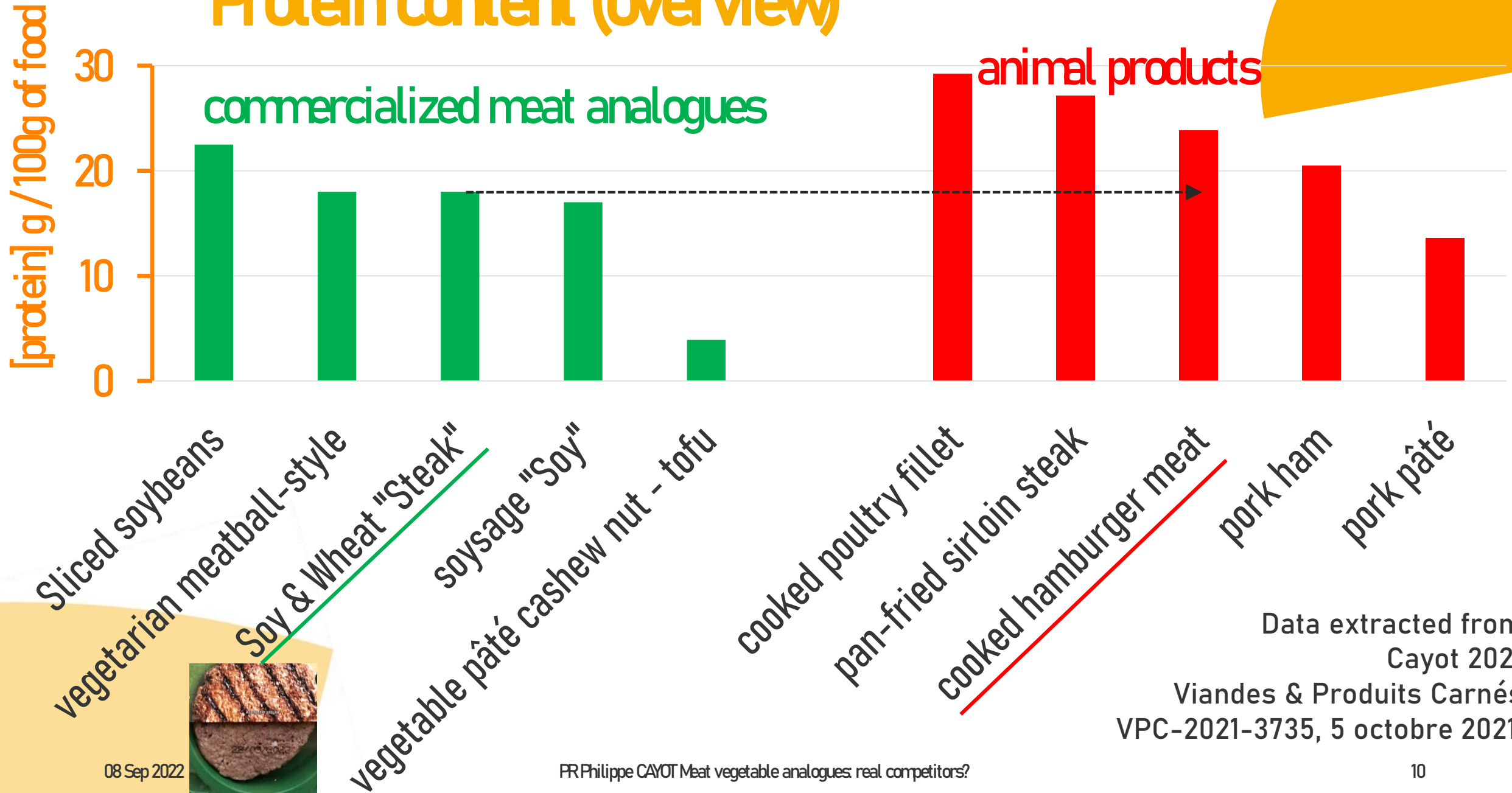
Major European charcuterie brand

Nutritional Facts	/ 100 g of product
Energy	540 kJ
Protein	21 g
Total Fat (saturated fat)	5 g (2,3 g)
Total Carbohydrate (sugars)	0 g (0 g)
Fibers	0 g
Salt (Na Cl)	0 g

=

Nutritional Facts	/ 100 g of product
Energy	913 kJ
Protein	21 g
Total Fat (saturated fat)	11 g (1,2 g)
Total Carbohydrate (sugars)	6,2 g (3,2 g)
Fibers	5,5 g
Salt (Na Cl)	1,4 g

Protein content (overview)



Data extracted from
Cayot 2021
Viandes & Produits Carnés
VPC-2021-3735, 5 octobre 2021.

