Food emulsion - Plant protein

Emulsifying and stabilization properties

Context

Plant-based protein use has been expanding over the past years and offers numerous advantages: sustainable origins, vegan alternatives, cost-effective, and health benefits. Proteins obtained from sustainable sources do not have the same performances compared to conventional emulsifiers and with the increasing offer, selecting the right protein can represent a bottleneck in new product development.

This paper shows TURBISCAN DNS capabilities to study the emulsifying and stabilizing properties of plant-based protein in a single experiment.

Formulating with Plant proteins

Removing or partially replacing traditional emulsifiers with plant-based proteins can be very complex: protein selection (including its origin), possible functionalization, optimum concentration... Three parameters must be considered: protein solubility, protein emulsifying and stabilizing properties.

Several methods are available to characterize* proteins' functional properties but they usually request several instruments, multiple tedious experiments, and sample preparation. TURBISCAN technology offers a complete solution to study all these properties with only one device and for fast decision-making.

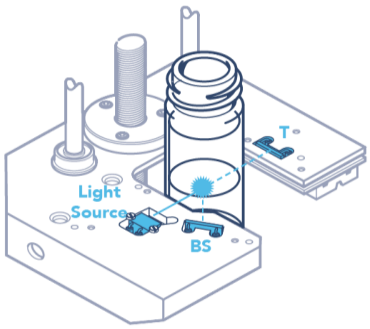
In this note, two plant proteins' solubility will be tested online using the TURBISCAN DNS functionalities. Emulsifying and stabilization properties are covered in a separate application note.

** McClements et al, Proposed methods for testing and comparing the emulsifying properties of proteins from animal, plant, and alternative sources.*

  part of VERDER scientific

TURBISCAN: How it works

TURBISCAN technology, based on Static Multiple Light Scattering (SMLS), consists of sending light pulses (880 nm) into a sample along its height. The reading head scans the sample by moving vertically along the analysis cell and acquires data each 20 µm. Measurements are made over time and variations in the backscattering and transmission levels due to sample instability are recorded. The signal is directly linked to the evolution of particle concentration (φ) and size (d) by the Mie theory. Samples with a particle concentration from **10^{-4} to 95% (v/v)** and from **10nm to 1mm** in particle size can be measured as is.



$$BS = f\ (\varphi, d, np, nf)$$

Figure 1. TURBISCAN measurement head

The instrument enables monitoring of changes in physical stability (coalescence, creaming, sedimentation, phase separation, etc...) **without any dilution or any stress** and thus follows **ISO TR13097 guidelines**.

The **TURBISCAN DNS** for **Dispersibility** and **Stability** is composed of 2 modules:

- **T-MIX** for automated fast formulation screening, and particle dispersibility studies with a stirring bar directly adapted inside the measurement cell.

- **T-LOOP** for online measurements and scale-up/process optimization with an integrated peristaltic pump. The formulation is pumped from the reactor in and out of the measurement cell, creating a circulation loop.

Figure 2. TURBISCAN DNS with a focus on the T-LOOP module

Plant proteins efficiency with TURBISCAN?

The emulsifying and stabilizing properties of two plant-based proteins (pea and soy) were studied. First, 30g/L of protein is solubilized into 500ml of water at pH=7, 25°C over 30min. Sunflower oil is added (20% v/v) and the emulsification is performed via Ultraturrax at 13500rpm for 3 minutes. During the emulsification process, the emulsion backscattering value is recorded at a high frequency (every 0.1 second) for accurate emulsifying studies.

The measurement is performed thanks to the TLOOP, without any dilution or sampling for online study of the droplet size.

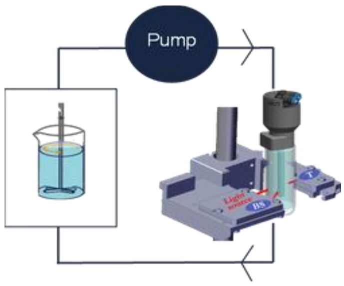


Figure 3. Illustration of SMLS technology combined with T-LOOP module

As backscattering value is directly related to particle size, its evolution over time is directly linked to protein emulsification efficiency. After 3 min of Ultraturrax, sample circulation is stopped, and stability is monitored for 5 hours using the scan mode. Stability is measured directly after the emulsification, and still without any dilution or sample preparation.

RESULTS

Emulsifying properties - Online emulsion droplet size

The graph below displays the evolution of the mean droplet size (dSMLS), determined from the backscattering profile, as a function of emulsification time.

