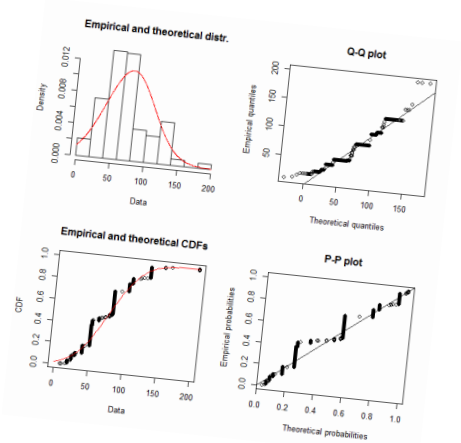
$$f(x) = \frac{\beta^{-\alpha} x^{\alpha-1} \exp(-x/\beta)}{\Gamma(\alpha)}$$



ARTISANE food - Workshop
Building a quantitative risk assessment

L. Guillier & F. Tenenhaus

21st November 2022

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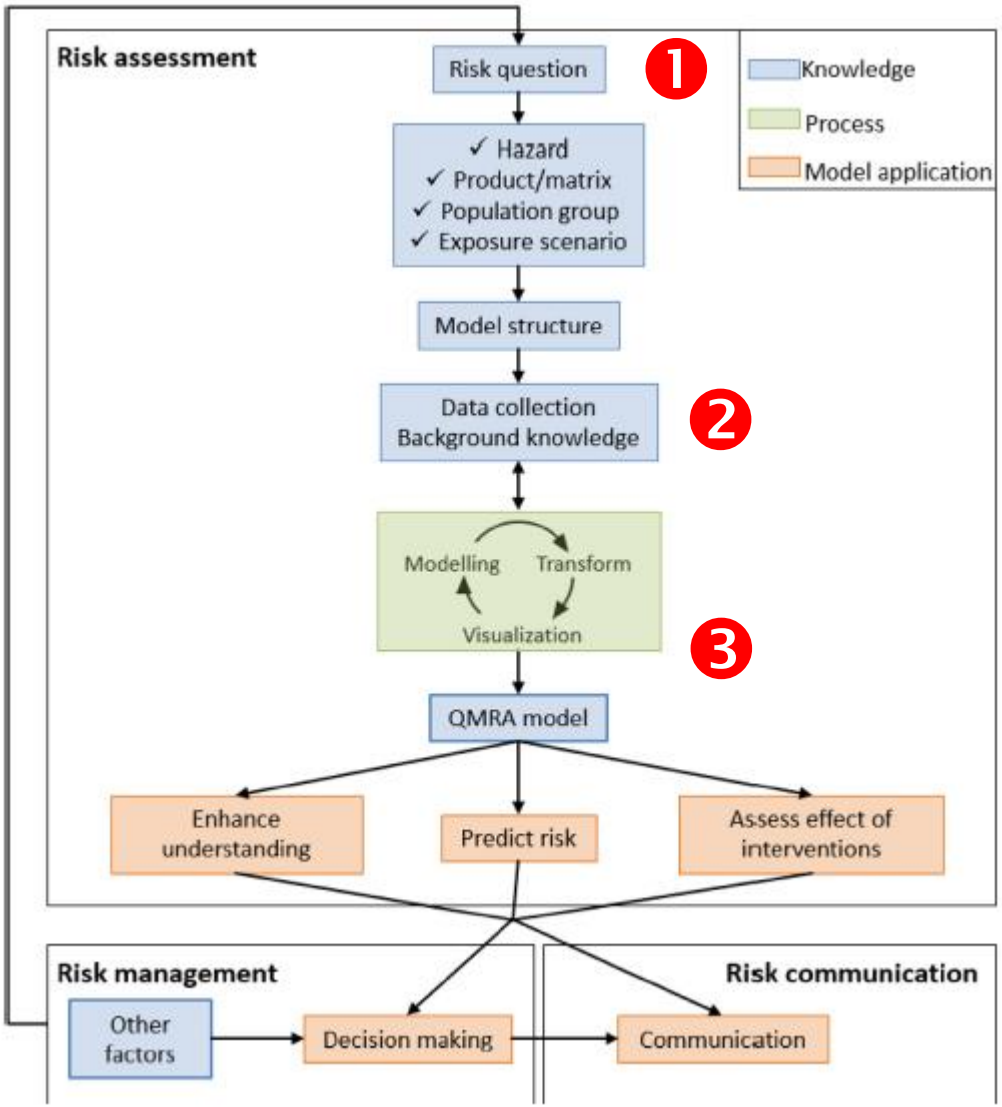
ARTISANE FOOD

