Near InfraRed Spectroscopy applied to non-invasive assessment of physical-chemical attributes of dairy powders

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Background

The quality of dairy powders is evaluated by physicochemical and functional attributes such as stickiness, flowability, bulk density, wettability, dispersibility and solubility. Currently, assessing these quality attributes is time consuming and these are conducted ex-situ in the laboratory.

There is a need for the development of non-invasive techniques that could be used on-line and in-situ to monitor the powder attributes in order to achieve better process and quality controls.

Introduction & Overview

Currently processes are monitored with samples collected hourly, and most of the measurements are labor dependent, with subjective evaluation.

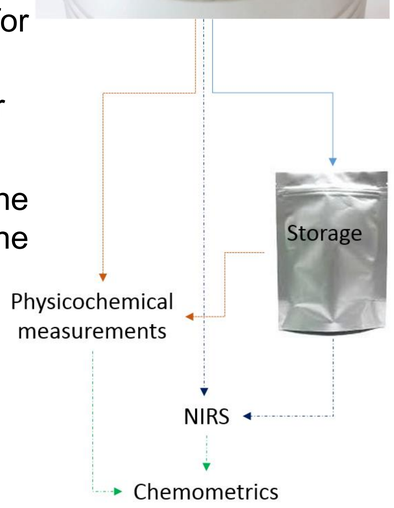
We observed that Near InfraRed Spectroscopy (NIRS) was able to detect changes in dairy powders due to different treatments which could be associated to their physicochemical and functional characteristics.

Aim: To investigate the ability of NIRS to assess the quality of dairy powders based on prediction of physicochemical and functional attributes.

Methodology

Dairy powders:

- Infant milk powder (bovine and goat milk) of stage 1 for 0-6 months of child age, stage 2 for 6 to 12 months of child age and stage 3 for 12+ months of child age,
- bovine whole milk powder
- bovine skim milk powder
- Brands: Two for bovine derived powders and one for goat.



Stored at controlled temperature (21±1 °C).

Sample collection simulated a consumer getting powder from the can. Samples were collected when cans were opened and 3 weeks post opening. For each weekly time point 180 g of powder was collected from the each can and transferred into Ziploc aluminium foil bags. Quality attributes evaluated with standard protocols (GEA, 2006; Kim, Chen & Pearce, 2002; Teehan, 1997) (ISO, 2011) (Fernandes, Borges & Botrel, 2013)

VIS-NIR (350 nm to 2500 nm) reflectance spectra collected with LabSpec 5000 (ASD Inc. USA) spectrophotometer.

Data analysis carried out using Solo+MIA v 7.9.5 (Eigenvector Research Inc., Washington, USA) and R language.

Results

VIS-NIR spectra and physicochemical attributes are significantly correlated (Table 1).

Functional Attributes	Pre-processing	LV number	R^2 Value	RMSECV
Bulk density	Mean center	15	0.82	0.01
Insolubility	Normalize	16	0.74	0.04
Surface free fat	None	17	0.90	0.002
Moisture	SNV	13	0.84	0.37
Water Activity	Mean center	20	0.74	0.04
L* measurement	Normalize	10	0.96	0.01
a* measurement	Mean center	13	0.42	0.02
b* measurement	Mean center	1	0.56	0.01

SNV= Standard normal variate

L*= lightness, a*= Redness, b*= Yellowness, LV= Latent Variable, RMSECV= Root mean square error of cross validation.

Table 1. Association between VIS-NIR spectra and physicochemical attributes assessed with Partial Least Square (PLS) modelling. The cross validation was carried out with 10 random splits and 5 iterations.

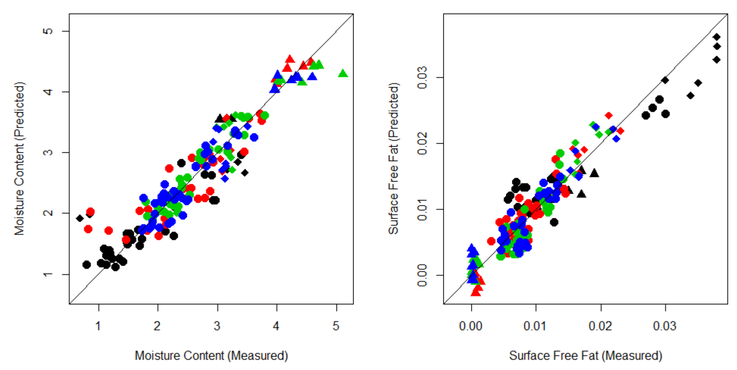


Figure 1. Scatter plot of predicted values by PLS and expected values. The colours indicate the time point when measurements were carried out (black week 0, red one week after opening, green and blue 2 and 3 weeks after opening respectively). The symbols refer to powder type.

Values for moisture content and free fat were spread across the ranges of measured values and there was no confounding effect between length of storage and quality attributes (**Fig. 1**)

Values for bulk density and insolubility index were observed to be spread across the different types of dairy powders and there was no confounding effect between product type and quality attributes (**Fig. 2**)

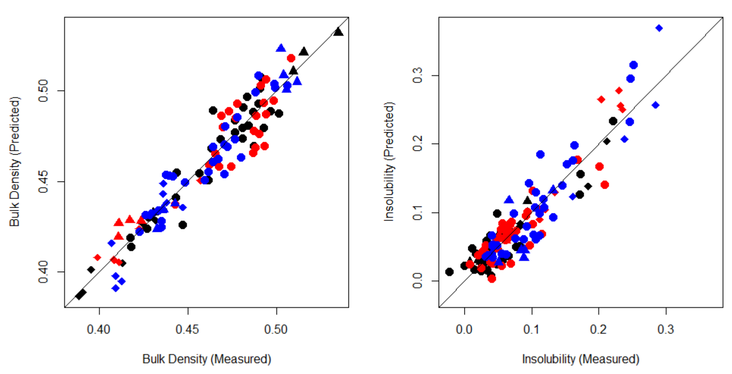


Figure 2. Scatter plot of predicted values by PLS and expected values. The colours indicate the time point when measurements were carried out (black week 0, red one week after opening, green and blue 2 and 3 weeks after opening respectively). The symbols refer to powder type.

