

TEXTURE, COLOR AND AROMA INSTRUMENTAL ANALYSIS FOR PREDICTING VEGETABLES FRESHNESS PERCEIVED BY CONSUMERS

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Context & Objective

- Freshness** is a key parameter considered by consumers for evaluating the quality of fruits and vegetables and therefore plays a crucial role for both purchase decisions and food loss and waste (FLW) (Jaeger et al. 2023).
- Freshness perception is closely related to **flavour, texture and appearance** (Péneau et al. 2007). Volatile organic compounds (VOCs) therefore plays an important role in determining freshness.
- The work aims to develop a **predictive model of perceived vegetable freshness** by combining different instrumental analyses and sensory hedonic and descriptive evaluations.

Material & methods

- 3 vegetable types:** mushrooms (M), bell peppers (P), spinach (S).
- 6 freshness levels** achieved by varying harvest times and storage conditions: T6 +fresh, T1- fresh.
- 3 panels** (n=44-54, age=41.5-48.1 yo, female=56-58%) were involved.
- Sensory analysis:** visual and multisensory freshness (7-points freshness scale) + rapid sensory evaluation (Rate-all-that-apply) + willingness to buy and consume.
- Instrumental analysis** to monitor physical and chemical changes: texture (T), color (C) and aroma by a combination of SPME GC-MS and PTR-ToF-MS HS analysis.
- The contribution of instrumental parameters to freshness perception was estimated by predictive models with **Orthogonal Partial Least Squares (O-PLS)**.

Results

FRESHNESS, SENSORY PROPERTIES AND AROMA

- Consumers were able to discriminate the freshness levels for all the examined vegetables.
- Freshness assessed in multisensory modality (appearance, aroma, texture) is more discriminating for the freshness of mushrooms ($F=99.8$; $p<0.0001$) and spinach ($F=63.2$; $p<0.001$) than in the case of peppers ($F=7.7$; $p<0.001$).
- Sensory description grouped samples in accordance with shelf-life levels, especially in the case of mushrooms and spinach (**Figure 1**).
- Aroma compounds analysis with SPME GC-MS and PTR-ToF-MS, highlighted an evolution of foods volatilome as a function of freshness level. In **Figure 2** is presented an example for the GC-MS data of spinach leaves. Some of the spinach key aroma compounds like (Z)-3-hexenal and some terpenes decreased during shelf life while some aroma compounds previously identified as biomarkers for spoilage like dimethyl sulfide, methional and (Z)-3-hexen-1-ol increased (Huertas et al. 2017).
- In case of the PTR-MS analysis (data not shown), similar trends were obtained. Additionally, an increase in ethanol concentration was detected during shelf life, which is a well-known marker of microbial fermentation.

FRESHNESS PREDICTION

- For mushroom and spinach, good predictive results were obtained by the O-PLS model for both the visual (M: $Q^2=0.99$, S: $Q^2=0.82$) and the multisensory (M: $Q^2=0.94$, S: $Q^2=0.84$) freshness by using models based on complete instrumental data (color, texture and VOCs).
- For mushroom and spinach, the model that consider only VOCs emission obtained good predictive values (M: $Q^2=0.93$, S: $Q^2=0.83$) indicating a key role of the perceived aroma in determining products' freshness.
- For mushrooms, using only color parameters gives an acceptable model for the visual freshness. On the contrary, using only texture parameters (T) give an acceptable model for the multisensory freshness.
- For mushrooms and spinach leaves the model on sensory attributes (S) gave a predictive performance comparable to the overall instrumental dataset (M: $Q^2=0.94$, S: $Q^2=0.95$).
- For peppers, the predictive performance of the model for visual freshness based only on VOCs was higher ($Q^2=0.97$) than the one based on the complete instrumental data ($Q^2=0.92$). For the multisensory freshness only the texture data showed a good predictive performance ($Q^2=0.93$).