Deeper nutritional analysis: Nutritional Quality of Protein

DIAAS *

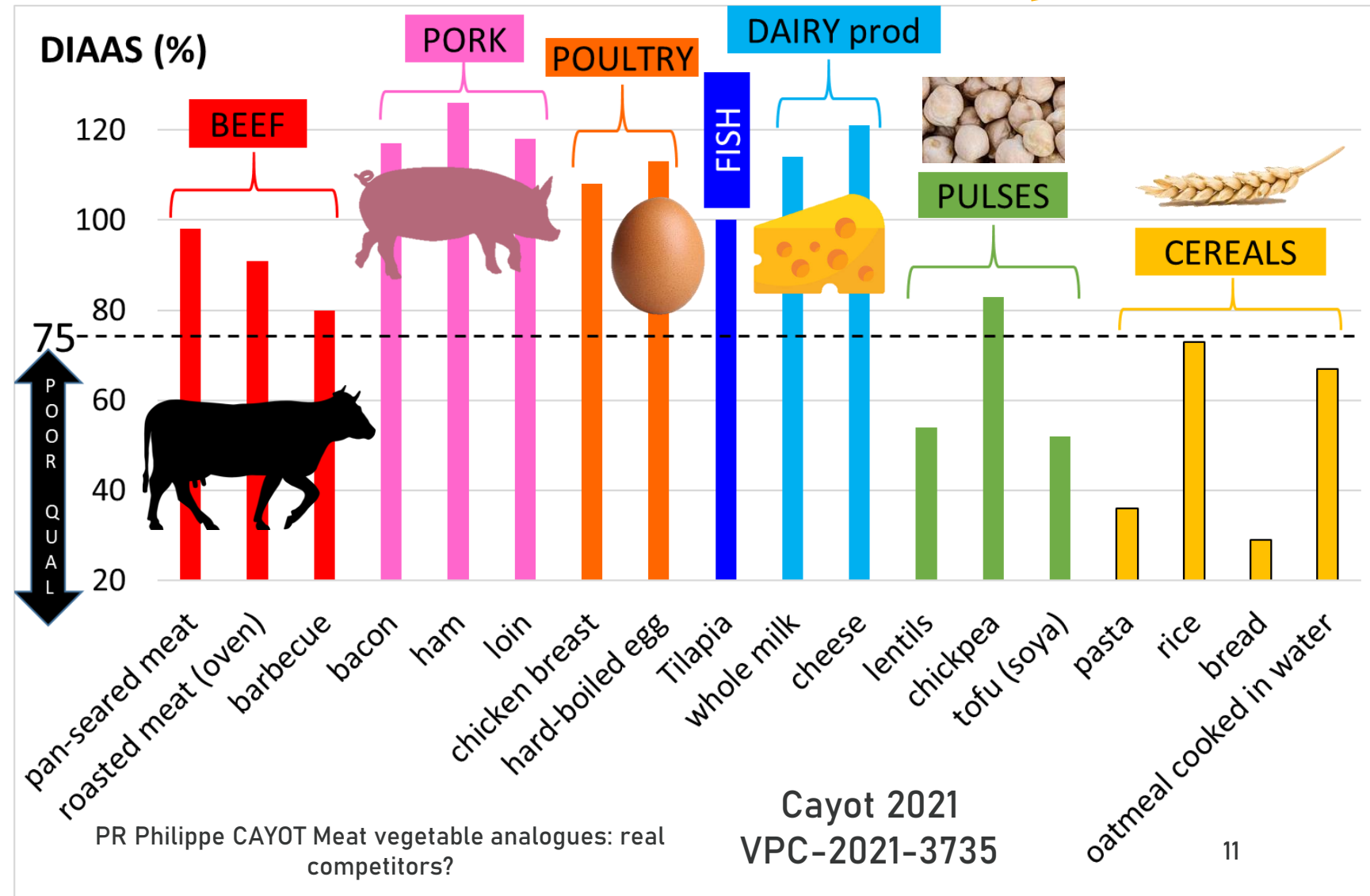
= 100 x

$$\frac{\text{mg L-EAA (one protein)}}{\text{mg L-EAA (ref protein)}}$$

content corrected with
digestibility in ileon

L-EAA = digestible dietary
Limiting Essential Amino Acids

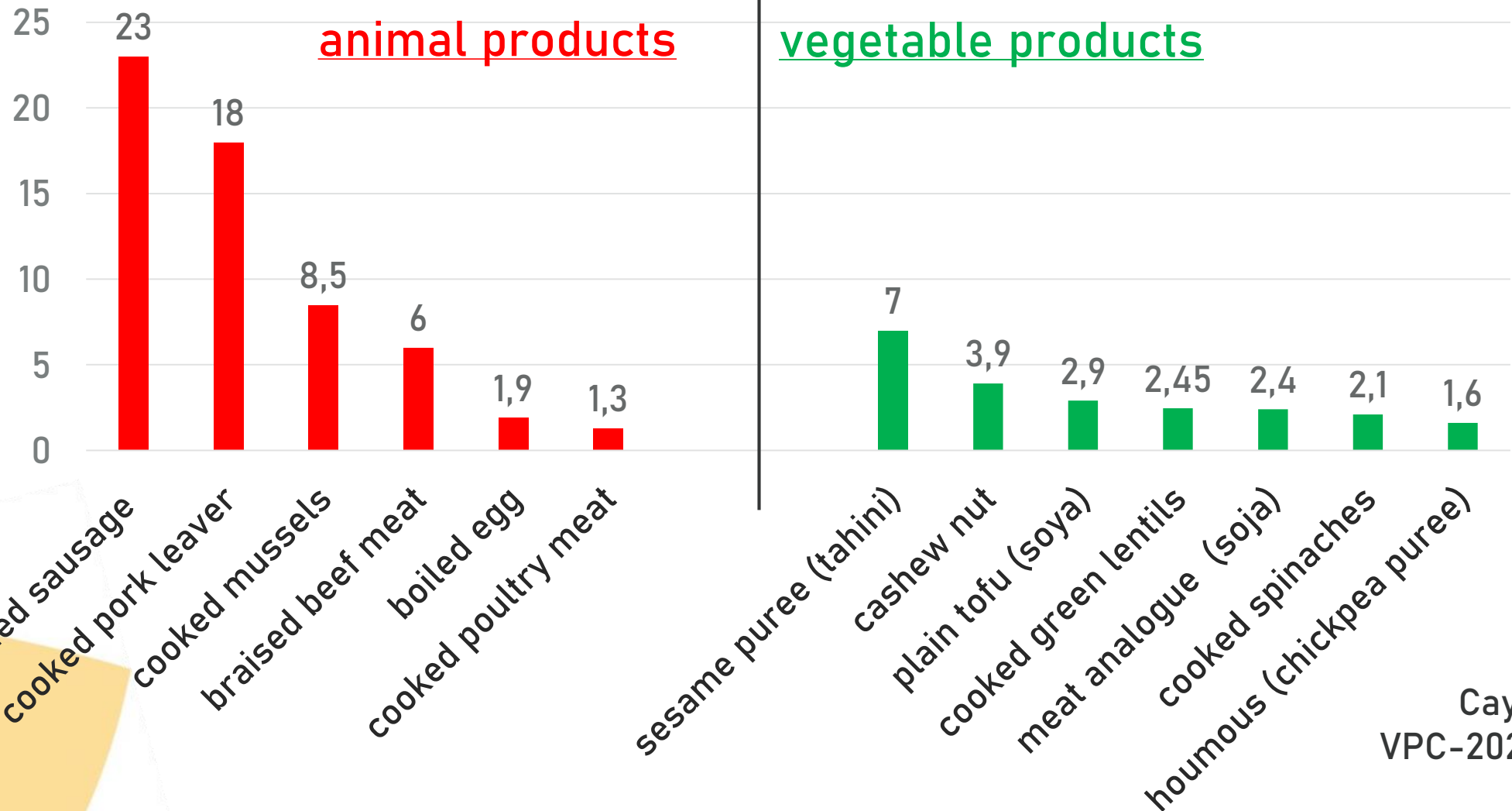
* digestible indispensable
amino acid scores