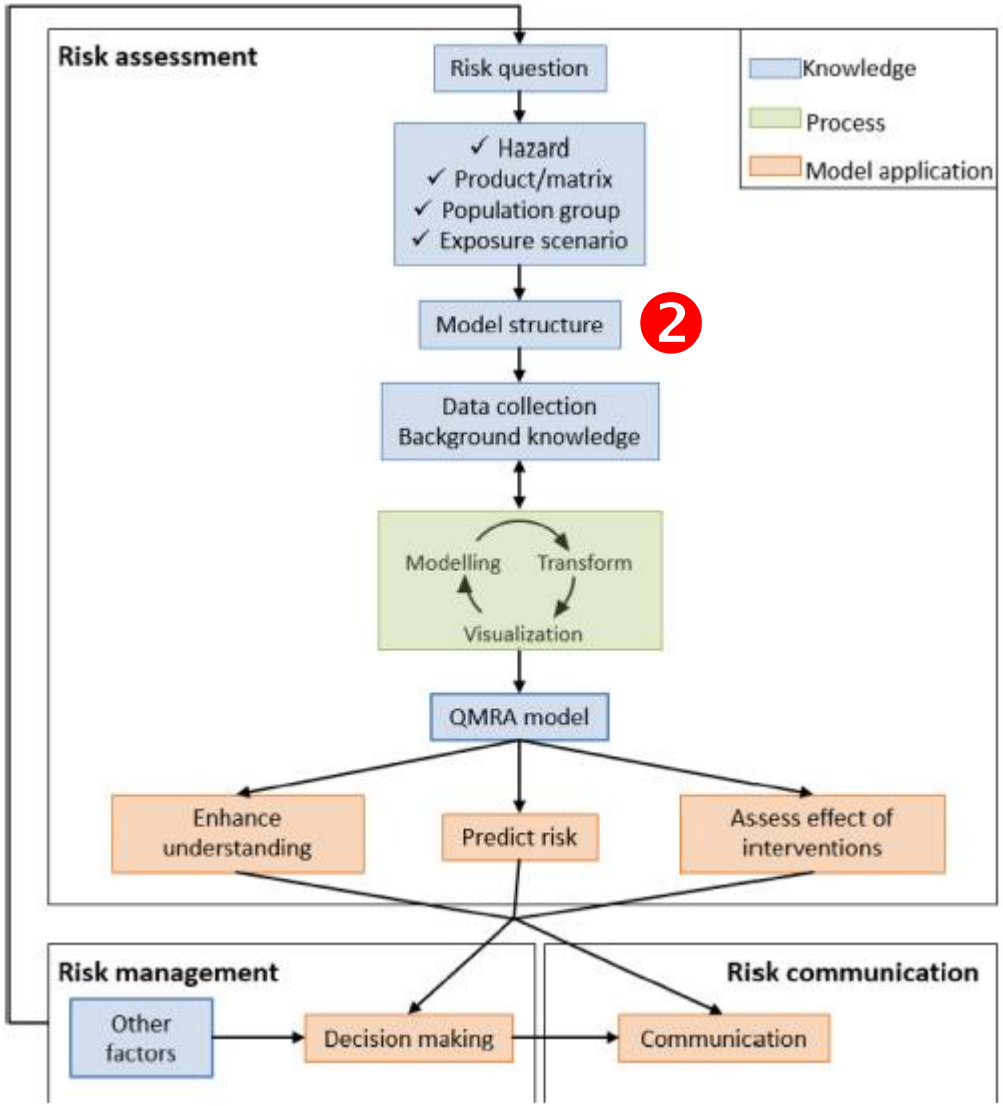
Quantitative risk assessment



The different stages

1. Define the question to be answered
   - 1.1 Which hazard (*E. coli* stx+, *E. coli* O157, EHEC,...)
   - 1.2 Which food? (*fresh minced steak, 20% mg steak, ...)*
   - 1.3 Which population (*children <5 years, <15 years, ...*)
   - 1.4 What is the exposure scenario (*product consumed raw or rare,...*)
   - 1.5 What purpose(s)? Decision-making based on the response (*Determine the impact of the control measure*$_1$ *, calculate the residual risk, ...*)

Quantitative risk assessment



The different stages (2)

2. Define the structure of the QMRA model

2.1 What is the starting point of the model?

2.2 Which stages of the manufacturing process, transport and storage, and consumer preparation should be included?

2.3 What data is available? What data do I need to acquire?

2.4 Processing of data before use in the QMRA

The different stages (2)

2. Define the structure of the QMRA model

2.1 What is the starting point of the model?

Must be upstream of the control measure

Often starts from the point where the most knowledge is available

2.2 Which stages of the manufacturing process, transport and storage, and consumer preparation should be included?

2.3 What data is available? What data do I need to acquire?

2.4 Processing of data before use in the QMRA

The different stages (2)

2. Define the structure of the QMRA model

2.1 What is the starting point of the model?

2.2 Which stages of the manufacturing process, transport and storage, and consumer preparation should be included?

Starting from the production diagram

Selecting the steps that have an assumed impact on the hazard

What basic phenomena (growth, destruction, mixing, partitioning, shrinkage, cross-contamination) come into consideration?

2.3 What data is available? What data do I need to acquire?

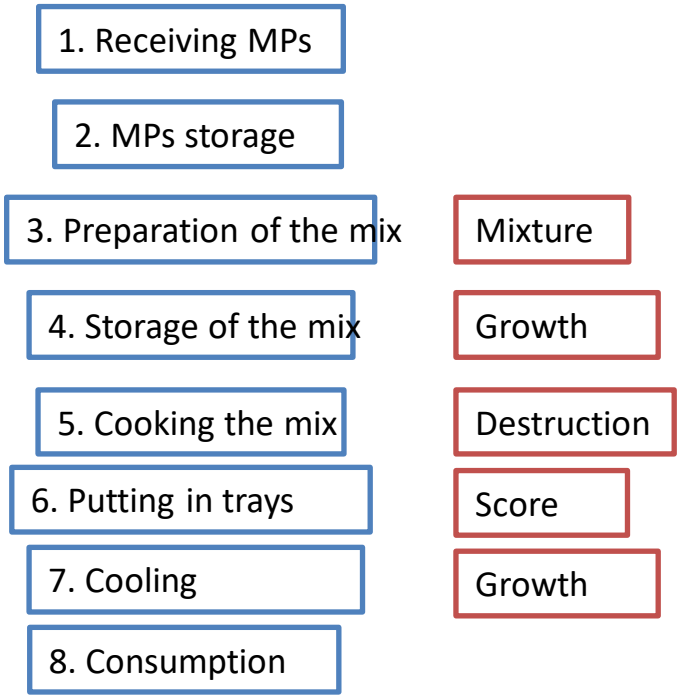
2.4 Processing of data before use in the QMRA

The different stages (2)

2. Define the structure of the QMRA model

2.1 What is the starting point of the model?

2.2 Which stages of the manufacturing process, transport and storage, and consumer preparation should be included?



This work is used to define the modelling assumptions.

- Storage of raw materials has no effect on contamination.
- There is no cross-contamination (everything comes from the raw materials)
- ...