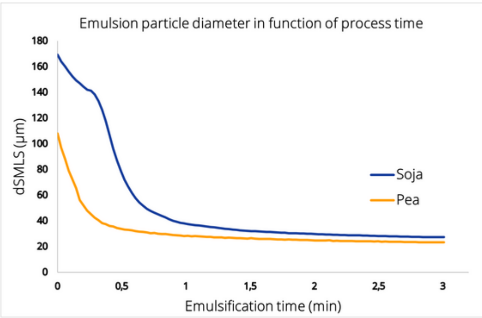


Figure 4. Emulsion particle diameter evolution over 3 min of emulsification

As expected, droplet size decreases in function of time. The high-frequency measurement highlights the importance of the very first minute of emulsion processing. Final droplet sizes are similar, pea protein shows a faster decrease, hence a more efficient emulsification properties.

Emulsions stability - Identification of destabilizations

Once the emulsification is done, the TURBISCAN is set in scan mode to monitor the emulsion stability (graph below). From this scan and in the very first minute, droplet migration (creaming) is detected for both emulsions. On the top of the emulsion migration, sedimentation of insolubilized pea protein is detected in the bottom of the vial.

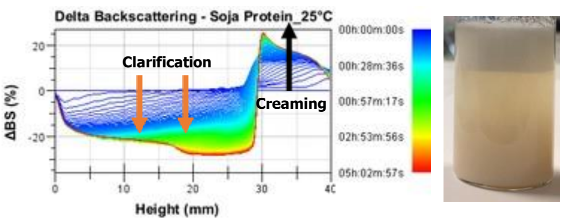


Figure 5. Soybean protein emulsion destabilization profile

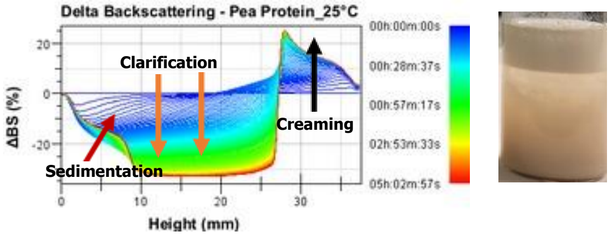


Figure 6. Pea protein emulsion destabilization profile

Stabilizing properties - Fast stability measurement

To assess emulsions' global stability, the TURBISCAN Stability Index (TSI) is plotted over time. TSI sums up all variations over the whole sample's height. **Therefore, the higher the TSI, the lower the stability**.

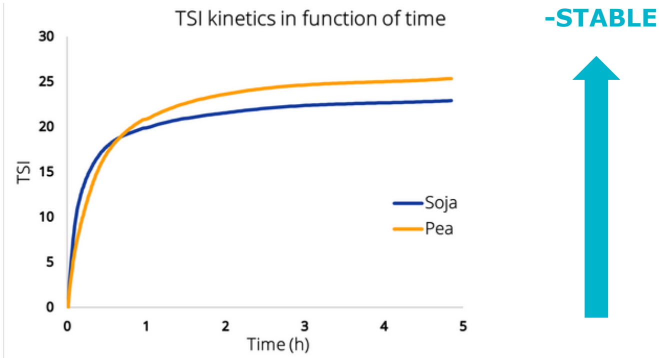


Figure 7. Overall emulsions destabilization kinetics

Initially, the stability of emulsion based on soybean evolves more rapidly than the pea emulsion. However, after 1-hour, overall pea emulsion destabilization increases because of the sedimentation.

Protein efficiency

The following table summarizes different parameters to compare the two proteins.

	Emulsification Property Final Droplet size	Droplets migration Creaming velocity	Stability TSI global
Soy	27.55 µm	47.3 mm/h	22.9
Pea	23.5 µm	43.7 mm/h	25.4

Table 1. Emulsions comparison based on different parameters

For this process and this formulation, pea protein has better emulsification properties compared to soy protein. Indeed, the final particle size is smaller (23.5µm) and the final droplet size is reached much faster than with soy protein (approx 1min).

However, pea protein's poor solubilization leads to sedimentation and has a strong impact on final stability results. For this reason, soy protein has better-stabilizing properties (lower TSI).

Conclusion

TURBISCAN DNS enables, in a single instrument, to follow multiple parameters in a single experiment. The DNS formulation platform offers a fast, time-saving characterization method to select the most suitable emulsifier alternative.

TURBISCAN RANGE

The world leader in Stability & Dispersibility Analysis