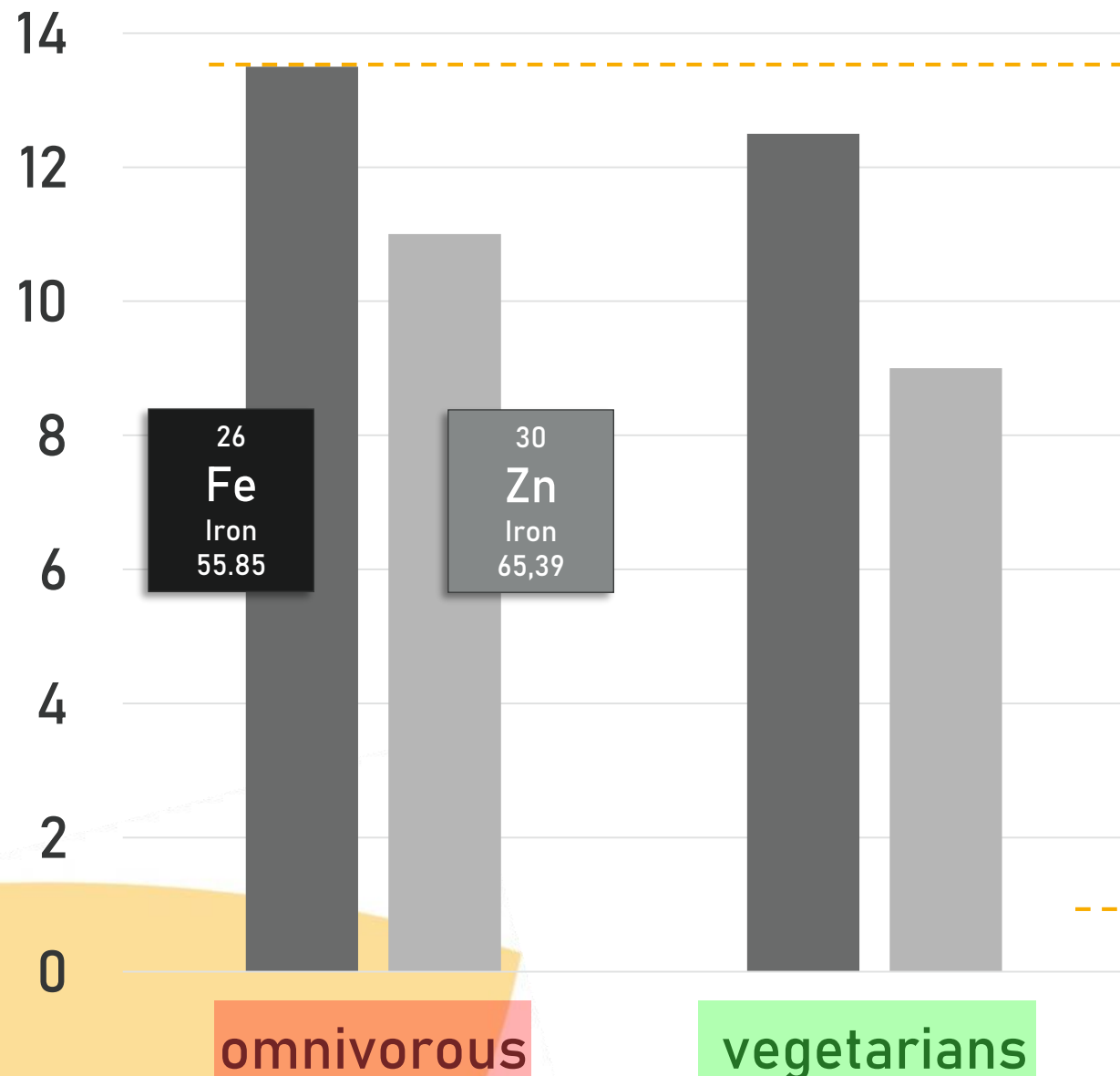
Iron intake

26
Fe
Iron
55.845

iron content (mg / 100g of ready-to-eat food)



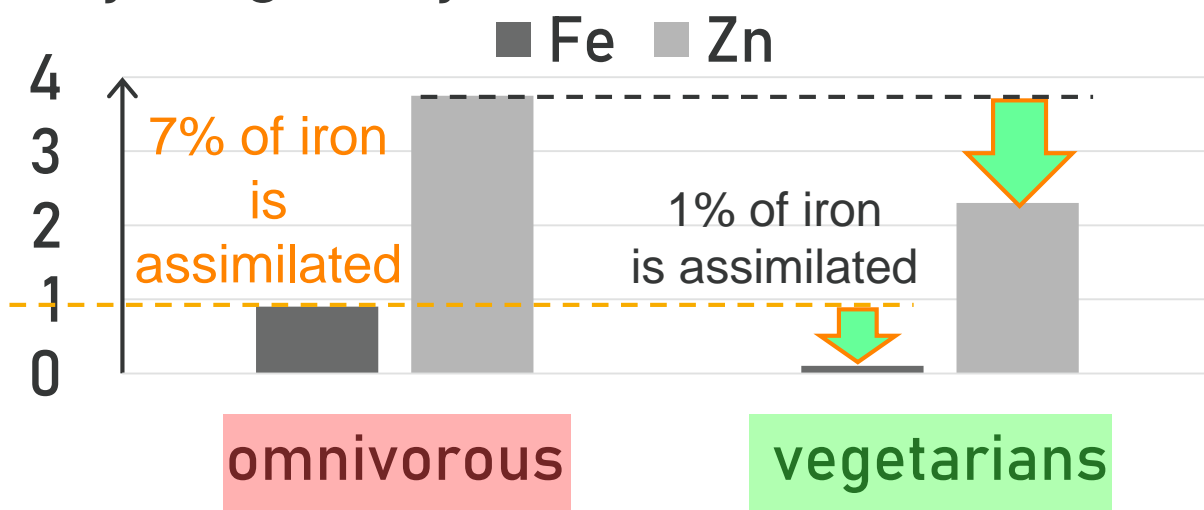
iron intake per day (mg / day)



