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Modeling sensory properties against instrumental measurements by PLS-Path Modeling: application to dairy products

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Context

To explain sensory perceptions from instrumental and composition data a PLS-PM approach was used. This method allows investigating in a same model, different variables to be explained by using latent variables. The objective of the present study is to find out the latent variables including nutritional contents (sugar, proteins and lipids), physico-chemical and rheological properties, which could explain texture and flavor perceptions, with a statistical method such as PLS-PM.

Materials & Methods

Products

8 plain yogurts selected from the French market including firm and stirred yogurts, with or without bifidus cultures and with various fat content.



Sensory characterization

- Conventional sensory profile performed by 12 trained judges (25-60 years old, 9 women, 3 men)
- 10 sessions performed including training and evaluation (two replicates) of 27 sensory attributes related to visual aspect, texture, odor, taste, flavor and aftertaste

Physico-chemical and Rheological characterization

- Physico-chemical properties of the yogurts were assessed : the water content (105° C), the Brix index, pH at 10° C and the color using the CIEL method based on L*/a*/b* representation of light and colors
- Rheological properties were also characterized:
 - Maximal normal force Fmax (N), original slope E (N.mm-1) and area under the curve A (N.mm), all measured by back extrusion test at 25° C
 - Viscosity η (Pa.s) and the shear-thinning index n, at 25° C using a 5 cm diameter striated plane/Peltier plane system, at five shearing rates: 5, 10, 50, 100 and 250 s-1
 - Particle size was measured using the refractive index of milk of 1.46
- All measurements were triplicated
- Nutritional contents were defined on the packaging

Data analysis

Data analysis of instrumental measurements

- Instrumental data were investigated by non-parametric tests (Kruskal-Wallis test)

Data analysis of sensory evaluation

- ANOVA with product, subject and replicate effects with product*subject and product*replicate interactions was performed

Modeling sensory properties

- Two PLS-PM models were built:
 - Model for sensory visual attributes
 - Model for sensory tasting attributes
- To form latent variables, VARCLUS procedure was used
- For the outer model, reflective mode was used
- For the inner model, PLSR and centroid scheme were used
- Prior to subsequent analysis, the validity of each model is evaluated according to the following criteria:
 - Quality of outer model (unidimensionality, homogeneity, convergent validity, discriminant validity of the LV and individual item reliability)
 - Quality of inner and global model (R-square and GoF)

Results

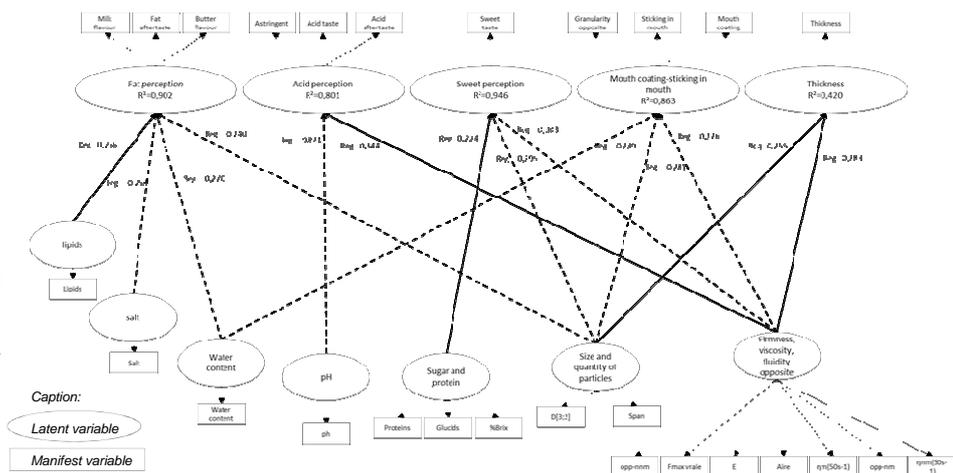
Preliminary analysis of instrumental data

- According to the Kruskal-Wallis test, all the instrumental variables allow to significantly discriminate at least one product from the others (pval < 0.005)

Preliminary analysis of sensory data

- For eight attributes, product effect is not significant (pval>0,05). They were deleted
- No significant product*subject interaction for 22/27 attributes
- No significant product*replicate interaction for 25/27 attributes

PLS-PM model



Main results

- Four sensory LV presented a value of R² superior to 0.8: *fat perception*, *acid perception*, *sweet perception* and *mouth coating*.
- LV related to *fat perception* is positively impacted by the LV *lipids* and negatively impacted by *salt content*, *water content* and *size and quantity of particles*.
- The LV *firmness*, *viscosity* four LV. These results show the key role of texture properties on the perception of dairy products.

Conclusion & Perspectives

- PLS-PM gives an overall picture of all the variables studied, which is a good tool for communication.
- Perception of *thickness* could not be correctly predicted from instrumental measurements. Food consumption is complex and induced multimodal variables.
- Instrumental measurements can hardly mimic physico-chemical parameters involved during eating process, such as the impact of thermal variation, saliva hydration, surface and interface of oral cavity.
- Studies including tribology and bolus kinetics during consumption should provide greater understanding of the texture-structure perception.