AgroStat

Marseille, 14-16 March 2018

Due to the increasing quantity of data in agrosciences, there is a need for specific tools which place statistics and data science at the heart of challenges of the contemporary world. The AGROSTAT conference gives statisticians, engineers and users of statistical methods a unique opportunity to exchange around topics, such as sensometrics, chemometrics, experimental designs, risk analysis, process control or big data.

This event brings together internationally recognized academic and industrial organizations representatives, to take stock of advances in statistics, express their needs and to anticipate future challenges.

This conference, which is held every two years, is organized this year by **Aix-Marseille University,** the "Mediterranean Institute of Biodiversity and Marine and Continental Ecology", UMR CNRS 7263 / IRD 237, team Toxicology & Environmental Health (TSE), under the auspices of the Agro-Industry Group of the French Statistical Society (SFdS). The SFdS is a non-profit organization bringing together researchers, engineers, teachers and statistics users.

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Wednesday 14 March

9h00			**Welcome speech - M. SERGENT, M. QANNARI**
			Inaugural conference
9h15	**PL1**	**B. K. Ersbøll**	**Big Data from Farm to Fork, advantages and challenges**
			Session 1: BIG DATA/MACHINE LEARNING/DEEP LEARNING - Chair: S. Marque
10h20	**O01**	P. Rebenaque	Automated analysis of tasting comments in sensory analysis
10h40	**O02**	M.-B Blanquart	Impact of the questionnaire structure on overall results in preference mapping: a meta-analysis on 285 consumer studies
11h00	**O03**	S. Bougeard	Current multiblock methods: competition or complementarity? A comparative study in a unified framework
11h20			***Coffee break***
			Session 2: DEVELOPMENT TOOLS - Chair: D. Brémaud
11h50	**O04**	N. Pineau	Use of R-Shiny apps to communicate sensory and consumer modeling tools outputs
12h10	**O05**	I. Rebhi	An interactive shiny tool for sensory and consumer data mapping : sensmapui
12h30			***Lunch***
			Session 3: CHEMOMETRICS - Chairs: D. Rutledge/ E. Vigneau
14h00	**PL2**	**P. Bastien**	**Use of sparse methods in cosmetics**
15h00	**O06**	B. Jaillais	Random forests for the prediction of water content by near-infrared hyperspectral imaging spectroscopy in biscuits
15h20	**OO7**	C. Peltier	What is the better test to detect multivariate differences in large dimensional data?
15h40	**O08**	D.N. Rutledge	Comparison of Principal Components Analysis, Independent Components Analysis and Common Components Analysis
16h00			***Coffee break***
16h30	**O09**	E. Vigneau	Analyse des relations entre plusieurs blocs de données par l'approche Path-Comdim: une application pour évaluer la qualité environnementale sur le littoral atlantique français
16h50			**Poster presentations**
17h15			POSTER SESSION
18h00			***Welcome Reception: Les Halles de la Major***

Thurs day 15 March

Session 4: SENSOMETRICS - Chairs : Ph. Courcoux / P. Schlich			
8h45	**PL3**	**J. Castura**	**Consumer diversity in sensory evaluation data**
9h30	**O10**	M. Brard	A latent class regression model for the clustering of multivariate binary ratings
9h50	**O11**	E. Qannari	One thousand and one ways to analyze free sorting data
10h10	**O12**	N. Pineau	CATA as an alternative method to free sorting
10h30			***Coffee break***
11h00	**O13**	F. Llobell	Clustatis: a cluster analysis of multiblock datasets. application to sensometrics
11h20	**O14**	G. Lecuelle	Modeling temporal dominance of sensations data with stochastic processes
11h40	**PL4**	**B. Boulanger**	**Round table: The world beyond p-values: how to make research in the 21st?**
12h30			***Lunch & posters***
14h30			***SOCIAL EVENT***
19h30			***Gala diner : Reverso - Les Terrasses du port***

Friday 16 March

Session 5: EXPERIMENTAL DESIGNS - Chairs: M. Claeys/M. Sergent			
9h00	**PL5**	**J-P Gauchi**	**Metamodeling and global sensitivity analysis for computer models with correlated input**
9h45	**O15**	S. Marque	Plan d'expériences et simulations sur le contrôle qualité des contaminants microbiologiques de produits finaux
10h05	**O16**	Q. Carboué	Experimental design and solid state fermentation: a holistic approach to improve cultural medium for the production of fungal metabolites
10h25			***Coffee break***
10h55	**O17**	V. Rodrigues	Food source attribution of human campylobacteriosis by meta-analysis of case-control studies
11h15	**O18**	U. Gonzales-Barron	An extended bigelow-type meta-regression model describing the heat resistance of neosartorya spores
11h35	**O19**	V. Cadavez	Dynamic determination of optimum growth rate of listeria monocytogenes in minas soft cheese during cold shelf-life
11h55		P. Schlich	Statistical analysis of chocolate tasting data obtained from participants
12h15			***Closing of the conference, Awards*** ***Lunch***