Iron Bioavailability

Hunt, J.R. (2003)
Am J Clin Nutri 78 (3), 633S-639S

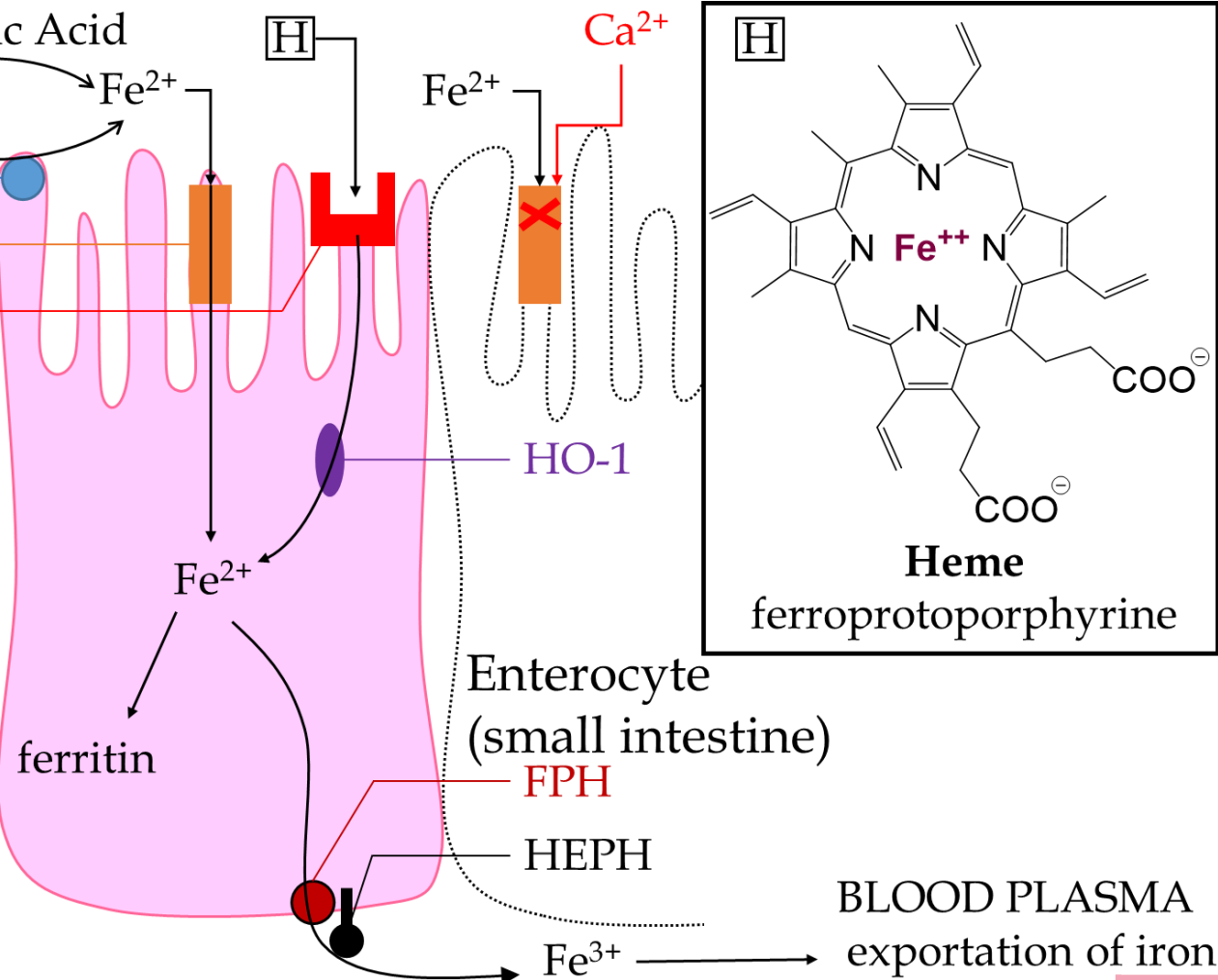
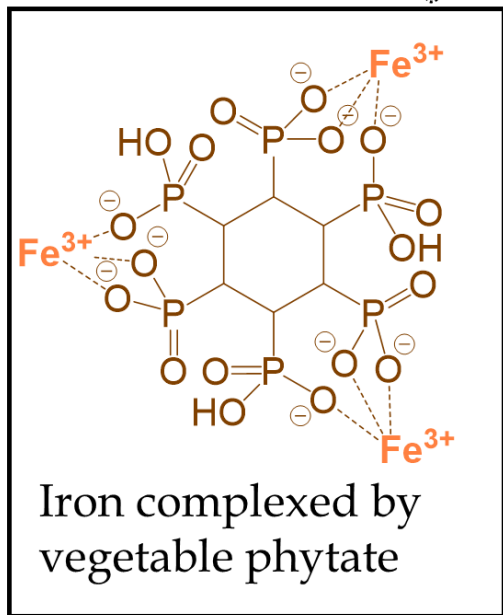
Amount of iron absorbed per day (mg / day)



INTESTINAL LUMEN



DCYTB
 DMT1
 HCP1



H
 Myoglobin
 Hemoglobin

Specific transporter
 HCP1 : Heme
 Carrier Transporter

Iron absorption in duodenum

Cayot 2022 hal-03714339

iron bioavailability	
heme Fe	ionic Fe
10 – 25 %	1 – 5 %

Process & Formulation to increase iron bioavailability of hummus

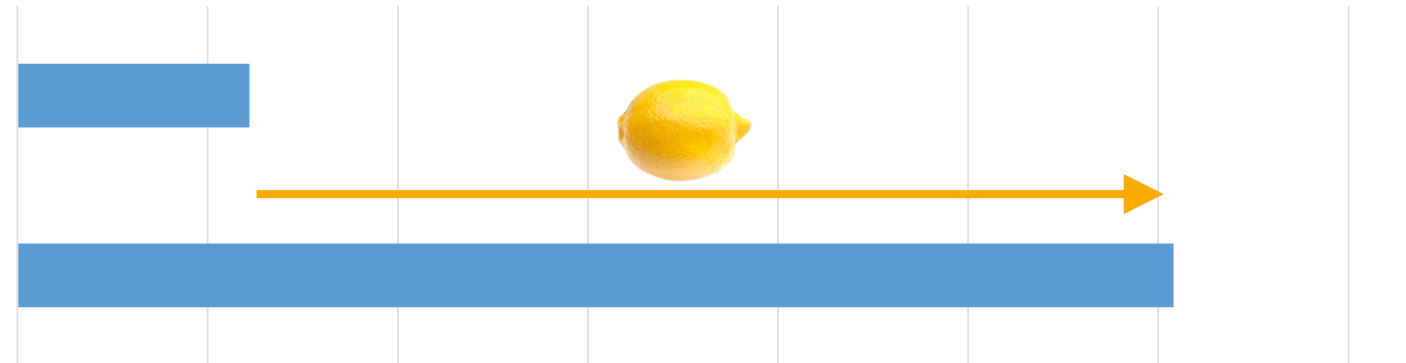


Doumani et al. Foods 9 (2020) Issue 4, article N° 474



Iron uptake by Caco-2 cells (in ng of synthesized ferritin per mg of total cell protein)