The different stages (2)

2. Define the structure of the QMRA model

2.1 What is the starting point of the model?

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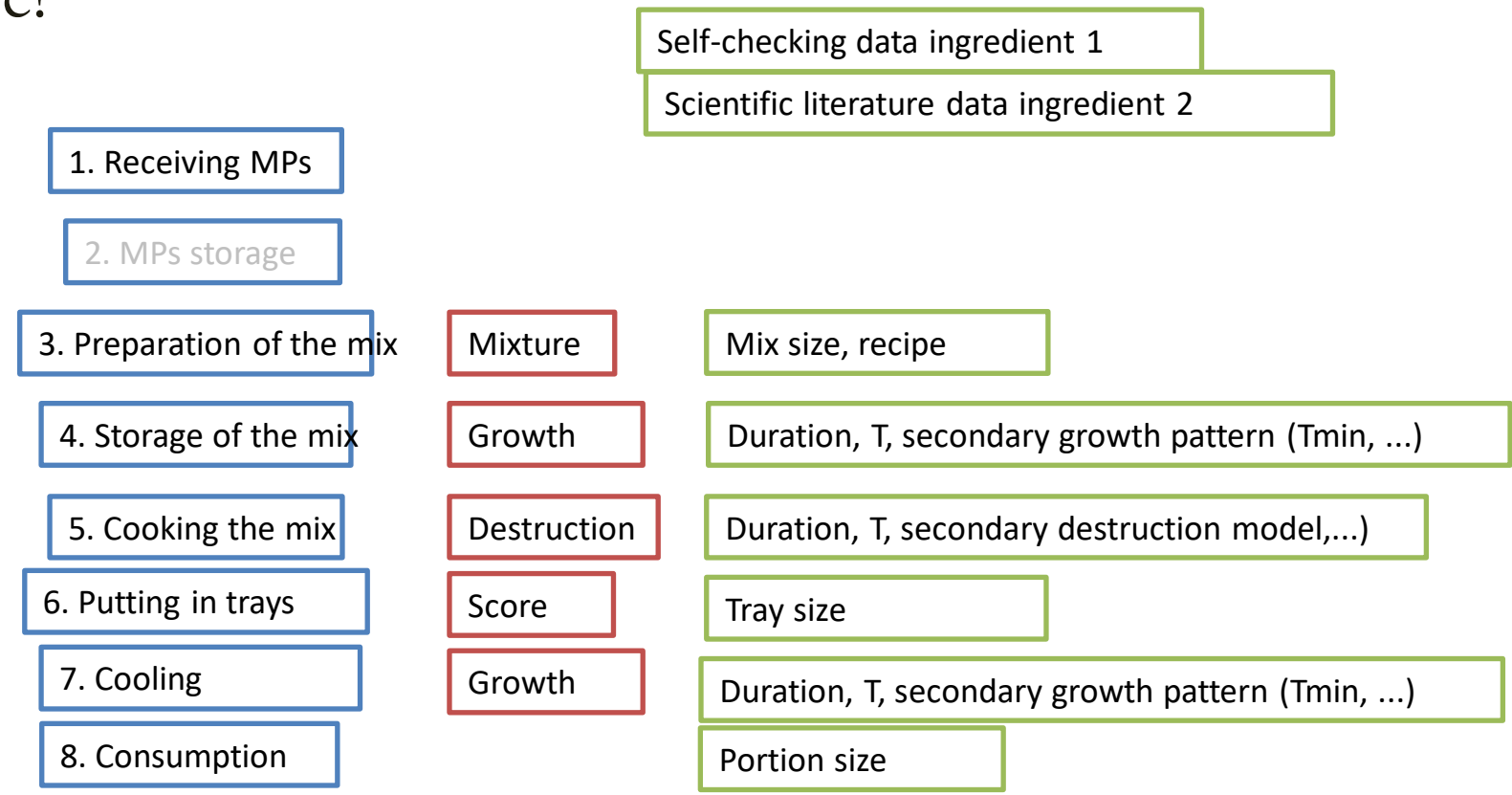

The different stages (2)

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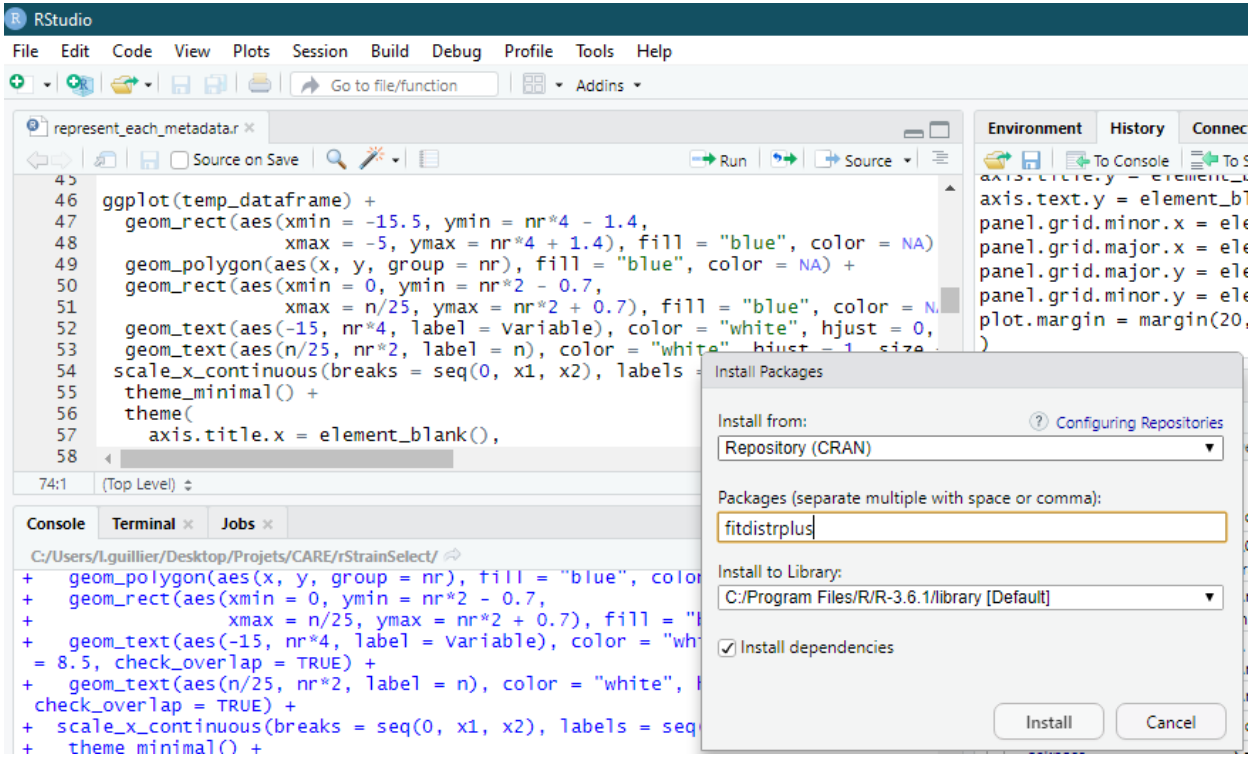
Workshop_AQR1.r (Variability characterisation work)

