Flavour investigation of pulses: linking sensory with instrumental analyses

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Background

The demand for pulse-derived proteins, such as those from peas and faba beans, is increasing as a substitute for animal proteins. However, using pulses in food presents challenges due to off-flavours. Although these off-flavours can be identified through sensory evaluation, this process is labour-intensive. Instrumental analyses can detect the key volatile compounds responsible for "beany" and "green" aromas, including aldehydes, alcohols, ketones, acids, pyrazines, and sulphur compounds. Similarly, it is also possible to detect non-volatile compounds like saponins, phenolics, and alkaloids linked to "bitterness" and "astringency" (1). Having an instrumental method to identify these sensory off-flavour attributes would be highly beneficial.

Objective

The aim of this study is to find instrumental approaches that can quickly detect off-flavors in pulse-derived proteins and yield results that align with sensory evaluation.

Samples and Methods

Samples

7 samples were investigated namely, 4 commercial protein isolates (1x soy, 2x pea, 1x faba) and 3 concentrates (3x faba).

Sensory evaluation

- A trained panel (n=9) (NIZO Food Research, The Netherlands) conducted a sensory evaluation on the 7 samples dispersed in a 2% watery solution.

Medium throughput instrumental methods for targeted analysis

- Headspace Solid Phase Micro Extraction (Arrow) in combination with Gas Chromatography-Mass Spectrometry (SPME-GC-MS).
- Liquid Chromatography-Mass Spectrometry (LC-MS) for non volatiles.

High throughput instrumental methods for untargeted analysis

- Static Headspace-Proton Transfer Reaction-Mass Spectrometry (PTR-MS).
- Static Headspace-Gas Chromatography-Ion Mobility Spectrometry (HS-GC-IMS). Software: VOCal (GAS, Germany), Python GC-IMS-tools [2]