Hummus without lemon juice



Hummus with lemon juice

* Chickpea soaked 24h before pressure cooking

0 5 10 15 20 25 30 35
ng of ferritin / mg of cell protein

3. Sensory services

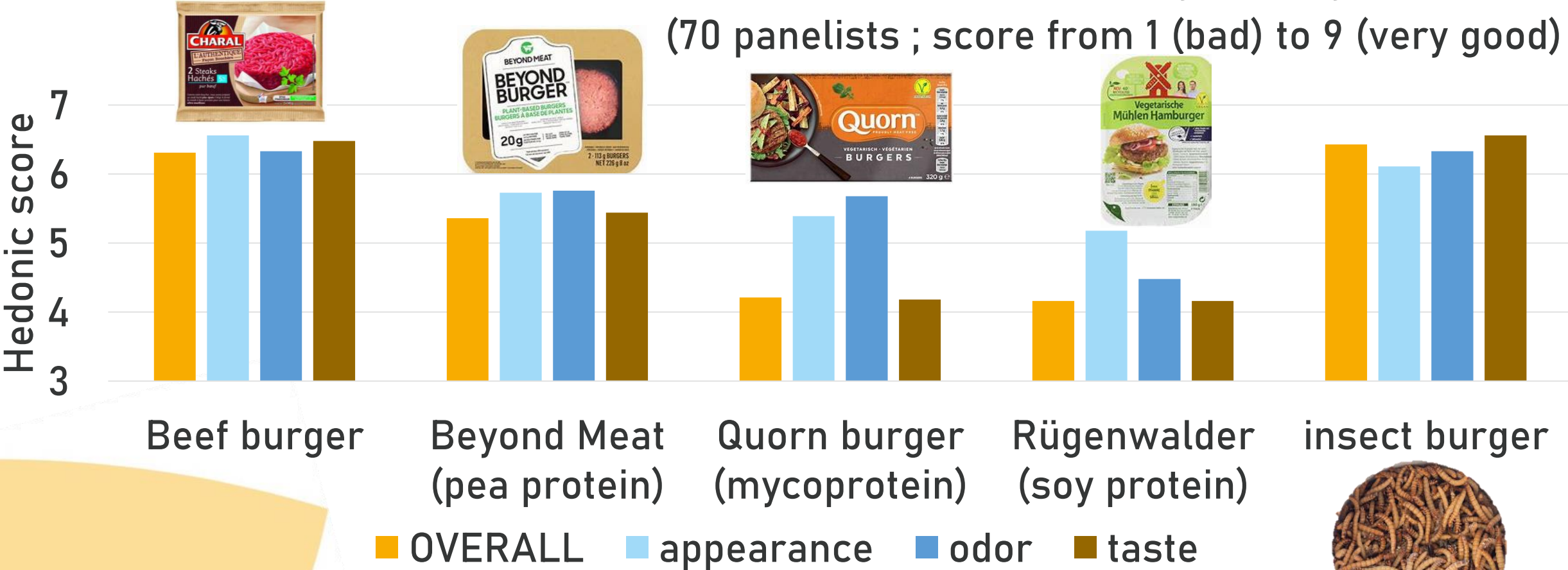
Is meat analogues a real meat replacer?

Hedonic score of meat burger analogues compared to beef burger

Smetana Future Foods 4 (2021) 100042

Hedonic Sensory Analysis

(70 panelists ; score from 1 (bad) to 9 (very good))

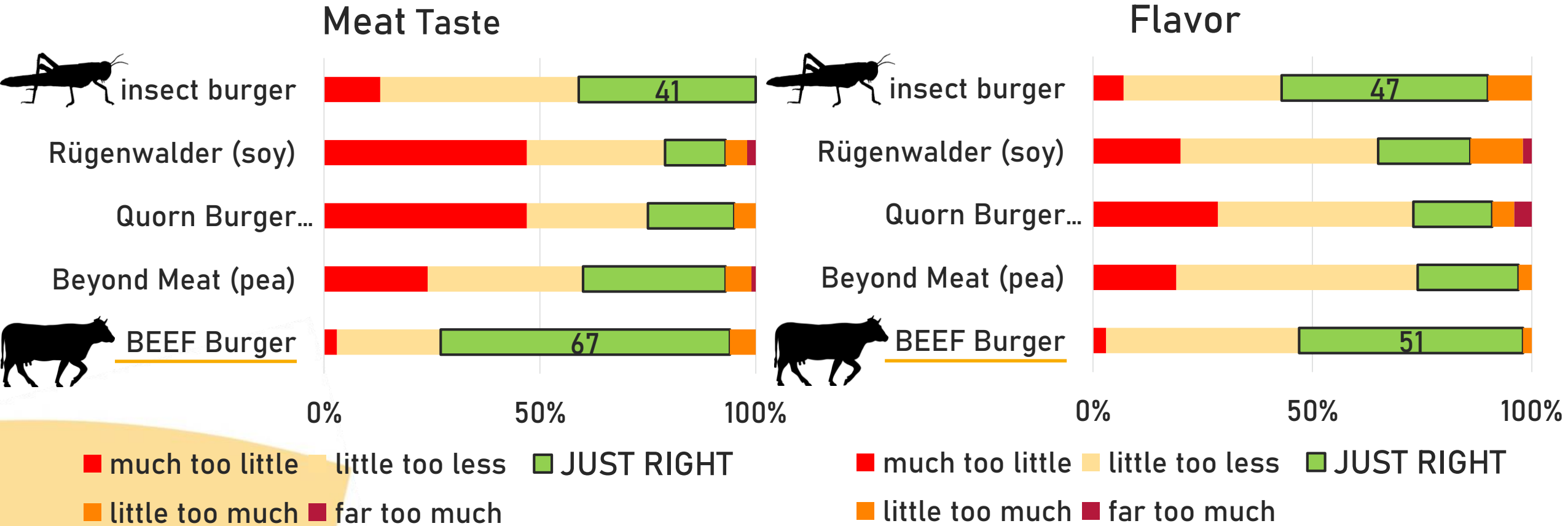


Differences in taste and odor: J.A.R.* sensory test



Smetana Future Foods 4 (2021) 100042

* Just-About-Right evaluation





Non-conventional western protein source: addition of earthworm powder to “arepa de maíz” (corn pancake)



