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EVALUATION OF ALTERNATIVE MODELS FOR RESPIRATION RATE OF READY-TO-EAT STRAWBERRY (cv. 'Ágata')

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INTRODUCTION & AIM

Modified atmosphere packaging (MAP) is an essential technology for maintaining quality attributes and extending fresh-cut products' shelf-life. When designing MAP conditions, it is necessary to determine the influence of internal gaseous atmosphere and temperature on fresh-cut metabolism, allowing to predict best conditions for shelf-life extension. While respiration rate models for various strawberry cultivars are well-documented, there is limited literature specifically addressing fresh-cut strawberries.

Evaluate and compare alternative models for the respiration rate (RR) of ready-to-eat strawberries as a function of O_2, CO_2, and temperature, with the goal of developing a robust mathematical model applicable in MAP.

METHODS

01 – Strawberry process

- cv. Ágata (from north of Uruguay)
- Dehulled and sanitized (peracetic acid 80 ppm, 5 min)
- Dried

Parameters associated with ripening stage: pH and Brix

02 – Respiration Experiences

- Factorial experiment:
- Temperature: five levels (4, 10, 14, 19, 26°C)
- Oxygen: three levels (5, 12, 21%)
- Carbon dioxide: three levels (0,7,14%)
- Four replicates

Parameters:
Respiration rate: based on O_2 consumption and CO_2 production measurements using closed system method

03 –Model Evaluation

- Phenomenological approch: Lagmuir and Michaelis-Menten with and without inhibition
- Non-phenomenological approach: exponential, linear and quadratic models.
- -Temperature effect: Arrhenius, exponential and power models.

Model selection was performed based on R2-adjusted, RMSE and IAC indicators. Models with R2 > 0.80 and higher AIC and BIC were selected.

04 –Validation

- Best model was used to predict RR of fresh-cut strawberries on closed systems at 12°C for 45h.
- Four replicates

Parameters:
- O2 and CO2 evolution was measure in closed system method

RESULTS & DISCUSSION

A significant effect of pO_2, pCO_2 and temperature, and their interactions were obtained on respiration rate (RRO_2) (p-value>0.05, Tukey test).