The tool used :

fitdistrplus: http://cran.at.r-project.org/web/packages/fitdistrplus/index.html

Pouillot, R., and M.-L. Delignette-Muller. 2010. Evaluating variability and uncertainty separately in microbial quantitative risk assessment using two R packages. International Journal of Food Microbiology 142:330-340.

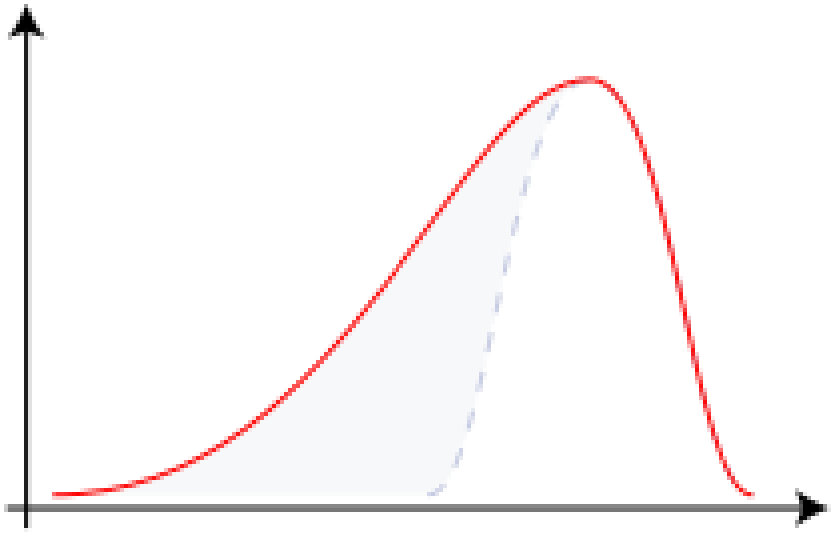
Delignette-Muller, M. L., & Dutang, C. (2015). fitdistrplus: An R package for fitting distributions. Journal of statistical software, 64(4), 1-34.