AN EXTENDED BIGELOW-TYPE META-REGRESSION MODEL DESCRIBING THE HEAT RESISTANCE OF *NEOSARTORYA* SPORES

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Abstract

A meta-regression based on an extended-Bigelow equation was adjusted to 326 D-values of *Neosartorya* spp., taken from the literature, in order to summarise its heat resistance parameters. As the meta-regression accommodated relevant study characteristics, it was possible to estimate D*-values and z-values of temperature, pH and ºBrix for the various beverages, inactivation methods, fruits and preservative use/no use.

Keywords - Meta-analysis, Secondary model, D-value, z-value, Temperature, pH, ºBrix

INTRODUCTION

The pasteurisation normally applied to juices and nectars activates dormant ascospores of *Neosartorya* that will initiate the germination processes, causing deterioration in the final product. Since *N. fischeri* is an important quality indicator of heat treatment processes, many researchers have estimated its thermal inactivation parameters (D-values and z-values) under different conditions. Thus, the objective of this study was to extract all published findings on the heat resistance parameters of *Neosartorya* spores, and summarise them by constructing a single meta-regression model based on an extended Bigelow-type equation capable to accommodate relevant study characteristics. The resulting meta-regression should allow the estimation of overall D- and z-values for the various beverages, inactivation methods and fruits considered.

METHODOLOGY

Literature search was conducted using the bibliographic databases Pubmed, Scopus and Web of Science using appropriate key terms in English, Spanish and Portuguese to identify studies that published D-values from conventional heat treatment. From each of fourteen studies regarded as appropriate for inclusion, the following study characteristics were extracted: D-value (***D***, min); inactivation temperature (***T***, ºC); pH (***pH***); ºBrix (***ºBrix***); type of medium, rather related to consistency (***Type t***={"model", "juice", "concentrate"}); fruit (**f**, a series of fruits, also including "water" and "buffer"); use of preservative (***Preserv p***={"yes", "no"}); inactivation method (***Inac m***={capillary tubes – "CAP", screw tubes – "SCW", three-neck round – "TNR", thermal death tubes – "TDT", polythene bags – "PTB", Erlenmeyer – "Erlen"}), age of spores (***Age***, days) and study (***j***={"1", "2",... "14"}). The meta-analytical data set comprised 326 observations. To describe the combined effect of temperature, pH and ºBrix on the heat resistance of *Neosartorya* spores, the Bigelow-type linear model.

$$logD = logD^{*} + \left(\frac{1}{z_T}\right)(T - T^{*}) + \left(\frac{1}{z_{pH}^2}\right)(pH - pH^{*})^2 + \left(\frac{1}{z_{ºBrix}}\right)(ºBrix - ºBrix^{*})$$

was used as a basis for the construction of a parsimonious meta-regression model,

$$\boldsymbol{logD^{*}_{jfm}} = (\alpha_0 + \alpha_{1m}Inac_m + \alpha_2 \log(Age)) + u_{jf} = logD^{*}_{mean\,m} + u_{jf}$$

$$\frac{1}{z_{T_{jfp}}} = \beta_1 + \beta_2 Preserv_p + v_{jf} \qquad \frac{1}{z_{pH}^2} = \delta_1 \qquad \frac{1}{z_{ºBrix_t}} = \gamma_1 + \gamma_{2t} Type_t$$

which allowed the estimation of z_T (conventional thermal z-value, reference T*=90ºC); z_{pH} (distance of pH from reference pH*=3.5 which leads to a ten-fold reduction of D); $z_{ºBrix}$ (distance of ºBrix from reference ºBrix*=12 which leads to a ten-fold reduction of D); and D^{*} (D at T*, pH* and ºBrix*), as affected by relevant moderators. The random effects u_{jf}, v_{jf}, with subject of variation study×fruit, modelled shifts in log D* and z_T, respectively.

