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SIMTREA

SISS

Development of multiresponse kinetic models for the prediction of stability and shelf life of dry foods

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Today, the use of novel bio-based materials for food packaging is increasing exponentially. However, their application could dramatically affect food stability, especially when dealing with long-life low-moisture foods. The higher sensitivity of novel packaging to moisture compared to that of conventional packaging materials results in a less effective barrier against water uptake, ultimately compromising the stability, and thus the shelf life, of low-moisture food. This Ph.D. project aims to develop multiresponse kinetic models for the shelf life prediction of dry foods.

Sviluppo di *multiresponse kinetic models* per la previsione della stabilità e *shelf life* di alimenti a basso valore di umidità

Al giorno d'oggi l'utilizzo di nuovi materiali *bio-based* per l'imballaggio di alimenti sta aumentando esponenzialmente. Tuttavia il loro impiego potrebbe influenzare sostanzialmente la stabilità degli alimenti, soprattutto nel caso dei prodotti secchi e a lunga durabilità. La maggiore sensibilità di questi materiali al vapore acqueo rispetto ai materiali convenzionali determina una minor efficacia in termini di barriera contro l'assorbimento di acqua, compromettendo così la stabilità, e pertanto la durabilità, degli alimenti secchi. Questo progetto di dottorato si prefigge l'obiettivo di sviluppare dei *multiresponse kinetic models* per la previsione della *shelf life* degli alimenti secchi.

Keywords: dry foods; shelf-life, multiresponse modeling, packaging, biopolymers

1. State-of-the-art

Dry food stability and, hence, shelf life mostly depends on water uptake during storage. Water may be responsible for undesired physical changes or trigger chemical reactions whose extent depends on the dynamic change in moisture content and, thus, in water activity. For this reason, these foodstuffs are usually protected by employing high water barrier packaging materials such as petroleum-derived polymers. Their barrier properties against water vapor guarantee a negligible water uptake during storage. Despite their worldwide extensive application in food packaging, their use brings about severe environmental impacts, due to poor biodegradability, micro-plastic pollution, and leaching of chemical compounds (*e.g.*, plasticizers) in oceans and lands. To overcome these issues, several compostable and biodegradable packaging solutions have been developed. Even though this new class of bio-based polymers (or biopolymers) represents a promising alternative to conventional ones, their application is critical due to their moisture sensitivity. The transition from conventional to bio-based packaging materials is thus expected to be responsible for modifications of food stability, bringing about the need for a careful re-assessment of product shelf life. To date, moisture uptake in packaged dried foods has been evaluated based on a canonic modeling approach which aims to estimate the time needed to reach a "critical moisture content", corresponding to food water monolayer (Labuza, 1980). This approach, introduced by Heiss (1958) is based on the following two hypotheses: (i) food water content and water activity affect the rate of quality decay and the relevant kinetic model; (ii) the water vapor permeability of packaging material does not depend on the partial pressure gradient between the relative humidity inside and outside the film. However, until now this last assumption has been demonstrated only for conventional polymers. By contrast, based on the few data available in the literature, biopolymers exhibit a humidity-dependent behavior, whose effect on food quality and stability is still unknown and difficult to predict based on conventional kinetic models (Lee and Robertson, 2021). The development of mathematical models, taking into account the humidity-dependence of the packaging materials, is thus required to predict both the performances of biopolymeric materials during storage and the stability and shelf life of food. Based on these considerations, this Ph.D. project aims to develop multiresponse kinetic models (Bahmid et al., 2021) accounting for the conjoint behavior of biopolymer and dry food under different environmental conditions (*e.g.*, temperature and relative humidity). These models will be able to simulate the shelf-life evolution of dried foods while considering dynamic changes in food properties (e.g. water activity, glass transition temperature, micro-structure), packaging characteristics (e.g., water vapor permeability, film thickness, head-space volume), and different environmental conditions (*e.g.*, temperature and relative humidity). For this purpose, different food matrices and different bio-based packaging materials will be considered, and, depending on food features, different quality decay reactions will be monitored.

2. Ph.D. Thesis Objectives and Milestones

During the first year, the evaluation of physical and physicochemical properties (*e.g.*, a_w, T_g) of different dry food matrices (*i.e.*, potato chips, corn flakes, whey protein isolate powder, instant and ground coffee) were assessed. Indicators suitable to monitor food quality decay and relevant acceptability limits were also identified. Considering the next 24 months, according to the Ph.D. thesis project, the following activities will be pursued (Table 1):
A0) **Literature review**;
A1) **Permeability assessment** of conventional and bio-based materials as a function of different parameters (e.g., temperature, relative humidity) to investigate their behavior in the whole environmental conditions range;
A2) **Kinetic data collection** relevant to quality decay rates of the chosen food matrices under different conditions (e.g., temperature, relative humidity);
A3) Based on A1 and A2, different **multiresponse kinetic models** accounting for the conjoint behavior of packaging materials and food matrices under different environmental conditions will be developed and validated;
A4) **Mobility period**;
A5) **Papers and thesis writing.**

***Table 1.** GANTT Diagram for this PhD thesis project*

Months / Activity		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A0)	***Literature review***																								
A1)	***Permeability assessment***																								
	1) Permeance evaluation of petroleum-based materials at different temperatures																								
	2) Permeance evaluation of *bio-based* materials under different conditions																								
A2)	***Kinetic data collection***																								
	1) Kinetic modeling and stability assessment																								
	2) Modeling the dependence of the environmental variables on quality decay rates																								
A3)	***Multiresponse kinetic model development and validation***																								
A4)	***Mobility period***																								
A5)	***Papers writing and thesis development***																								

3. References

Bahmid NA, Heising J, Dekker M (2021) Multiresponse kinetic m of the formation, release, and degradation of allyl isothiocyanate from ground mustard seeds to improve active packaging, *J. Food Eng.*, **292**:110370
Heiss R (1958) Shelf life determination, *Mod. Packaging*, **31**:119
Labuza, TP (1980) Water activity: Physical and chemical properties, *J. Food Process Eng.*, **1**:320-325
Lee DS, Robertson GL (2021) Interactive influence of decision criteria, packaging film, storage temperature and humidity on shelf life of packaged dried vegetables, *Food Packag. & Shelf Life*, **28**: 100674