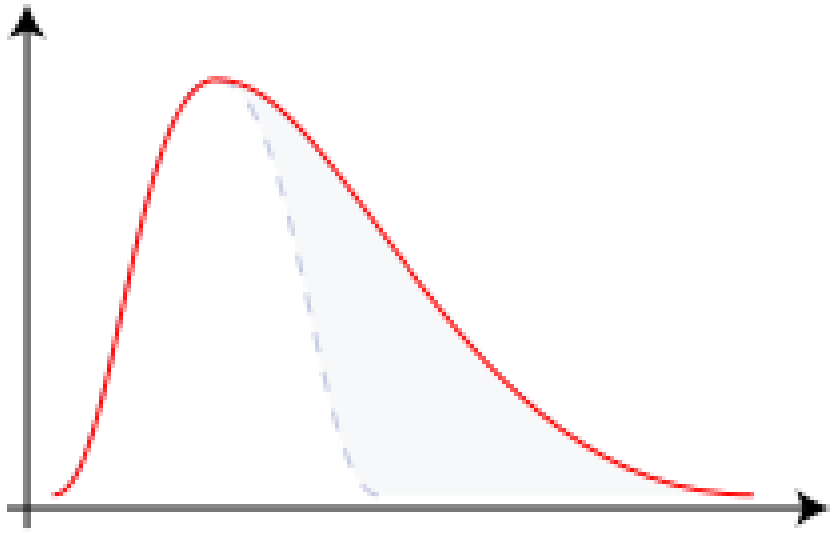
Asymmetry coefficient

Skewness

$$skewness = \frac{1/n \times \sum(x_i - \mu)^3}{\sigma^3}$$



Negative Skew

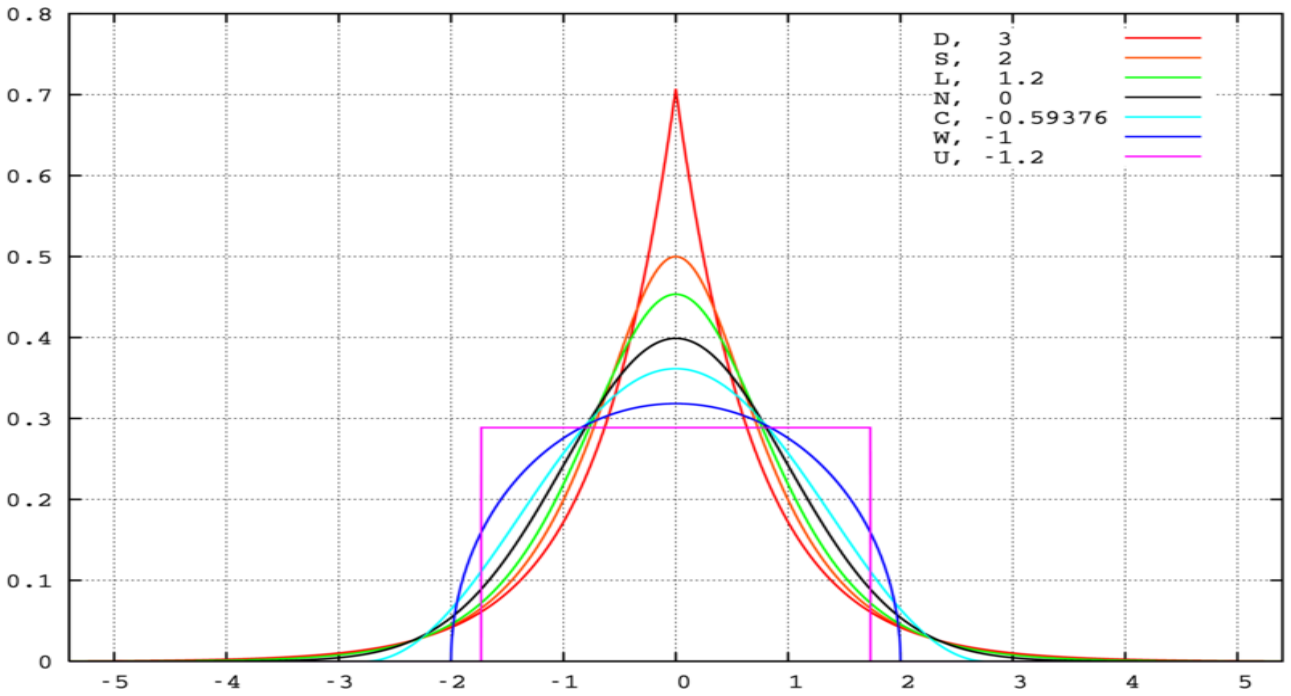


Positive Skew

Flattening coefficient

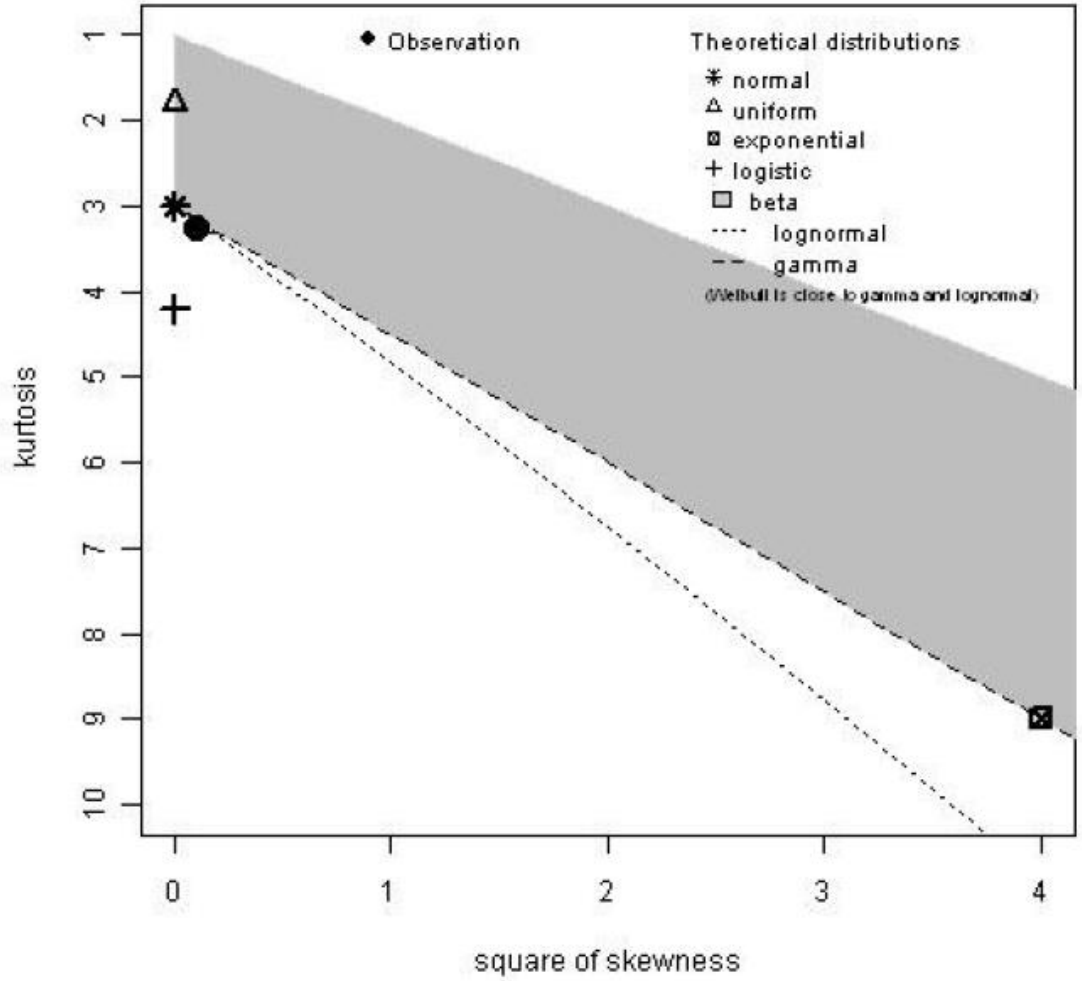
Kurtosis (measure of "peakedness")

