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UV irradiation on solid food matrices, a meta-analysis towards an accurate prediction of the treatment effects

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Introduction

The increased demand for minimally processed products that maintain the same level of safety as those preserved using traditional methods has motivated researchers to focus their efforts on developing novel methods for extending the shelf life of fresh-cut products, ready to eat (RTE) meals, fruit juices, packaged foods, among others.

Application of non-thermal technologies for shelf-life extension of food products has always been on the spotlight as an alternative to heat treatments in order to improve its sensory and nutritional quality. The effectiveness UV-C light for the inactivation of microorganisms has been known for a long time, and yearly improvements to both the technology and the application to a wider range of products have been made. However, there are some aspects that must be considered in order to apply an effective treatment, especially if the treatment is going to be applied over a solid food matrix, such as surface smoothness, distance from the light source, emitting wavelengths, among others.

Objectives

- Perform a systematic review and meta-analysis on microbial inactivation by UV-C light in solid food matrices, including results of UV-C by low pressure mercury lamps treatments, Pulsed Light treatments, and UVC-LED treatments.
- Evaluate the effects of the UV-C treatments over microbial inactivation in solid food matrices.

Methodology

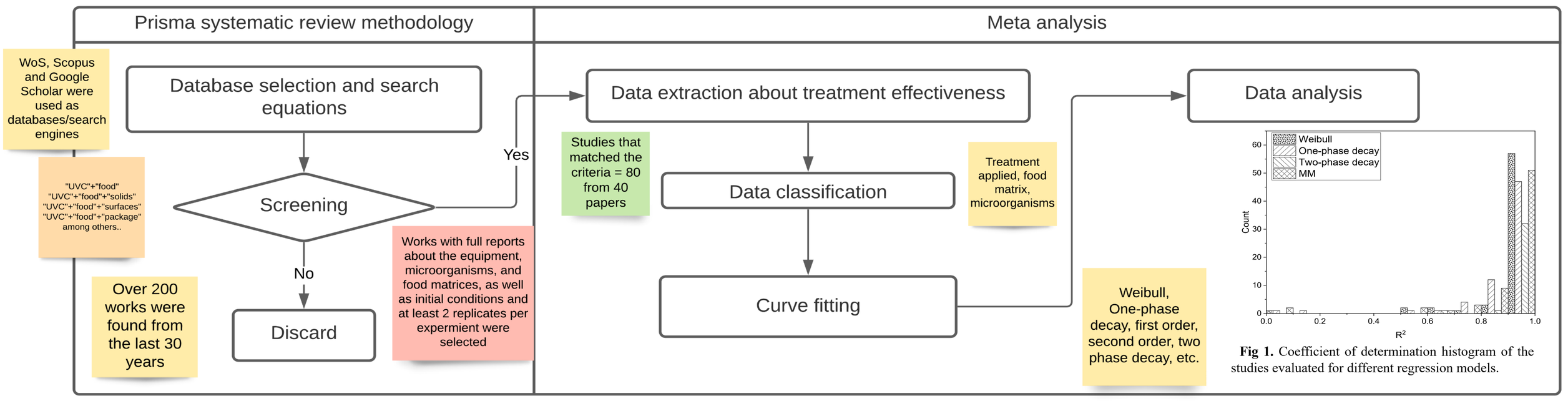

Fig 1. Coefficient of determination histogram of the studies evaluated for different regression models.

