Session 1: Novel Technologies in Food Technology

foods MDPI

New insights in the quality of *Phaseolus vulgaris* L.: nutritional value, functional properties and development of innovative tools for their assessment

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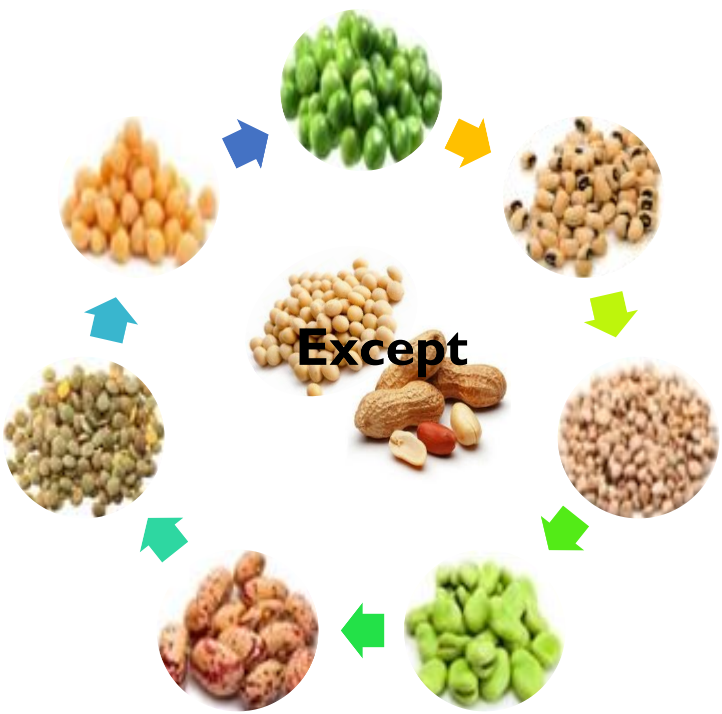
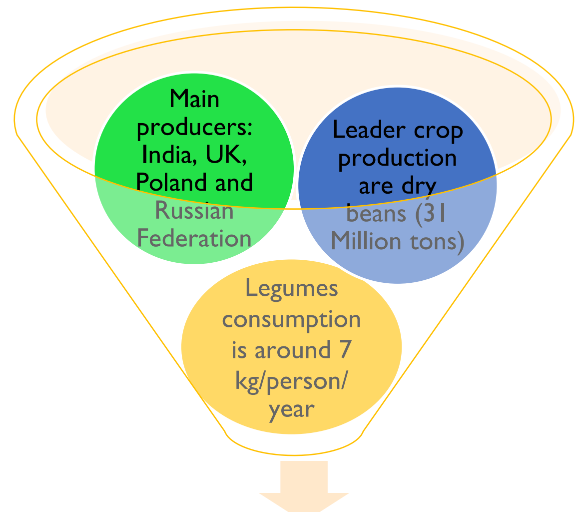
Contents

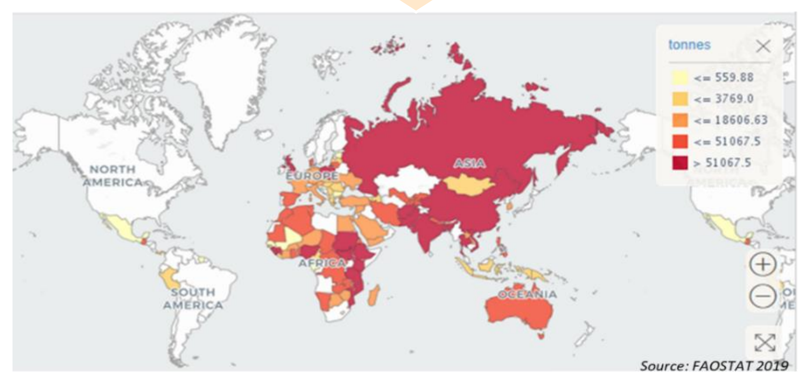
Introduction

Legumes (Fabaceae) are the second most important family of plants, after the grass family (Poaceae), representing 27% of the world crop production.