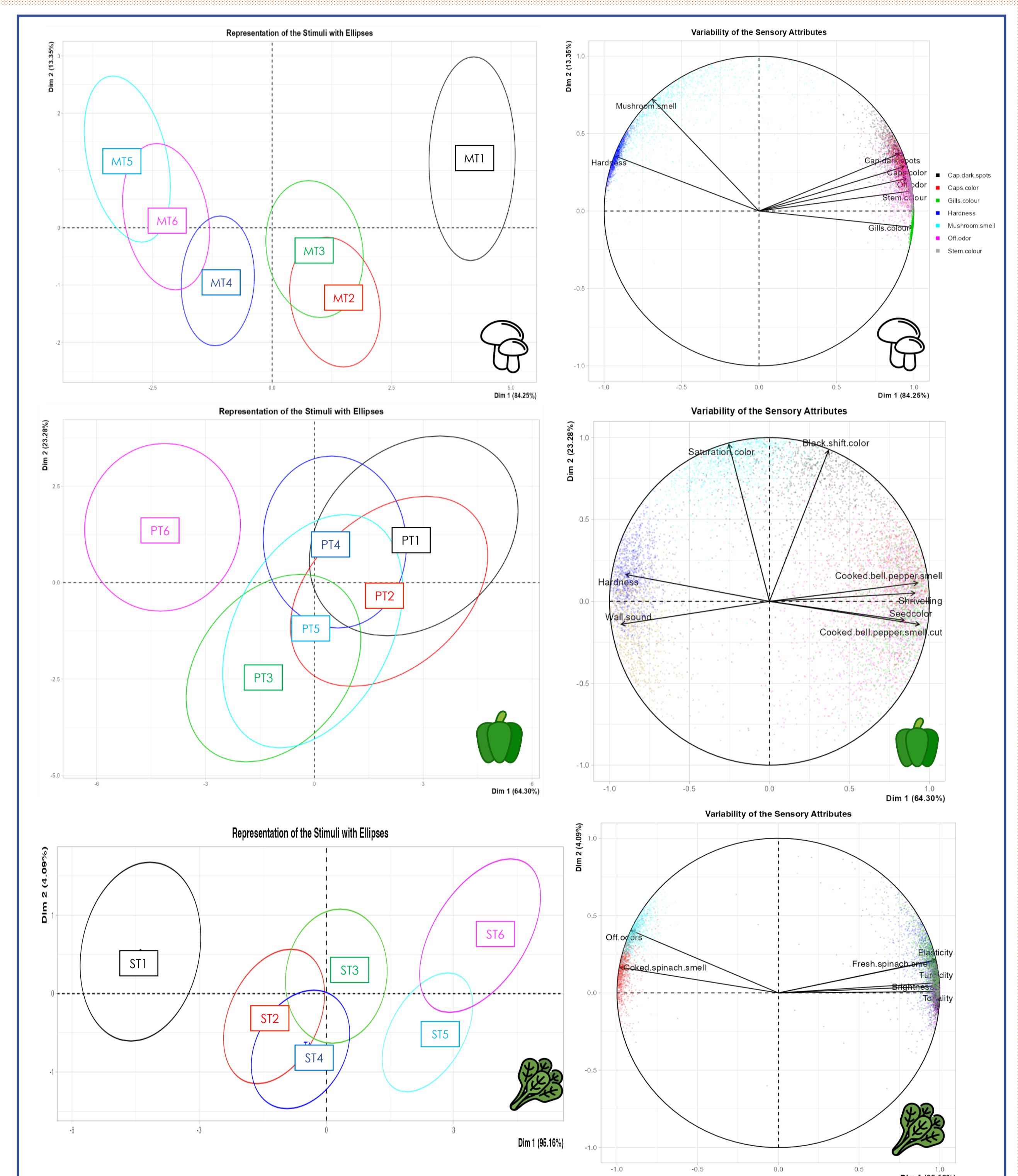


Figure 1. PCA with resampling on RATA attributes for the model samples of mushrooms (M), peppers (P) and spinach (S) at different freshness levels (T1 – less fresh; T6 – fresher). Resampling parameters: factor = sample, n° subjects= 20, n°panel = 1000, pvalue sample effect= 0.05. Score plots on the rights and correlation loading plot on the left.