Results

Sensory evaluation. Significant attributes

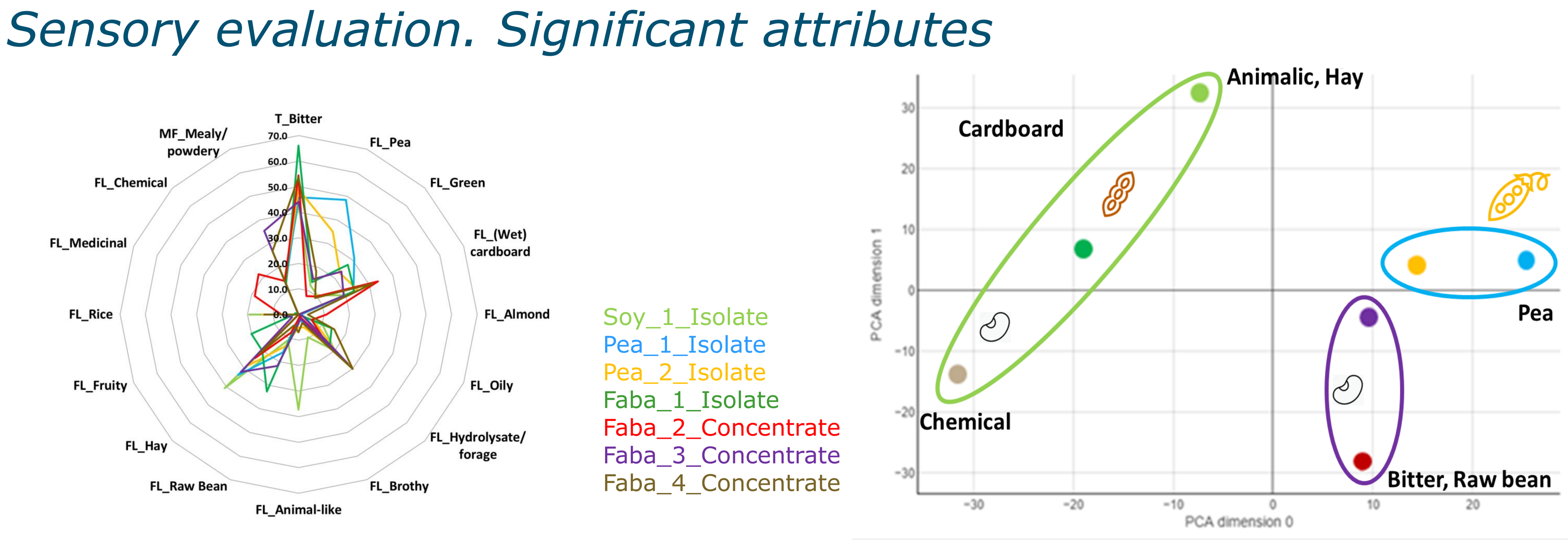

Figure 1. Spider plot of significant attributes and scores (ANOVA) (on the left, FL=Flavor, T=Taste, MF=Mouthfeel). Principal Component Analysis (PCA) was run using the most important attributes to visualize sensory results (on the right). 62.2% information preservation in PCA .

- Three of the faba concentrates are grouped together, primarily due to their shared attributes of bitter taste and raw bean aroma.
- Pea isolates are grouped together due to their distinct pea aroma.
- Soy isolate is grouped with one faba isolate and one faba concentrate. This cluster is characterized by chemical, cardboard, and animalic aromas.

Targeted analysis

The flavour profiles were analysed using SPME-GC-MS and LC-MS to detect volatile and non-volatile compounds, respectively. Volatile compounds included aldehydes, alcohols, ketones, acids, pyrazines, and sulphur compounds. Non-volatile compounds included saponins, phenolic acids, and alkaloids.

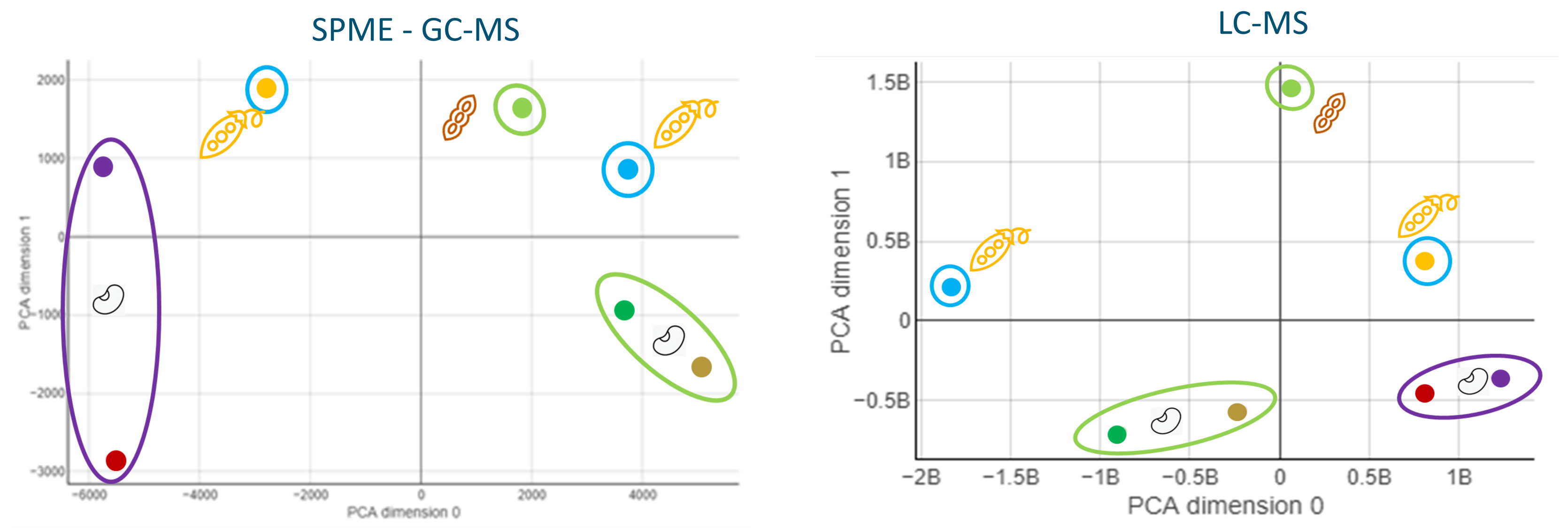

Figure 2. PCA for SPME-GC-MS data covers 86.7% of information preservation (on the left). Regarding LC-MS data, 86.8% information preservation in PCA. Same legend of Fig1 and 3.