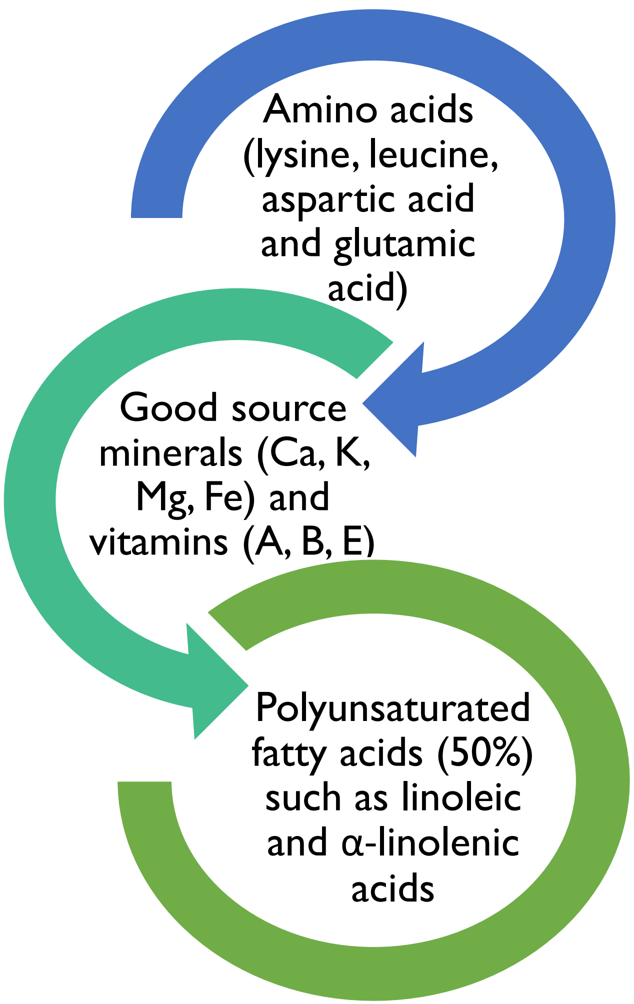
Legumes are limited to crops harvested solely for dry grain, excluding the crops used for oil extraction.