Universidad de los Andes
Merida, Venezuela

Protein conversion efficiency = 36%



Eisenia foetida



drying



earthworm powder
65 g prot./100 g

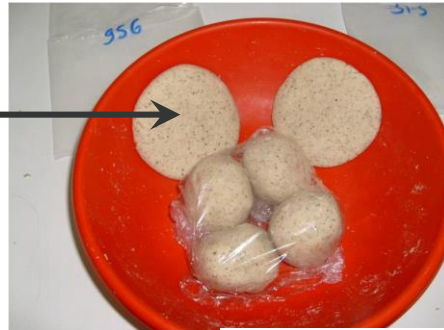
08 Sep 2022

Minimum 25% of under-nourished children

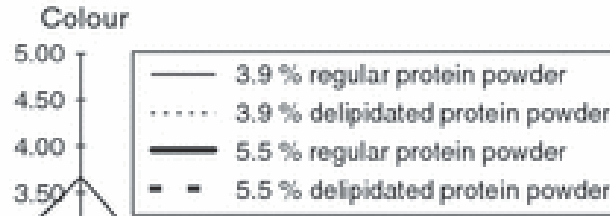
Classical arepa de maíz
< 3g protein with 100% maize

TASTE

supplementation



ODOUR



+5,5% powder = 5 g of protein in a 50g-pancake

3 pancakes (+5,5%) = Needs for a 4-year old child: (15g/d of protein)

Sensory acceptability:

+ 5.5% (m/m) regular powder
+ 7.7% (m/m) delipidated powder (10,5 % to 5% of lipid)

Close to 2.5

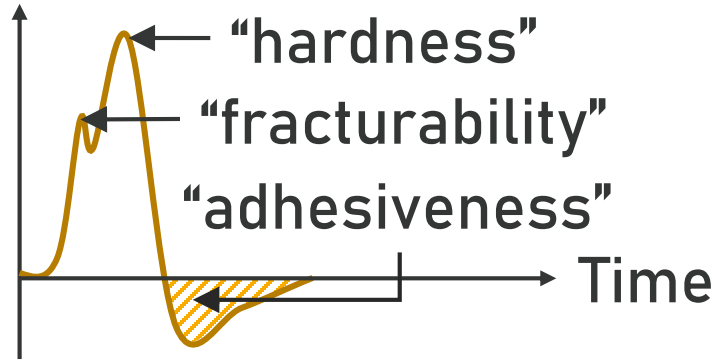
Neither too weak nor too intense

Cayot et al. 2009 International Journal of Food Science and Technology 44 (2009) 2303-2313

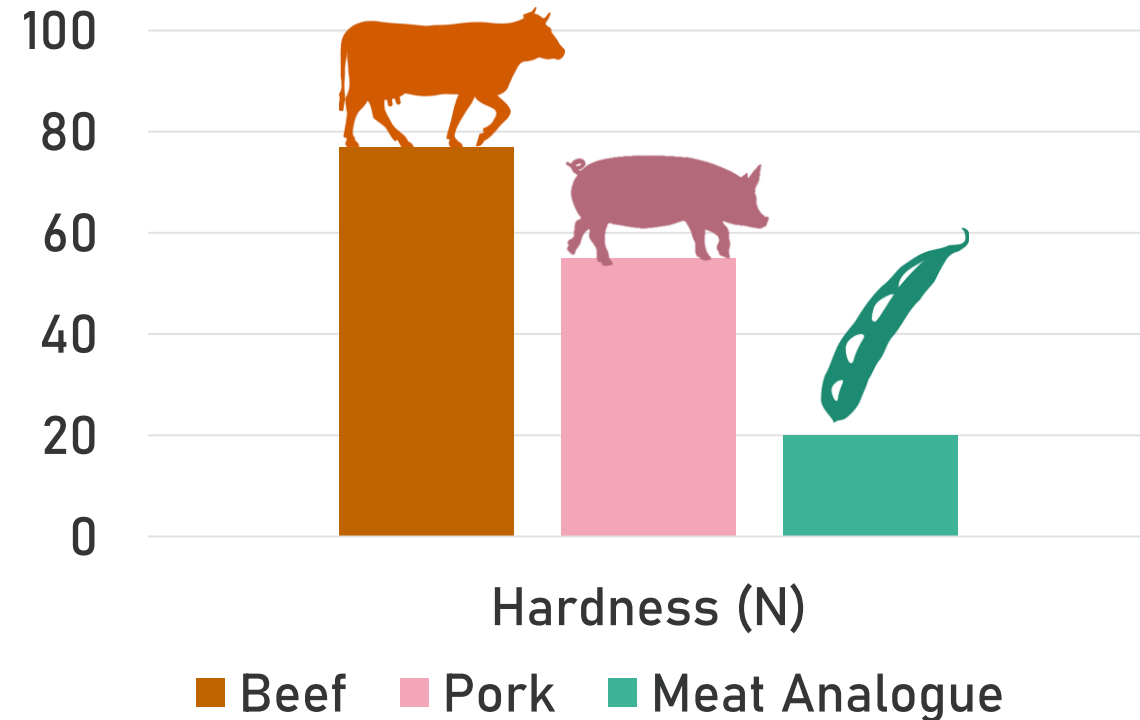
PR Philippe CAYOT Meat vegetable analogues: real competitors?