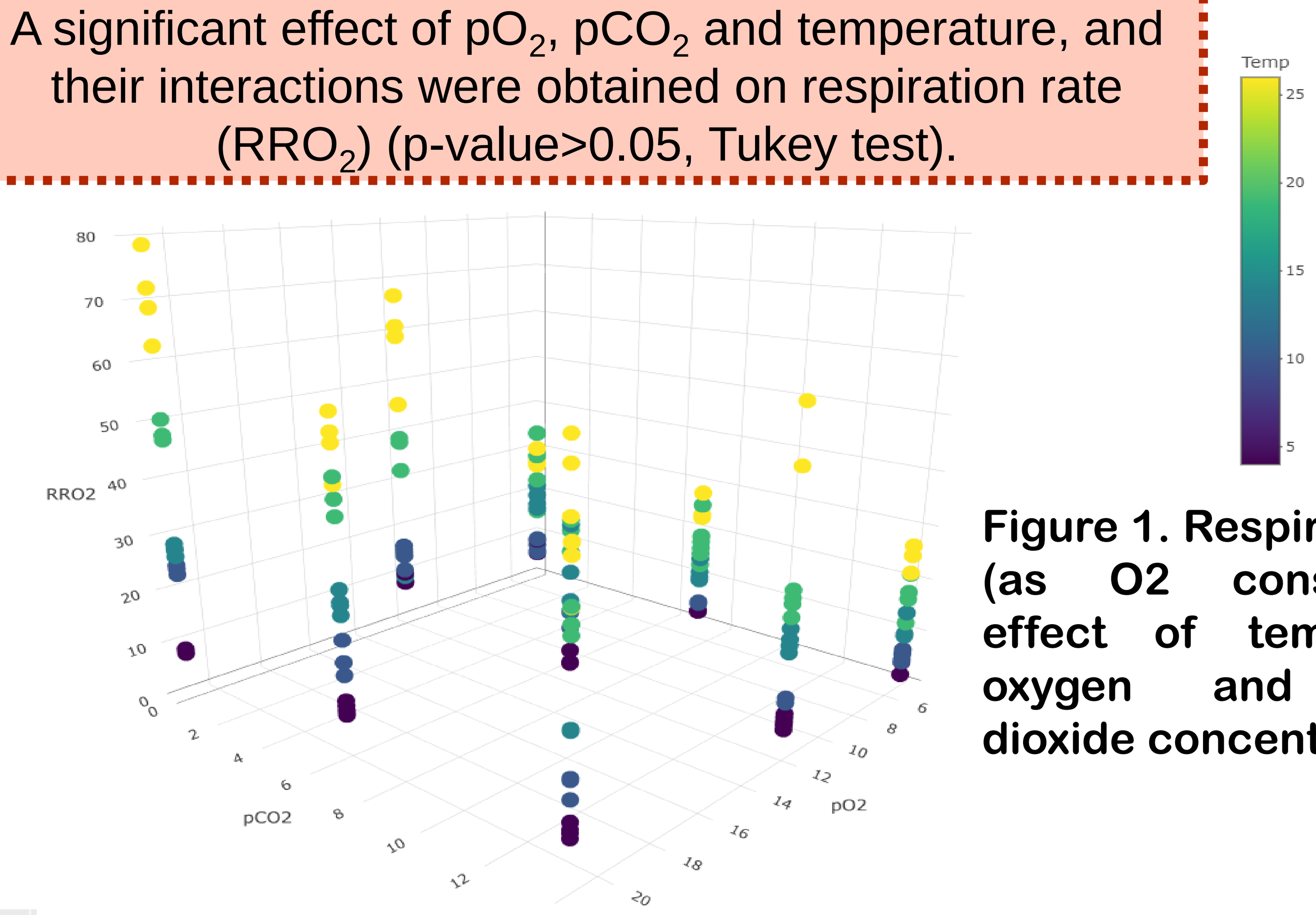

Figure 1. Respiration rate (as O2 consumption) effect of temperature, oxygen and carbon dioxide concentration.