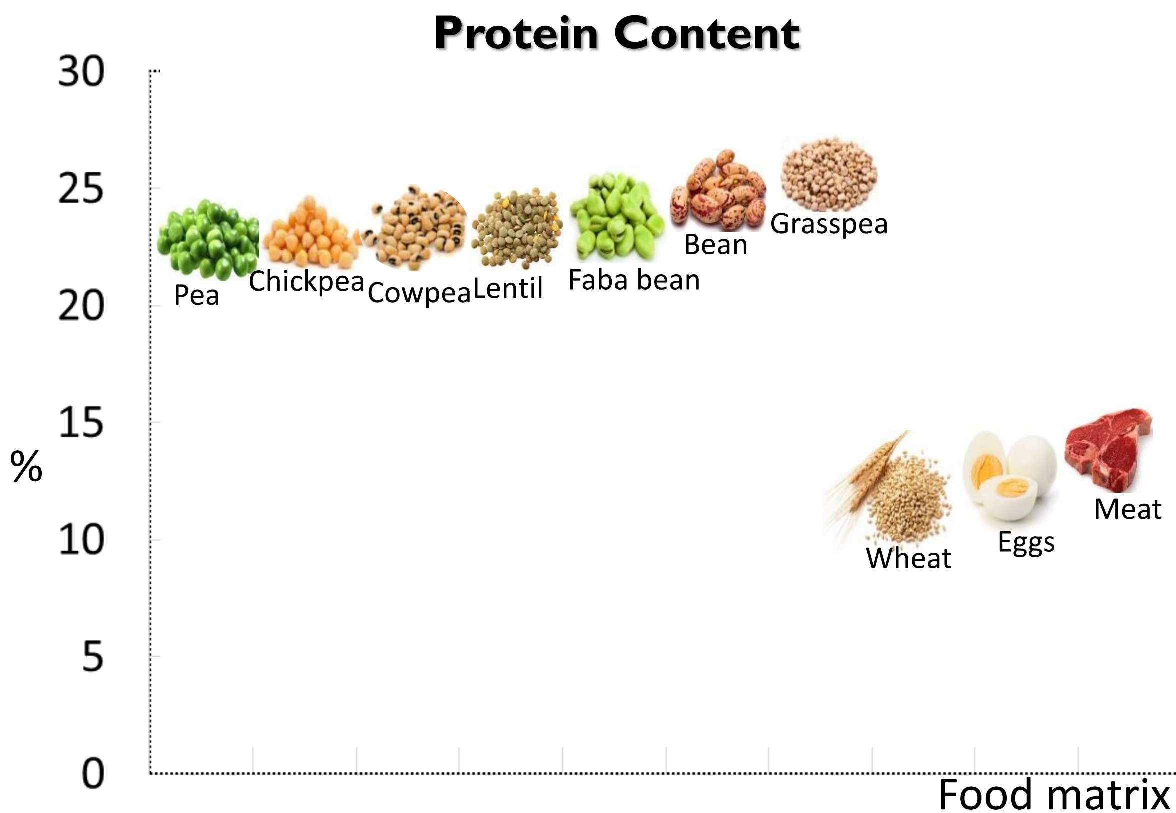




Introduction

Nutritional composition





Introduction

Phenolic compounds

Flavonoids

- ✓ Catechin
- ✓ Epicatechin
- ✓ Kaempferol
- ✓ Quercetin

Represent ≈60% of phenolic compounds in legumes

Distributed mainly in seed coat

Phenolic acids

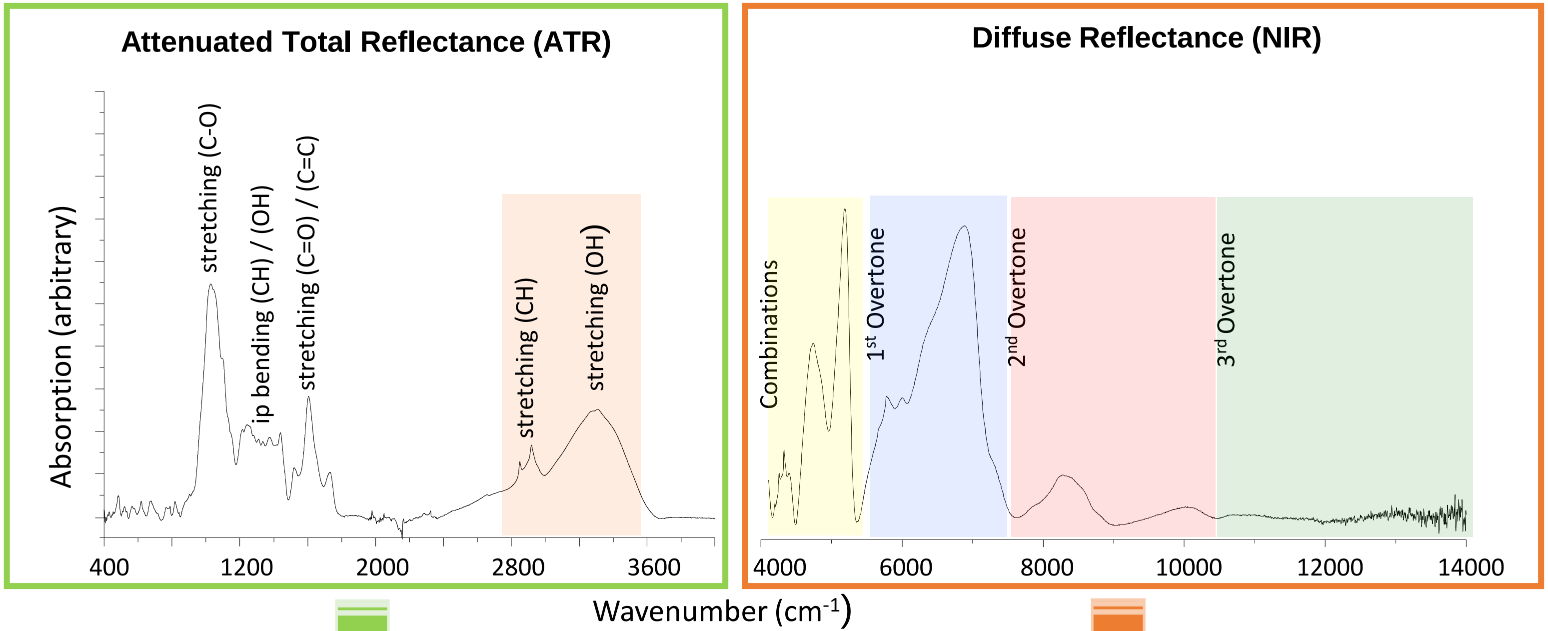
- ✓ Cafeic acid
- ✓ Coumaric acid
- ✓ Gallic acid
- ✓ Protecatechuic acid

Represent ≈40%;

Distributed mainly in the cotyledon

Fourier Transform Infrared Spectroscopy

This method is based on chemometrics, that can generate correlations between the spectra (MIR and NIR) and the composition of the tested samples through multivariate data analysis.



The peaks in the spectrum are due to vibrational modes from specific functional groups

Combining X - H (X = C, N, O) stretching modes with other fundamental vibrations; besides overtones, in the higher frequencies

Fourier Transform Infrared Spectroscopy

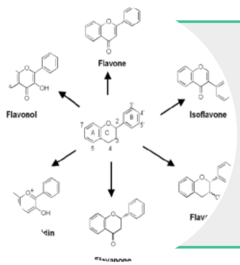
Advantages

- Fast
- Non-destructive / Non-invasive
- Cost-effective
- Avoid the use of harmful chemicals
- Eco-friendly

Applications

- NIR has been successfully applied to determine composition in legumes
- Few studies using MIR, and comparison MIR vs NIR to determine legumes composition