Results and discussion

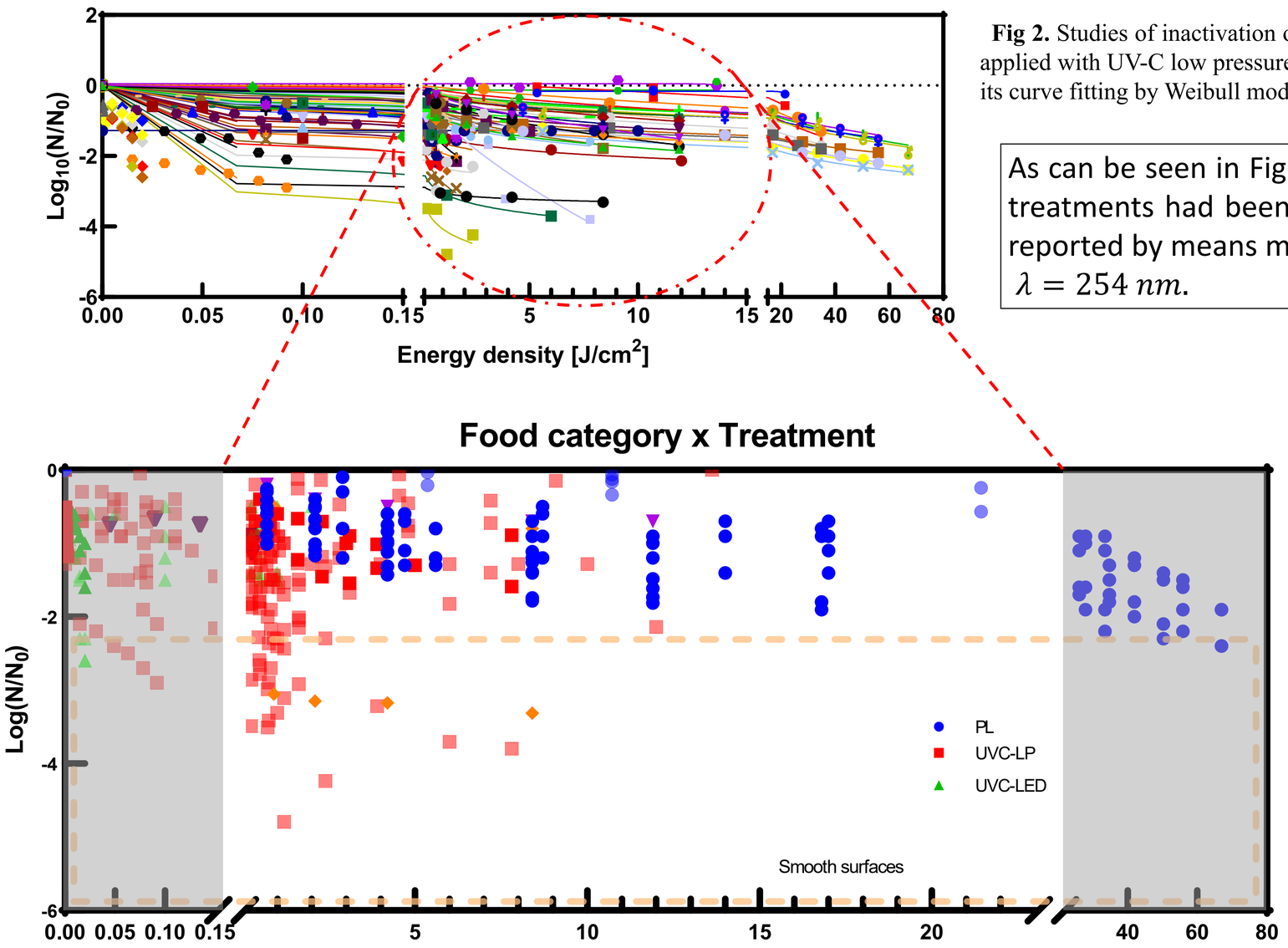

Fig 2. Studies of inactivation of microorganisms in different solid food matrices by the dosage applied with UV-C low pressure mercury lamps, pulsed light or UV-C light emitting diodes, and its curve fitting by Weibull model of microbial inactivation represented by the continuous lines.

As can be seen in Fig 2 and 3, there are **three** zones in which the different treatments had been applied and these zones correspond to the dosages reported by means mostly of radiometers measuring irradiation at $\lambda = 254\ nm$.

- **UVC-LEDs Zone:** UVC-LEDs emitting wavelength is around 275 – 280 nm but the dosage was measured at 254 nm.
- **UVC-LP Zone:** Low pressure mercury lamps emit light at 254 nm and the irradiance is measured at 254 nm.
- **Pulsed Light Treatments:** in which some studies measured the irradiation at 254 nm (and corresponding to around 30% of the total light emitted, UVC-LP zone), and other studies measured the irradiation as the sum of the different wavelengths emitted and being in the third zone of energy dosage.