Texture Profile analysis

Compression force (N)



Maximum of compression force (named "hardness")



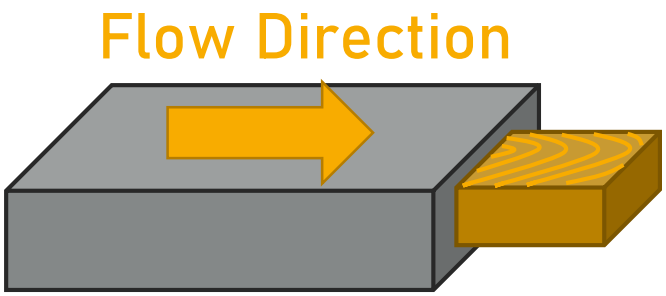
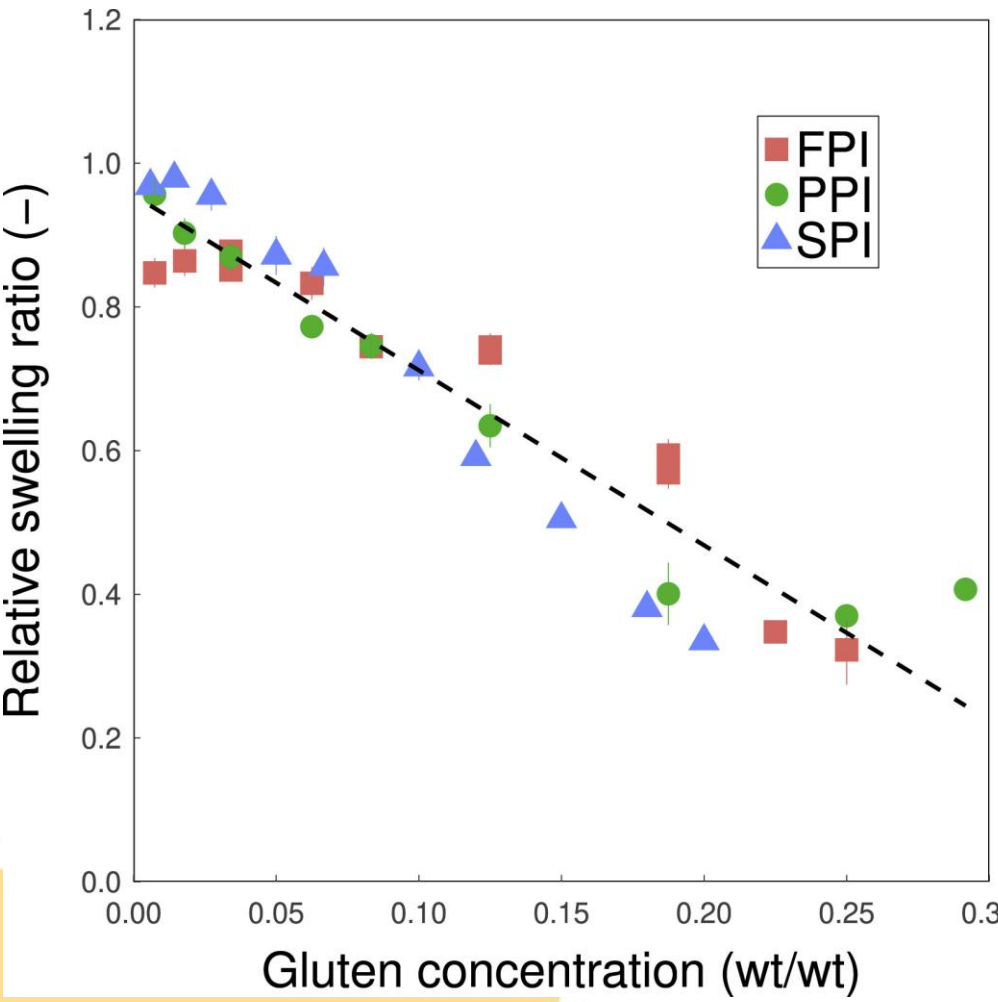
<https://texturetechnologies.com/blog/plant-based-burgers-vs-the-real-thing>

08 Sep 2022

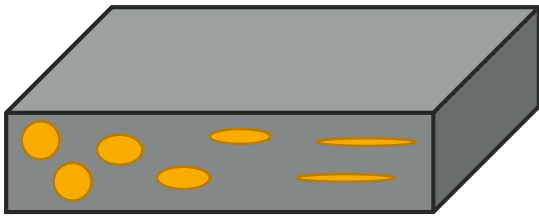
PR Philippe CAYOT Meat vegetable analogues: real competitors?

Bakhsh et al. (2021)
Food Sci Anim Resour 41 (6) 983-996

Design fiber structure with extrusion & mixture of gluten and leguminous proteins



Sun et al. (2022)
Food Biophys 17 (2)
(2022) 137-149



- Laminar flow
- Fiber marking
- & Gelation



Cornet et al. (2021) Food Hydrocolloids 120 (2021) 106788

4. Recent progress

What should be the innovation?

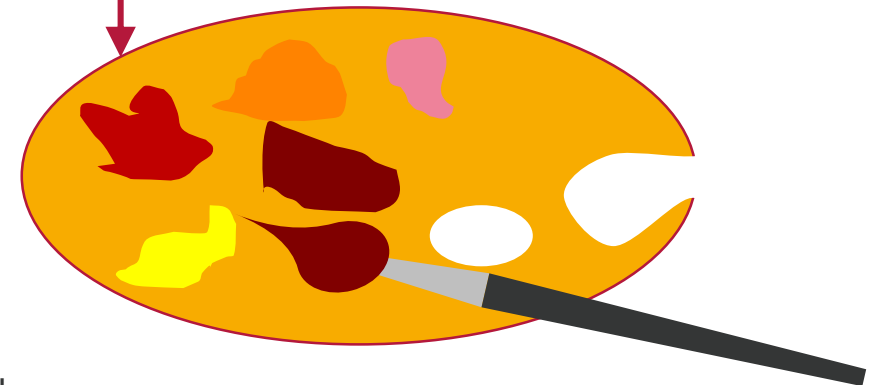
One source of protein

More simple formulation

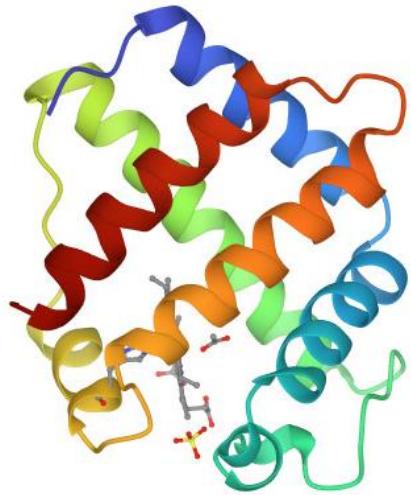
~~NO EGGS~~



Ingredients: rehydrated **SOY PROTEINS** 48% (water, soy protein 20%), water, vegetable oils (rapeseed & coconut), spirit vinegar, aromas, stabilizers (methylcellulose, corn starch), **vegetable concentrates** (apple, beetroot, carrot, hibiscus), salt, barley malt extract powder