Objectives

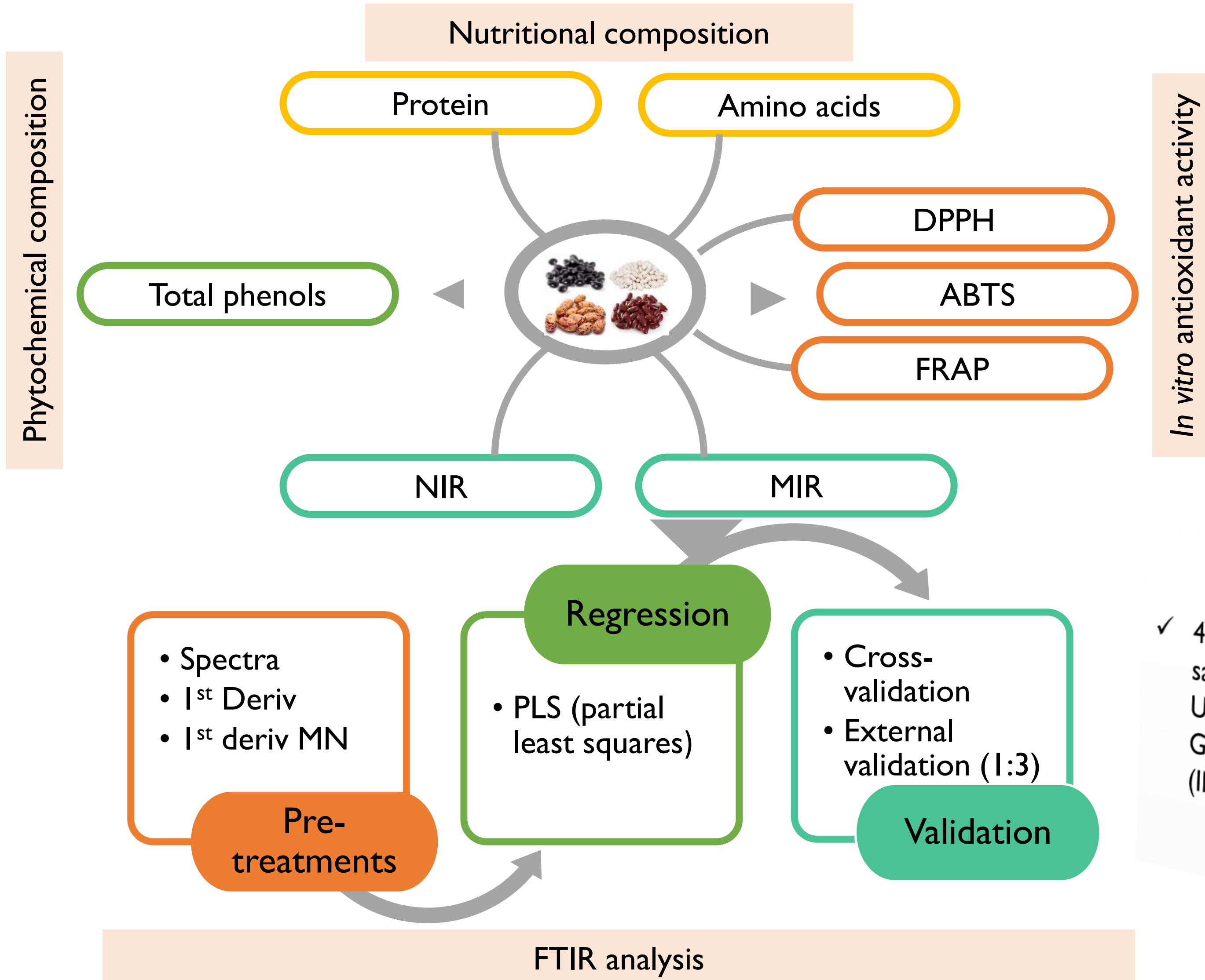


Characterization of nutritional, total phenols and *in vitro* antioxidant activities in different common bean cultivars

Evaluation of the potential use of each bean flours for developing novel legume-based foods with health benefits to be used in the food industry

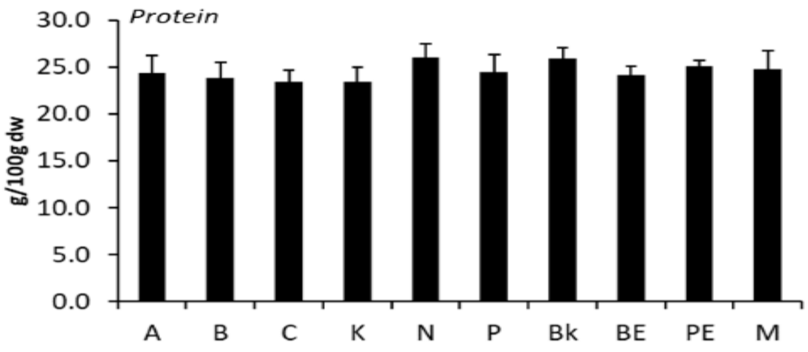
Understanding the performance of FTIR techniques for the assessment of bean flours, regarding protein content, amino acids, total phenols and *in vitro* antioxidant activity

Material and methods



✓ 42 common beans samples from Research Unit Biotechnology and Genetic Resources (INIAV)

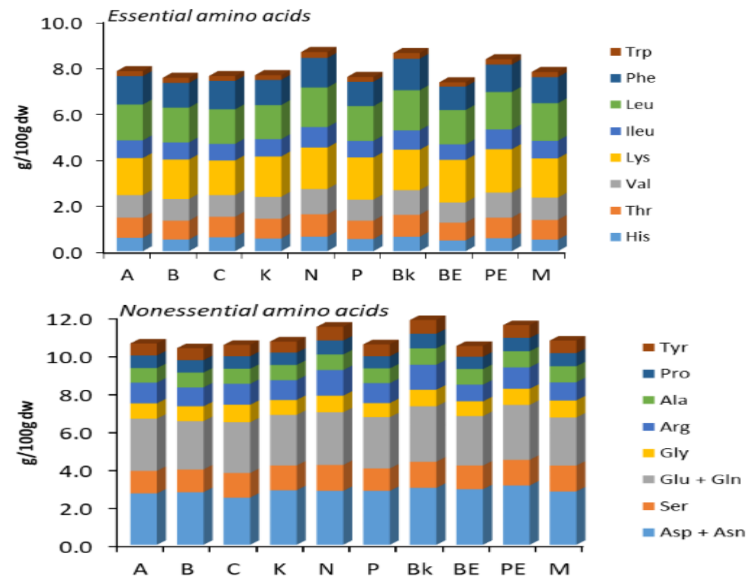
Nutritional composition



- Highest amounts of protein were respectively found in N> BK> PE> B> M> P> A > BE> K> C.