- Two of the faba isolate and the faba concentrate form distinct clusters in both SPME-GC-MS and LC-MS, like sensory results, while soy and pea isolates are spread, with no clear clustering observed.

Untargeted analysis

HS-GC-IMS and PTR-MS were used to detect volatile compounds.

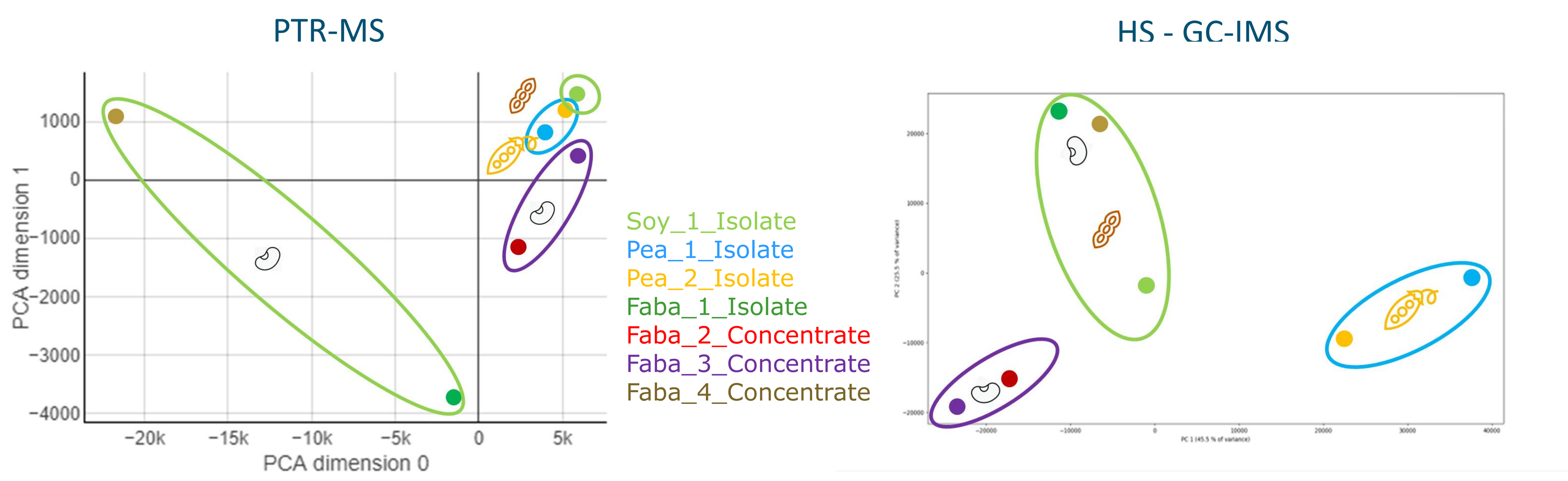

Figure 3. PCA for PTR-MS covers 96.4% of information preservation (on the left). Regarding HS-GC-IMS data 71% information preservation in PCA.

- The volatile profile generated from PTR-MS primarily differentiates two faba samples (one concentrate and one isolate) from the rest.
- The HS-GC-IMS profile tends to cluster samples similarly to sensory evaluation, suggesting a possible indirect link with aroma attributes.

Conclusions

- Sensory evaluation and analytical techniques were able to detect differences within pulses, as well as pulse isolates and concentrates.
- HS-GC-IMS appears to be best-in-class for correlating with sensory data, particularly for aroma and volatile compounds.
- Currently, HS-GC-IMS is successfully applied by Symrise through the ProtiScan™ system for protein volatile profiling.
- Volatile profiles measured with SPME-GC-MS and PTR-MS, along with non-volatile compounds measured with LC-MS, primarily distinguish the faba samples from pea and soy.
- Further investigation, regarding bitterness and responsible non-volatile compounds (LC-MS) is recommended.

Acknowledgements

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1) Roland, W.S.U., Pouvreau, L., Curran, J., van de Velde, F., & de Kok, P.M.T. (2017). Flavor aspects of pulse ingredients. Cereal Chemistry, 94, 58–65
2) https://github.com/Charisma-Mannheim/gc-ims-tools