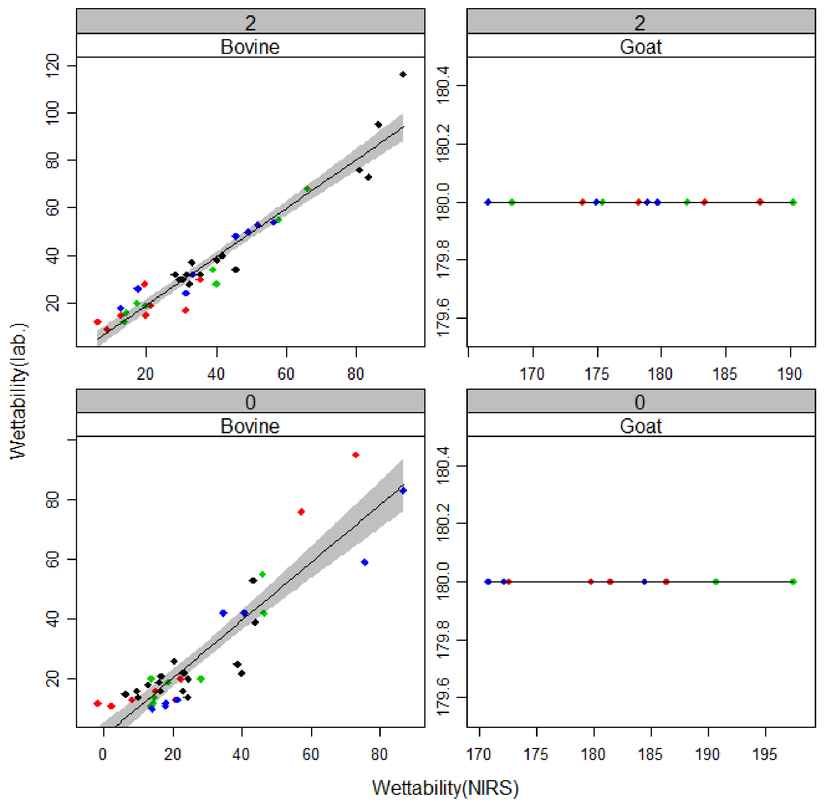


Figure 3. Scatter plot of predicted values by PLS and expected values. The colours indicate type of product (black skim and whole milk powder, red, green and blue infant formula for stage 1 to 3, respectively). The two panels corresponds to weeks 0 and 2.

Results

Wettability for goat infant formula is much higher than for other products, but correlation exists at lower value range (**Fig. 3**).

VIP scores shows that spectral range between 1500 and 1600 nm is important for predictions of bulk density and free-fat while 1900 and 2000 nm is associated with moisture content and insolubility index (**Fig. 4**). The former corresponds to a region where water have low absorbance in the NIR, suggesting that the NIRS' ability to predict bulk density and free-fat is less associated with presence of moisture in the powder, but for insolubility the opposite effect is observed.

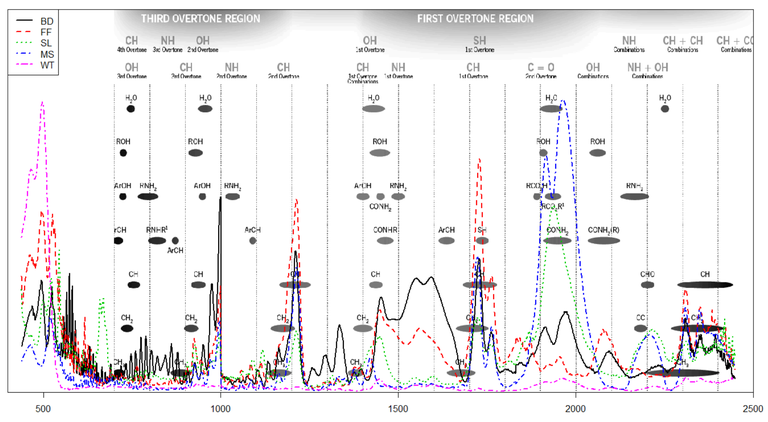


Figure 4. VIP scores from PLS models fitted for bulk density (BD), free-fat (FF), insolubility index(SL), moisture content (MS) and wettability (WT). Bands chart: ASD
https://panalytical.asdi.com/thank-you-for-your-interest-in-our-nir-absorption-bands-chart

Summary

- **Reflectance measurements collected in the Visible-Near InfraRed spectral range showed correlation with physicochemical attributes of dairy powders;**
- **There is no indication that this correlation was due to confounding effects such as product type or length of storage;**
- **These results suggest that reflectance in the Visible-Near InfraRed spectral range could be used for the development of a non-invasive tool for physicochemical attributes defining quality of dairy powders.**
- **Future work will be dedicated to evaluate the effect of processing variability on the correlation of NIR with physicochemical attributes of dairy powders for a single type product.**

Acknowledgements & References

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