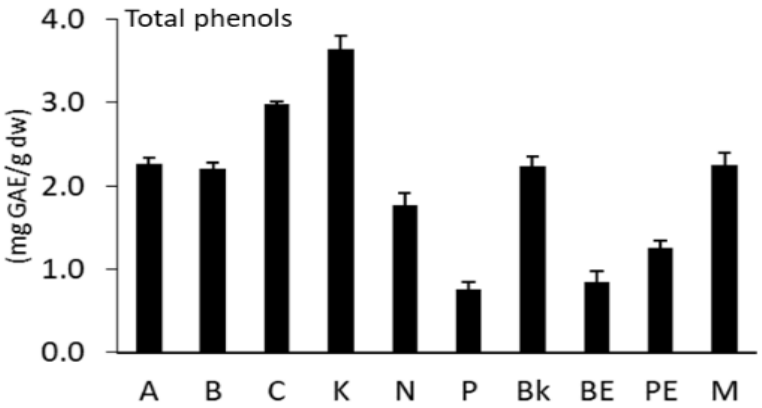
- ↑ Lys and Leu in the essential amino acids
- ↓ Trp, Tyr and Pro in all cultivars

N, Bk and PE combine the best protein-essential amino acid contents and should be prime candidates for protein-enhanced food products.

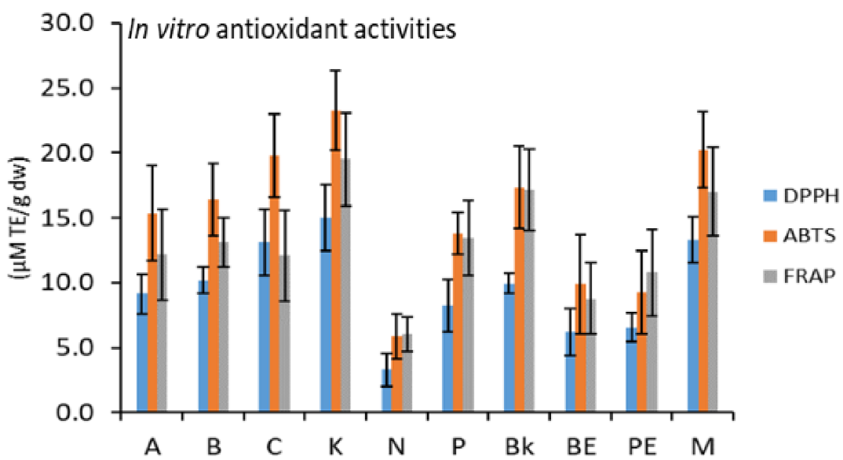


*Carbas, B.; Machado, N.; Oppolzer, D.; Ferreira, L.; Queiroz, M.; Brites, C.; Rosa, E.A.S.; Barros, A.I.R.N.A. Nutrients, antinutrients, phenolic composition, and antioxidant activity of common bean cultivars and their potential for food applications. Antioxidants **2020**, 9, doi:10.3390/antiox9020186.*

Phytochemical composition and *in vitro* antioxidant activity



- ❑ ↑ dark coloured samples (C and K)
- ❑ ↓ uncoloured samples (N and P)



- ❑ K, C, A are the most promising cultivars for phytochemical and antioxidant enrichment of food products
- ❑ Combinations with (pseudo)cereals as functional ingredients in food products

*Carbas, B.; Machado, N.; Oppolzer, D.; Ferreira, L.; Queiroz, M.; Brites, C.; Rosa, E.A.S.; Barros, A.I.R.N.A. Nutrients, antinutrients, phenolic composition, and antioxidant activity of common bean cultivars and their potential for food applications. Antioxidants **2020**, 9, doi:10.3390/antiox9020186.*

PLS regressions for protein content

MIR					NIR				
Analytical parameters	Treatment	PRESS (Factor number)	R^2c	R^2v	Analytical parameters	Treatment	PRESS (Factor number)	R^2c	R^2v
Nutritional Composition									
Protein	1st deriv (FI)	0.283 (4)	0.99	0.96	Protein	1st deriv	0.284 (4)	0.99	0.98
	1st deriv MN (LF)	0.316 (4)	0.98	0.96		1st deriv MN	0.273 (3)	0.99	0.97
	Spectra (LF)	0.337 (5)	0.97	0.95		Spectra	0.254 (6)	0.98	0.94

FI- full region; LF- low-frequency region; HF- High-frequency region

In MIR:

- ❑ Excellent PLS regression for predictive models of protein
- ❑ $R^2c \geq 0.97$ and $R^2v \geq 0.95$

In NIR:

- ❑ All the treatments showed good performances
- ❑ $R^2c = 0.99$ and $R^2v \geq 0.90$

- ❑ 1st deriv were the best performance in both methodologies
- ❑ Coefficients for proteincontent were higher using the NIR interval

Carbas, B.; Machado, N.; Oppolzer, D.; Ferreira, L.; Brites, C.; Rosa, E.A.S.; Barros, A.I.R.N.A. Comparison of near-infrared (NIR) and mid-infrared (MIR) spectroscopy for the determination of nutritional and antinutritional parameters in common beans. Food Chem. ***2020,*** *306, doi:10.1016/j.foodchem.2019.125509.*

PLS regressions for essential amino acids

MIR					NIR				
Analytical parameters	Treatment	PRESS (Factor number)	R^2c	R^2v	Analytical parameters	Treatment	PRESS (Factor number)	R^2c	R^2v
Essential amino acids									
Thr	1st deriv (FI)	0.772 (2)	0.75	0.66	Thr	1st deriv	0.773 (1)	0.71	0.70
	1st deriv MN (LF)	0.714 (7)	0.98	0.90		1st deriv MN	0.748 (2)	0.77	0.75
	Spectra (LF)	0.777 (5)	0.85	0.80		Spectra	0.733 (4)	0.77	0.74
Val	1st deriv (HF)	0.523 (3)	0.93	0.88	Val	1st deriv	0.609 (1)	0.84	0.84
	1st deriv MN (HF)	0.530 (4)	0.95	0.88		1st deriv MN	0.595 (2)	0.87	0.86
	Spectra (HF)	0.563 (6)	0.92	0.90		Spectra	0.530 (4)	0.89	0.88
Ileu	1st deriv (FI	0.557 (2)	0.88	0.83	Ileu	1st deriv	0.629 (3)	0.91	0.89
	1st deriv MN (HF)	0.497 (3)	0.91	0.85		1st deriv MN	0.622 (2)	0.86	0.85
	Spectra (HF)	0.550 (6)	0.92	0.88		Spectra	0.529 (4)	0.90	0.88
Leu	1st deriv (LF)	0.319 (5)	0.99	0.96	Leu	1st deriv	0.411 (5)	0.98	0.97
	1st deriv MN (FI)	0.325 (4)	0.98	0.94		1st deriv MN	0.410 (4)	0.98	0.97
	Spectra (FI)	0.305 (7)	0.98	0.94		Spectra	0.358 (6)	0.96	0.96
Phe	1st deriv (LF)	0.881 (6)	0.97	0.87	Phe	1st deriv	0.870 (1)	0.61	0.59
	1st deriv MN (LF)	0.856 (1)	0.60	0.59		1st deriv MN	0.876 (2)	0.68	0.65
	Spectra (FI)	0.885 (2)	0.64	0.60		Spectra	0.874 (2)	0.64	0.62
Trp	1st deriv (FI)	0.790 (4)	0.90	0.84	Trp	1st deriv	0.859 (3)	0.82	0.77
	1st deriv MN (FI)	0.807 (3)	0.85	0.79		1st deriv MN	0.839 (2)	0.72	0.68
	Spectra (LF)	0.816 (7)	0.86	0.78		Spectra	0.771 (4)	0.75	0.45

FI- full region; LF- low-frequency region; HF- High-frequency region

- ❑ MIR was more suitable for regression models of essential amino acids;
- ❑ PLS regressions were not suitable (R^2<0.60) for His and Lys

Carbas, B.; Machado, N.; Oppolzer, D.; Ferreira, L.; Brites, C.; Rosa, E.A.S.; Barros, A.I.R.N.A. Comparison of near-infrared (NIR) and mid-infrared (MIR) spectroscopy for the determination of nutritional and antinutritional parameters in common beans. Food Chem. ***2020****, 306, doi:10.1016/j.foodchem.2019.125509.*