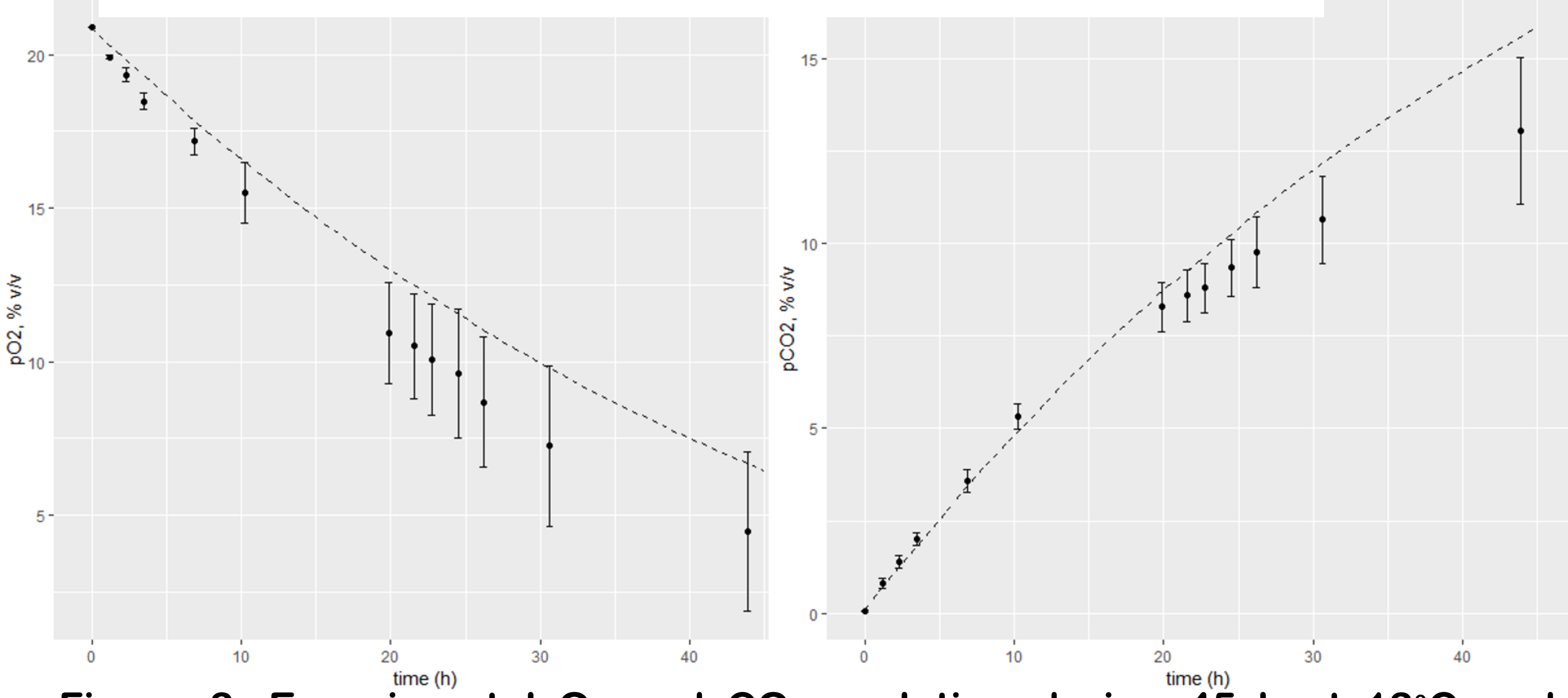

Figure 2. Experimental O_2 and CO_2 evolution during 45 h at 12°C and predicted with UMM model-Arrhenius model

Table 1. Model parameters for: Langmuir; Michaelis-Menten uncompetitive-UMM, noncompetitive-NMM and mixed-MixMM; and goodness of fit for O2 consumption: effect of temperature, oxygen and carbon dioxide concentration.

	Para-meters	Langmuir	Para-meters	UMM	NMM	MixMM
Arrhenius model	A	1.77e11 (0.166)	A	1.77e11 (0.166)	1.51e11 (0.168)	1.74e11 (0.170)
	Ea (kJ/mol)	52.4 ± 1.7 (<2e-16)	Ea	52.4 ± 1.7 (<2e-16)	52.3 ± 1.8 (<2e-16)	52.39 ± 0.24 (<2e-16)
	a	0.0641 ± 0.0092 (8.57e-11)	k_{m,O_2}	15.6 ± 2.2 (8.57e-11)	12.5 ± 1.6 (1.11e-12)	15.2 ± 2.9 (4.46e-7)
	i	0.0460 ± 0.0080 (4.12e-8)	k_{j,CO_2}	21.7 ± 3.8 (4.12e-8)	---	406 (0.855)
			k_{n,CO_2}	---	44.0 ± 6.6 (2.89e-10)	---
			k_{i,CO_2}	---	---	23.1 ± 9.1 (0.012)
	R2	**0.907**	**R2**	**0.907**	**0.906**	**0.907**
	RMSE	**5.09**	**RMSE**	**5.09**	**5.11**	**5.09**
	AIC	**1052**	**AIC**	**1052**	**1054**	**1045**
Quadratic model	$RRO_2 = \alpha_0 + \alpha_1 c_{O_2} + \alpha_2 c_{CO_2} + \alpha_3 T_C + \alpha_4 {c_{O_2}}^2 + \alpha_5 {c_{CO_2}}^2 + \alpha_6 {T_C}^2 + \alpha_7 c_{O_2} c_{CO_2} + \alpha_8 T_C c_{CO_2} + \alpha_9 T_C c_{CO_2} + \alpha_{10} T_C c_{O_2} c_{CO_2}$		α_0	0.67 ± 3.55 (0.849)	α_6	0.0325 ± 0.0073 (1.78e-5)
			α_1	0.64 ± 0.40 (0.111)	α_7	0.044 ± 0.022 (0.0492)
			α_2	-0.91 ± 0.40 (0.023)	α_8	0.026 ± 0.020 (0.194)
			α_3	-0.22 ± 0.428 (0.429)	α_9	0.098 ± 0.012 (2.40e-13)
			α_4	-0.031 ± 0.013 (0.177)	α_{10}	-0.0046 ± 0.0014 (0.00106)
			α_5	0.030 ± 0.017 (0.0778)		
	R2		**0.914**			
	RMSE		**4.90**			
	AIC		**1053**			

CONCLUSION

All model tested could explain over the 87% of the experimental data variance. The best fit was achieved with the quadratic empirical model, which is simple and easy to construct; however, its parameters lack physical or biological meaning, limiting its applicability. Among the phenomenological models (enzyme-based), the UMM (or its Langmuir equivalent) provided the best fit.