Vegetable colorant as close as possible to meat myoglobin

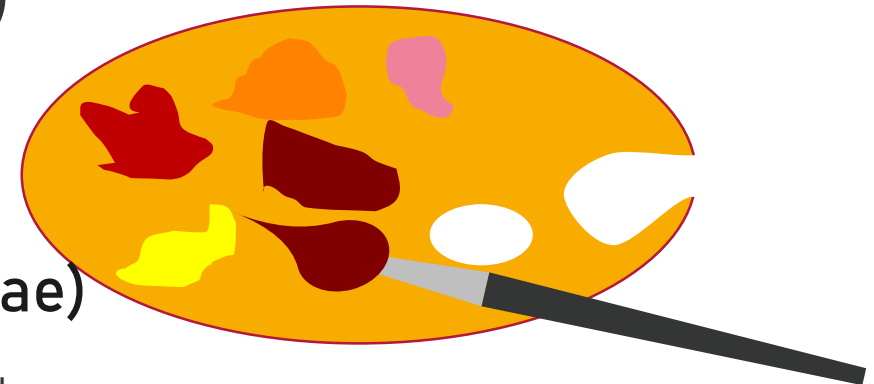


vegetable concentrates (apple, beetroot, carrot, hibiscus)

replaced by

GMO soy leghemoglobin

(used first in 2018, authorized by FDA in 2019)



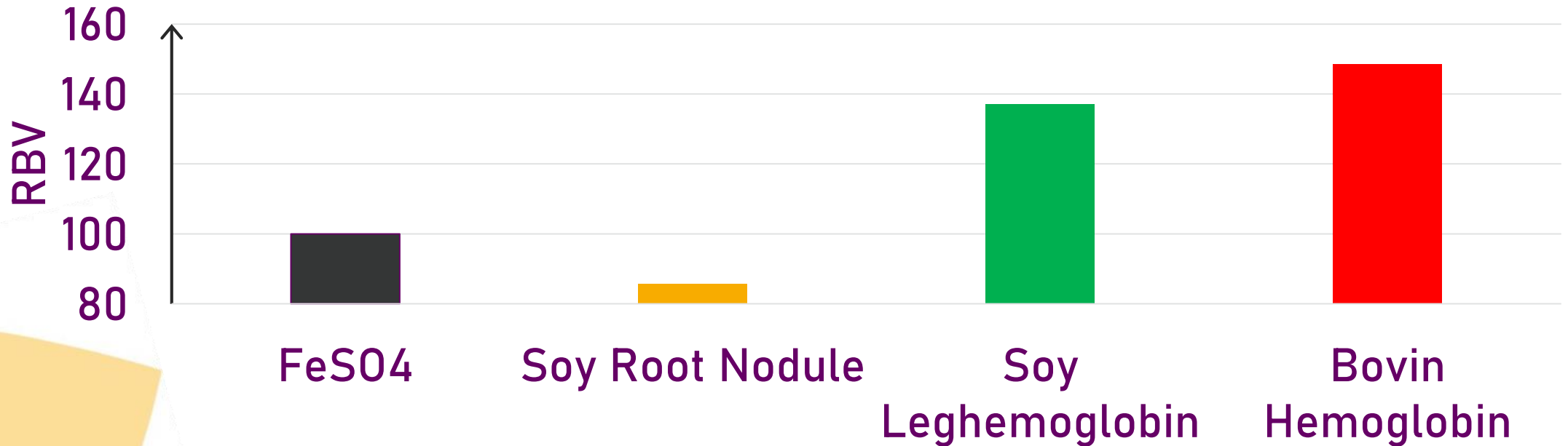
Metalloprotein with heme structure
From roots of Fabaceae (Leguminosae)

Iron bioavailability of leghemoglobin determined with a Caco-2 cell model

Proulx & Reddy (2006) J. Agric. Food Chem. 54 (4) 1518–1522



Iron bioavailability expressed as relative biological value (RBV with FeSO₄ as ref.)





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Thank you for your attention

Homo flexitarian

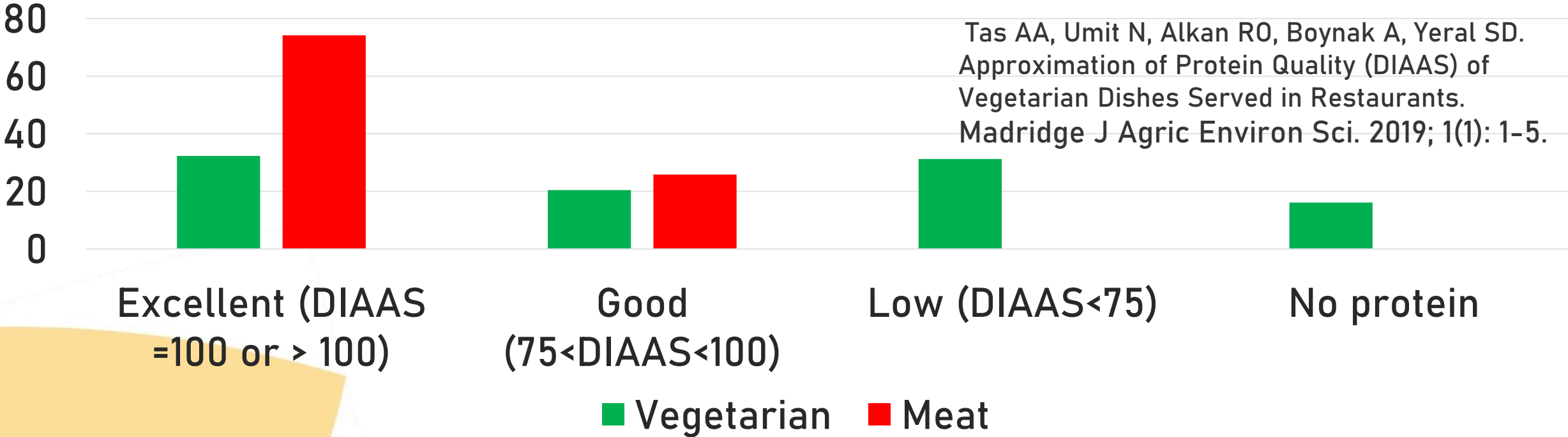


Possible questions

Graph answers

DIAAS in restaurant: vegetarian & meat dishes

Percentage of dishes by categories of nutritional quality of protein



DIAAS with mix of vegetable proteins