PLS regressions for nonessential amino acids

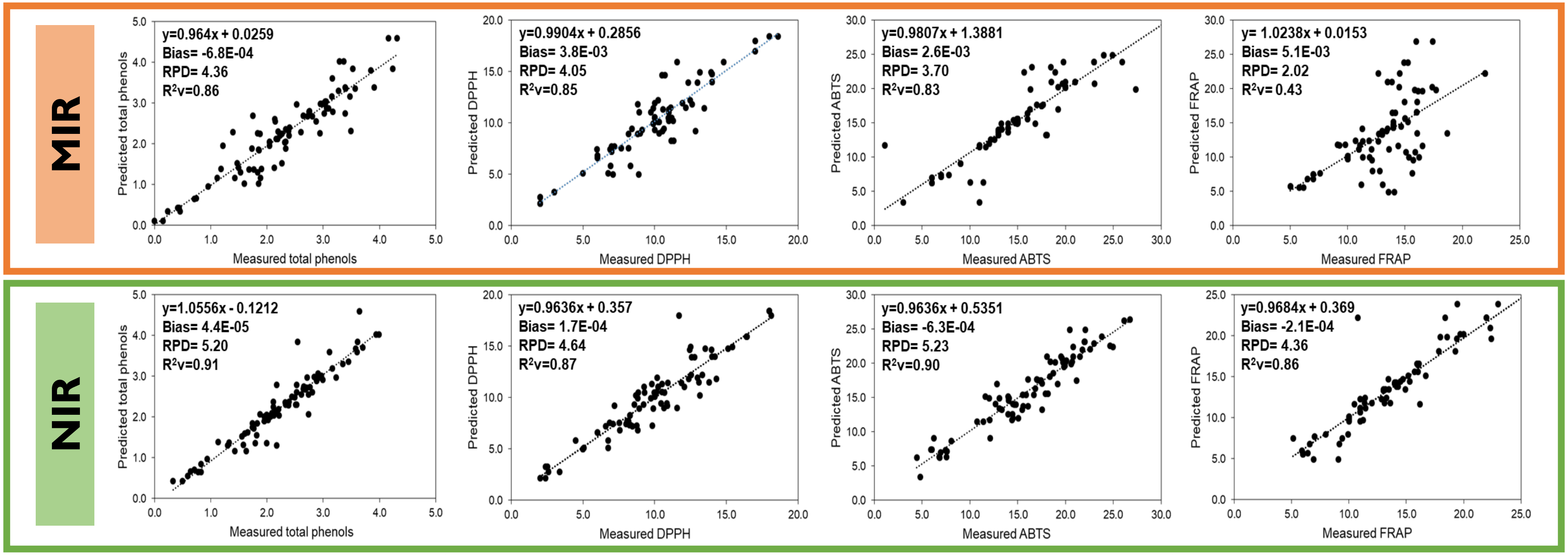
MIR					NIR				
Analytical parameters	Treatment	PRESS (Factor number)	R^2c	R^2v	Analytical parameters	Treatment	PRESS (Factor number)	R^2c	R^2v
Nonessential amino acids									
Asp+Asn	1st deriv (LF)	0.611 (6)	0.88	0.88	Asp+Asn	1st deriv	0.644 (2)	0.87	0.86
	1st deriv MN (HF)	0.649 (4)	0.93	0.86		1st deriv MN	0.625 (2)	0.85	0.84
	Spectra (LF)	0.649 (2)	0.81	0.77		Spectra	0.626 (3)	0.83	0.82
Ser	1st deriv (LF)	0.768 (2)	0.75	0.67	Ser	1st deriv	0.773 (1)	0.72	0.71
	1st deriv MN (HF)	0.791 (4)	0.91	0.78		1st deriv MN	0.730 (2)	0.79	0.78
	Spectra (HF)	0.778 (4)	0.74	0.71		Spectra	0.727 (6)	0.81	0.78
Glu+Gln	1st deriv (FI)	0.760 (2)	0.78	0.72	Glu+Gln	1st deriv	0.716 (2)	0.85	0.83
	1st deriv MN (LF)	0.712 (1)	0.75	0.73		1st deriv MN	0.687 (2)	0.83	0.82
	Spectra (LF)	0.691 (2)	0.79	0.76		Spectra	0.741 (1)	0.86	0.74
Gly	1st deriv (LF)	0.762 (5)	0.95	0.89	Gly	1st deriv	0.823 (1)	0.66	0.65
	1st deriv MN (LF)	0.765 (5)	0.96	0.88		1st deriv MN	0.814 (2)	0.74	0.70
	Spectra (HF)	0.788 (2)	0.71	0.68		Spectra	0.807 (4)	0.70	0.68
Ala	1st deriv (FI)	0.509 (3)	0.94	0.91	Ala	1st deriv	0.503 (2)	0.92	0.91
	1st deriv MN (FI)	0.491 (4)	0.96	0.93		1st deriv MN	0.486 (2)	0.92	0.91
	Spectra (FI)	0.517 (5)	0.92	0.88		Spectra	0.494 (3)	0.90	0.89
Pro	1st deriv (LF)	0.458 (6)	0.99	0.95	Pro	1st deriv	0.561 (2)	0.91	0.89
	1st deriv MN (LF)	0.457 (5)	0.98	0.94		1st deriv MN	0.526 (2)	0.90	0.89
	Spectra (LF)	0.501 (5)	0.94	0.91		Spectra	0.508 (4)	0.91	0.89
Tyr	1st deriv (SI)	0.793 (3)	0.87	0.80	Tyr	1st deriv	0.752 (5)	0.96	0.91
	1st deriv MN (SI)	0.865 (4)	0.93	0.84		1st deriv MN	0.722 (4)	0.94	0.90
	Spectra (LF)	0.742 (4)	0.83	0.79		Spectra	0.675 (5)	0.84	0.78

FI- full region; LF- low-frequency region; HF- High-frequency region

- MIR was more suitable for regression models of amino acids;
- 1st deriv exhibited the best performance
- PLS regressions were not suitable (R^2<0.60) for Arg

Carbas, B.; Machado, N.; Oppolzer, D.; Ferreira, L.; Brites, C.; Rosa, E.A.S.; Barros, A.I.R.N.A. Comparison of near-infrared (NIR) and mid-infrared (MIR) spectroscopy for the determination of nutritional and antinutritional parameters in common beans. Food Chem. ***2020****, 306, doi:10.1016/j.foodchem.2019.125509.*