$$kurtosis = \frac{1/n \times \sum(x_i - \mu)^4}{\sigma^4}$$



Skewness and kurtosis

Skewness and kurtosis plot for a continuous variable



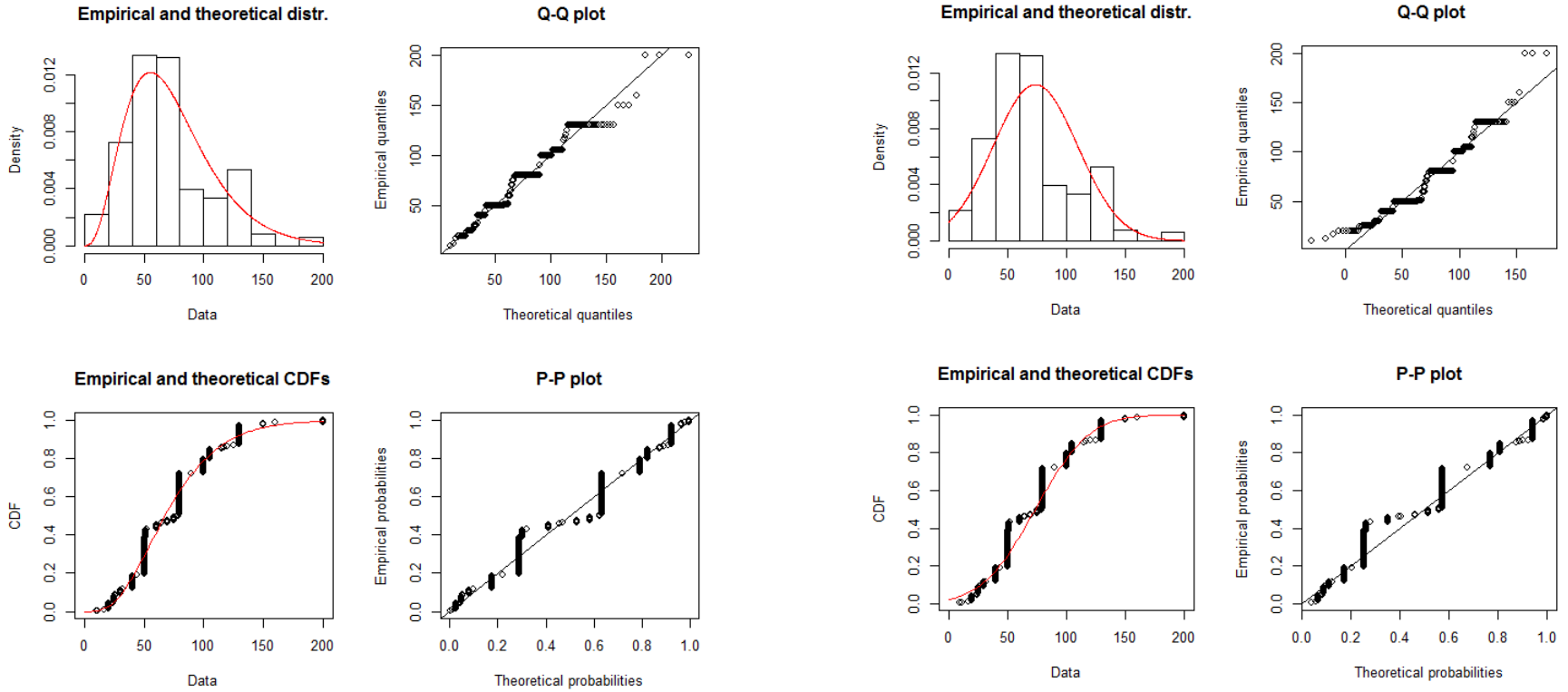
It's up to you!

```
#########
# I Portion size
#########

# 1. importing data
data<-read.csv("portions.csv",header=TRUE,sep=';')

# 2. Which distribution laws?
descdist(data$Portion) # Cullen & Frey graph

# 3. Adjustment
f_gamma<-fitdist(data$Portion, "gamma") # Gamma distribution adjustment
f_lnorm<-fitdist(data$Portion, "lnorm") # Fit lognormal distribution

plot(f_gamma)
plot(f_lnorm)
summary(f_gamma)
summary(f_lnorm)

hist(rgamma(1000,f_gamma$estimate[1],f_gamma$estimate[2]))

#########
# II Microbiological contamination data ingredient 1
#########
```