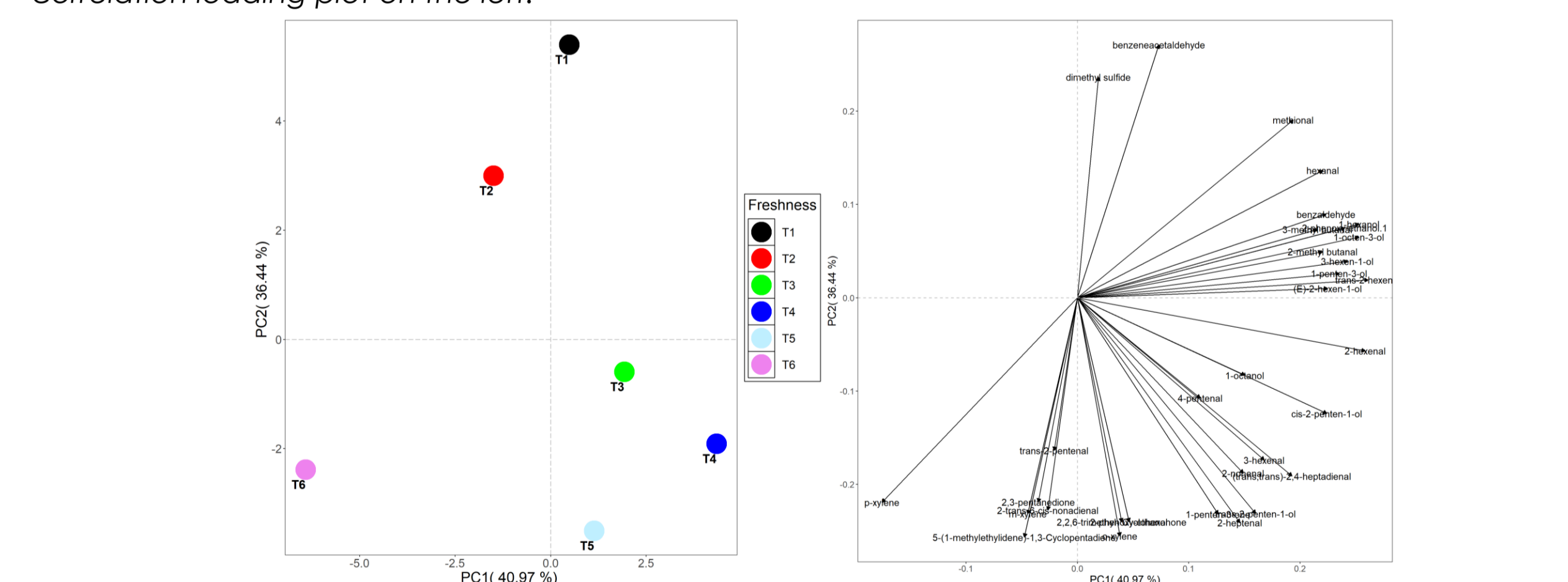


Figure 2. PCA on SPME HS GC-MS data on spinach at different freshness level (T1 – less fresh; T6 – fresher). Score plot on the right and loading plot with the on 33 aroma compounds.

Conclusions

- Predictive models based on VOCs are efficient and accurate for predicting both visual and multisensory freshness when the sensory variability of the model samples is sufficiently broad. This highlights a key role of aroma in determining products' freshness.
- The results show that, during storage, the products undergo significant changes in the monitored sensory attributes and the consumer panel was able to discriminate in blind the samples based on their actual freshness levels and sensory properties.
- Considering the use of rapid and non-invasive instrumental analysis for measuring VOCs, the study showed the potential for applying this approach in commercial contexts as well.

References

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