RESULTS

As expected, the inactivation temperature ($p<.0001$) affected the resistance of *Neosartorya* spp., whilst at a constant temperature, this heat resistance could be further undermined by a lower pH ($p=0.019$) or a lower ºBrix ($p=0.001$) of the medium. Notice that, unlike temperature, pH and ºBrix directly affect log D (as implied by the positive coefficients in Table 1). The overall (or meta-analysed) reference D*-value (at temperature 90ºC, pH 3.5 and ºBrix 12) for *Neosartorya* spores was estimated at 5.308 min (95% CI: 4.102 – 7.047 min). However, the reference D*, and consequently the D-values, are strongly influenced by the inactivation method used in their determination, with some methods leading to higher D than others (Table 1). Although both the SCW and TDT methods have been widely used, this meta-regression revealed that the former tends to produce significantly higher D values (overall D*=7.798 min; 95% CI: 5.035 – 12.10 min) than the latter (overall D*=3.069 min; 95% CI: 1.866 – 5.058 min). In addition, the older the spores, the higher the reference D* ($p=0.023$).

Table 1. Parameter estimates of the Bigelow-type meta-regression modelling the logarithm base 10 of the decimal reduction time D (min) of *Neosartorya* spores in liquid media and beverages, along with heterogeneity analysis

Parameters	Mean	Standard error	Pr > |t|	Heterogeneity
Predictors of log D*				
α_0 (intercept)	1.021	0.276	0.010	Null model
α_{1m} (inactivation method)				τ^2=0.0930
Method: CAP	-0.739	0.307	0.016	I^2=64.6%
Method: Erlenmeyer	-0.944	0.343	0.006	
Method: PTB	-0.711	0.303	0.019	With moderators
Method: SCW	-0.566	0.280	0.044	τ^2_{res}=0.0524
Method: TDT	-0.862	0.283	0.002	R^2=43.6%
α_2 (log spores age)	0.188	0.083	0.023	
Predictors of ($1/z_T$)				
β_1 (temperature)	-0.137	0.015	<.0001	
β_{2p} (temperature×preservative)				
Preservative: Yes	0.038	0.008	<.0001	
Predictors of ($1/z_{Brix}$)				
γ_1 (ºBrix)	0.023	0.007	0.001	
γ_{2t} (ºBrix×type)				
Type: Concentrate	-0.020	0.007	0.003	
Type: Juice	-0.015	0.007	0.046	
Predictors of ($1/z_{pH}$)				
δ_1 (pH)	0.021	0.009	0.019	

Solving the meta-regression for the random effects u_{jf} due to study×fruit, it was possible to estimate overall reference D* values for the different fruits as produced by any inactivation method. For instance, using TDT method, the overall reference D* values of juices were 2.786 min for papaya, 2.735 min for grape, 2.323 min for apple, 2.870 min for peach, 3.118 min for berries, 3.483 min for pineapple and 3.775 min for orange. The overall z_T-value of *Neosartorya* spp. was estimated at 6.944 ºC (95% CI: 6.166 – 7.723 ºC). However, it was found that the addition of preservatives, such as citric, malic, tartaric and lactic acid, sorbates and benzoates, has overall a strong effect on the z_T-values ($p<.0001$; Table 1). When any of the above preservatives is added to the juice, the global z_T-value of *Neosartorya* spp. increases to 8.913 ºC (95% CI: 7.000 – 10.83 ºC), causing therefore a decrease in heat resistance (D-value), as mathematically inferred from the Bigelow equation. Global z_T-values were also estimated by solving the meta-regression for the random effects v_{jf} due to fruits. To mention only some fruits, overall z_T-values for juices without preservatives were 6.431 ºC for berries, 7.321 ºC for apple and 9.042 ºC for grape, whereas, when a chemical preservative was added, overall z_T-values were 8.084 ºC, 9.551 ºC and 12.69 ºC, respectively. The global z_{pH}-value of *Neosartorya* spp. was estimated at 6.855 (95% CI: 5.230 – 11.92), and was not found to be affected by any of the moderators or study characteristics extracted. This meta-analysis characterised, for the first time, the influence of ºBrix on the thermal resistance of the fungus by defining a $z_{ºBrix}$ parameter. Nonetheless, such a parameter appeared to be influenced by the consistency of the medium. Global $z_{ºBrix}$-values were estimated at 44.01 (95% CI: 41.45 – 46.57) for model foods, 127.6 (95% CI: 120.5 – 134.7) for juices and 387.6 (95% CI: 343.8 – 431.3) for concentrates. This means that increasing soluble solids in juices causes a greater increase in the fungus' thermal resistance than increasing soluble solids in concentrates/pastes/purees, probably because the thermal resistance of spores in media of high osmotic pressure is already high. Analysis of heterogeneity indicated that between-study variability in the extracted D-values amounted to 64.6%. However, the strategic incorporation of the various moderators to the simple Bigelow equation enabled to explain 43.6% of the between-study variability.