Fig 3. Studies of inactivation of microorganism in different solid food matrices by treatment and dosage. Solid colors (●) are used for meat products, translucent colors (■) for fruit and vegetables, (♦) for cheese, (▼) for fish and (▼) for mushrooms.

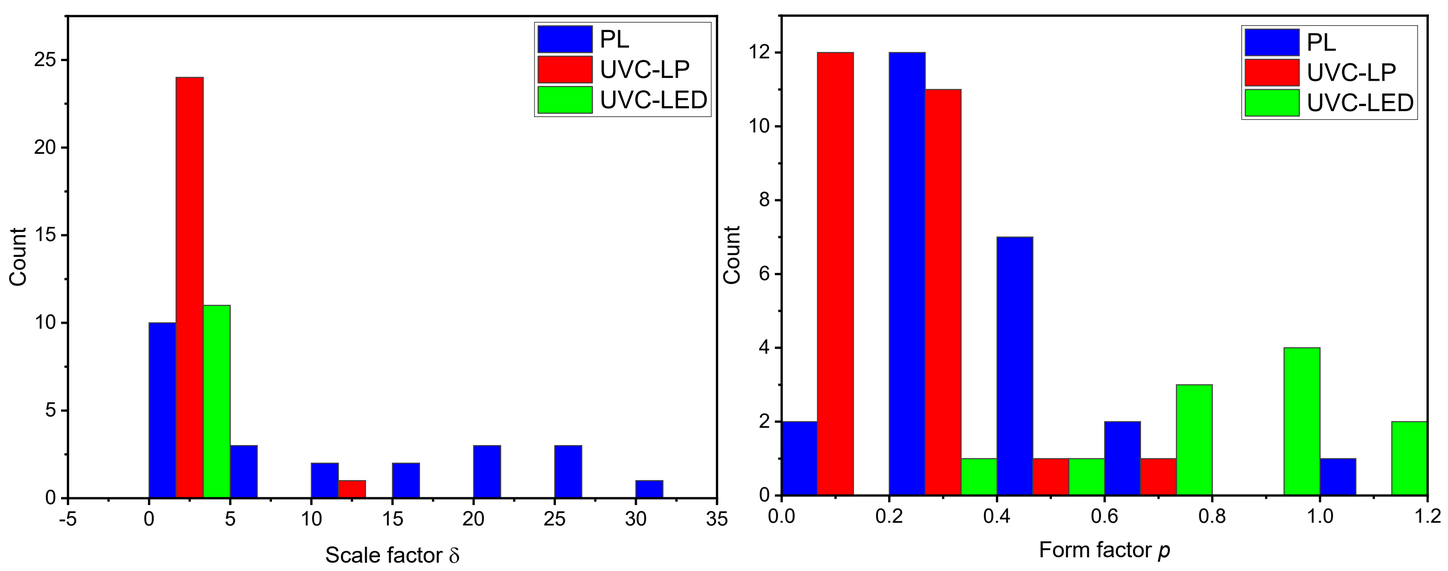

Fig 4. Histograms of scale and form factor of Weibull regression model

Fig 4 shows histograms related to the scale and form factors obtained from Weibull regression. Both PL and UVC-LP treatments present a lower more exponential decay while UVC-LED treatments tend to be more linear. However, the dosage reported for UVC-LED treatments needs to be fixed with a more accurate way of measuring the irradiance that the sample is getting from the lights.

Conclusion

- Smooth surfaces such as some kind of cheeses and fruit skins yields to higher microbial inactivation.
- Rough surfaces present similar inactivation yields regardless of the food matrix or microorganism evaluated
- Is necessary to stablish a standard methodology of measuring UVC-LEDs irradiance that allows a correct description of the treatment.
- Pulsed light and UVC-LP treatments present similar inactivation behaviors.

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References: https://docs.google.com/document/d/1i2Nx4ZiFDyjJXbPm1J23PViOqtAdZUrJxRZW2rrx1UE/edit?usp=sharing

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