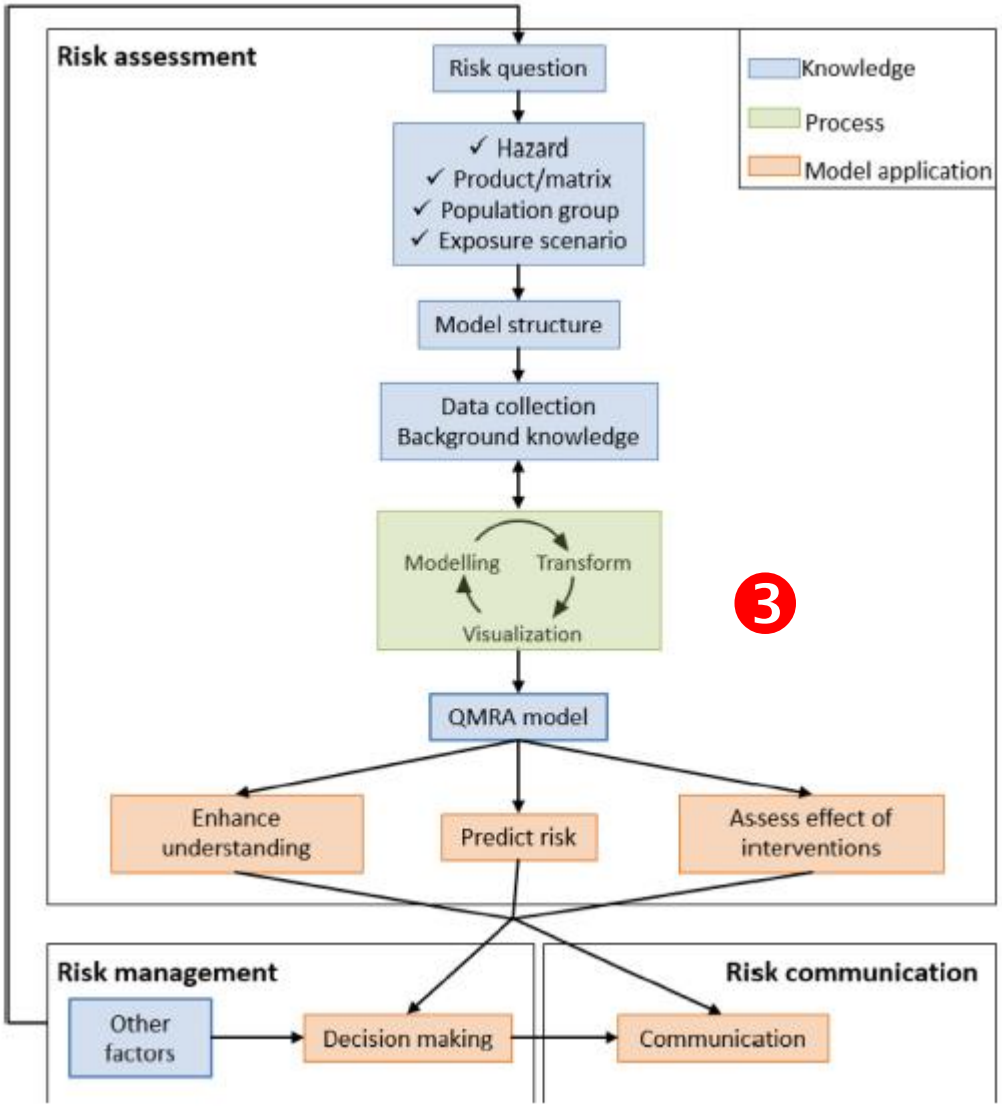
Which distribution fit the best the data?

By graphic observation:

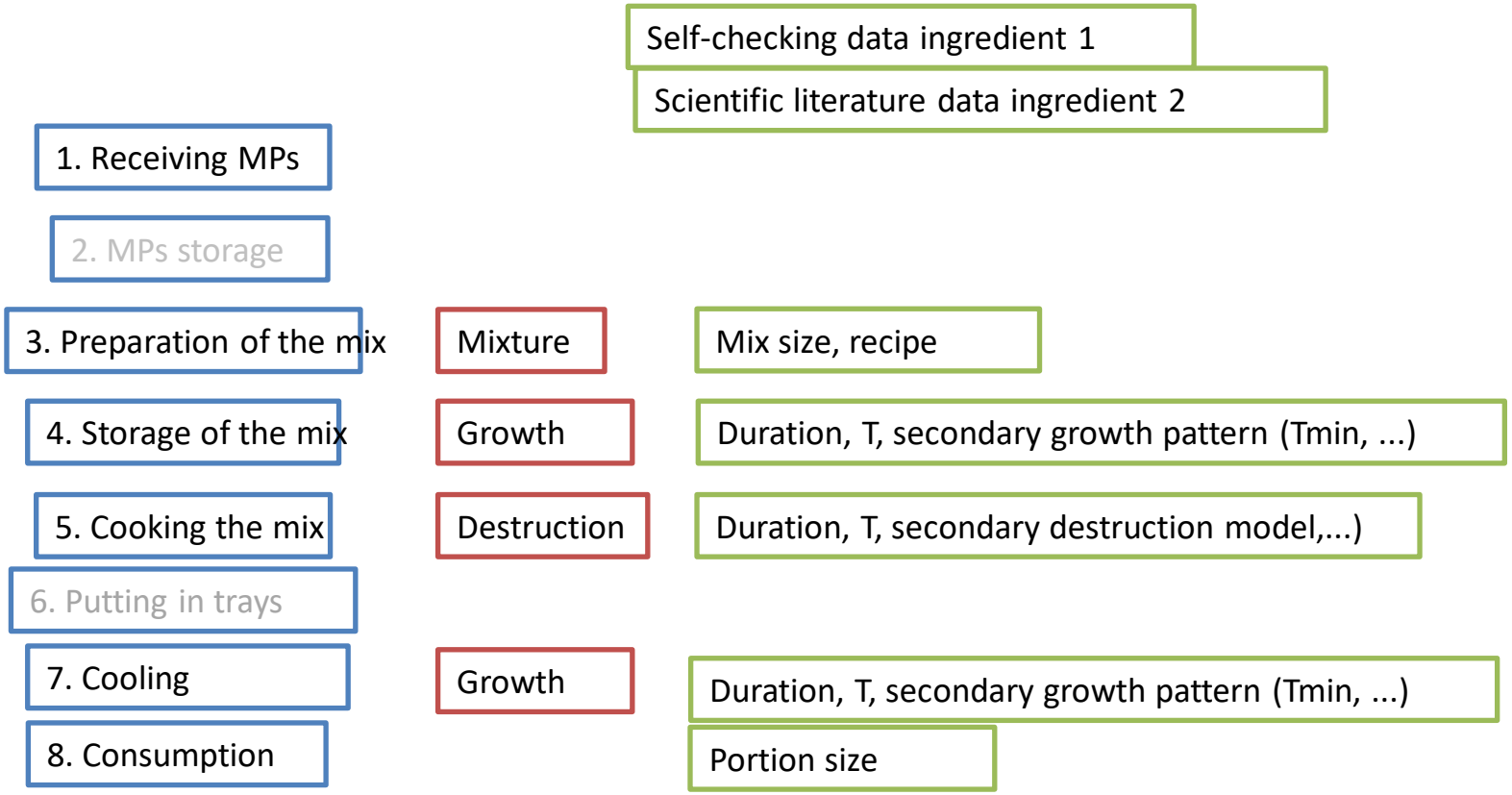
Distribution 1 Distribution 2



Quantitative risk assessment



Make a representation of the model



Make a representation of the model

Self-checking data ingredient 1 (N01)