PLS regressions for total phenols and *in vitro* antioxidant activity



- ❑ High correlations between predictive and real results for total phenols and in vitro antioxidant activities in NIR region, RPD values ≥ 5 meaning a very good predictive model

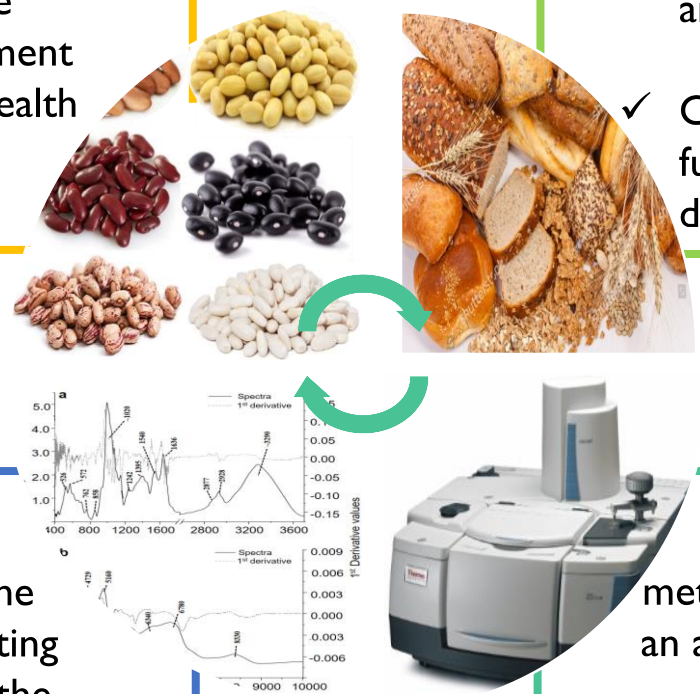
- ❑ In both region, the best results were obtained using 1st deriv treatment, except for ABTS in MIR (spectra) and FRAP in NIR (1st deriv MN)

Carbas, B.; Machado, N.; Oppolzer, D.; Queiroz, M.; Brites, C.; Rosa, E.A.S.; Barros, A.I.R.N.A. Prediction of Phytochemical Composition, In Vitro Antioxidant Activity and Individual Phenolic Compounds of Common Beans Using MIR and NIR Spectroscopy. Food Bioprocess Technol. ***2020****, 13, 962–977, doi:10.1007/s11947-020-02457-2.*

Conclusions

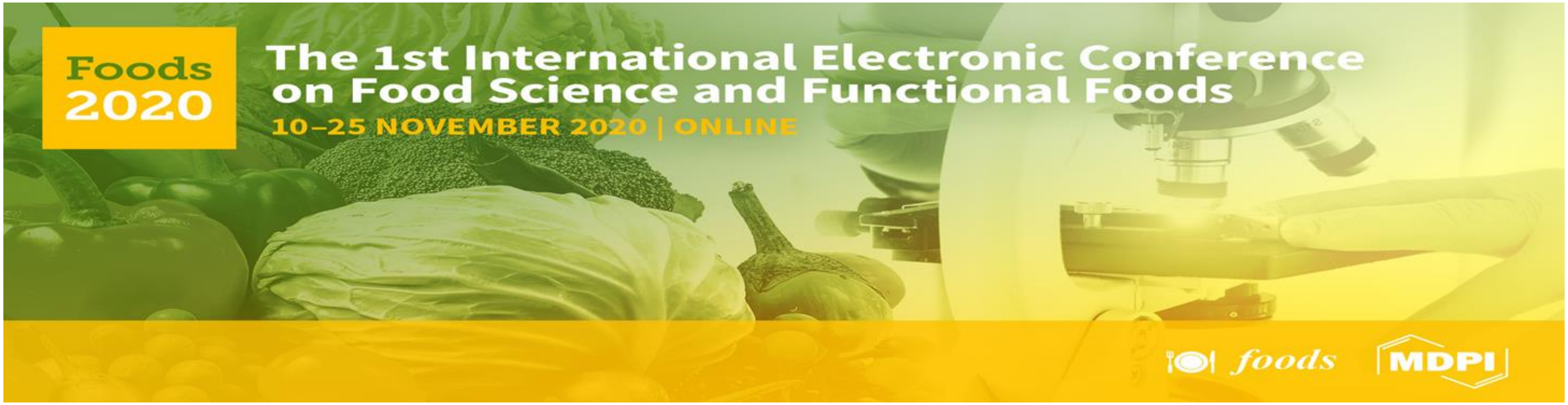
Potential use of beans in the food industry for the development or enrichment of food products with health benefits

- ✓ Uncoloured cultivars used for nutritional enrichment and for gluten-free products
- ✓ Coloured cultivars used as a functional ingredient to develop novel foodstuffs



Their applicability in the food industry representing an good alternative to the traditional approaches

Spectroscopical methodologies may represent an accurate and rapid method for quantification of macronutrients and minor compounds present in beans



Thank you for your attention

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