Scientific literature data ingredient 2 (N02)

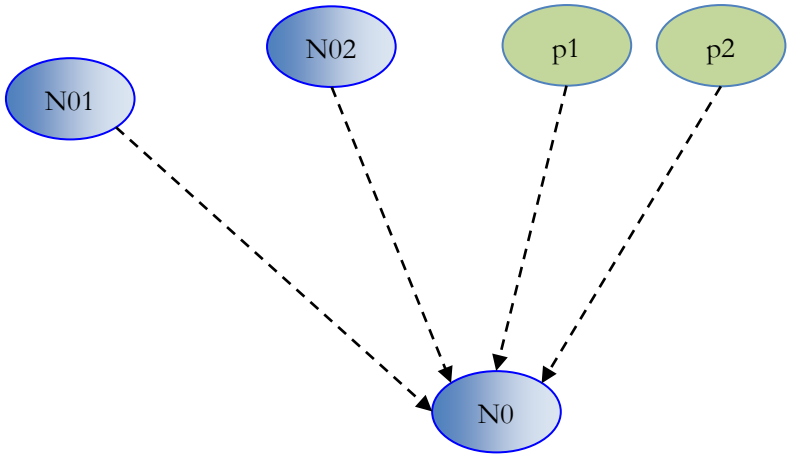
1. Receiving MPs

2. MPs storage

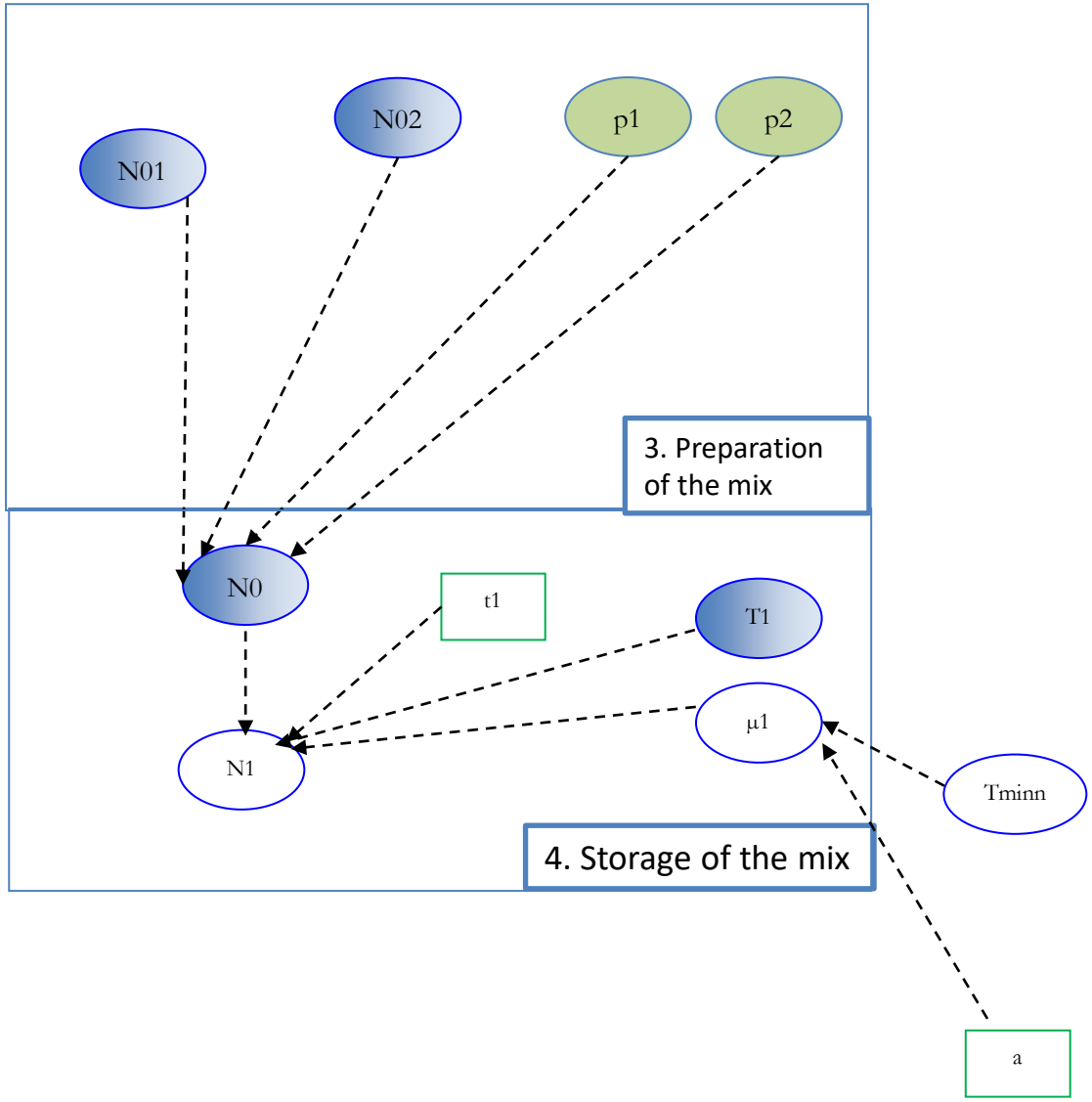
3. Preparation of the mix

Mixture

recipe (p1, p2)



Make a representation of the model (cf. DAG_AQR.pdf)



Growth

Duration (t1), T (T1), secondary growth pattern (Tmin, ...)

Describe the mathematical relationships of the nodes and between the nodes (see Variables and equations QMRA.pdf)

Model variables and equations	Abreviation	Definition	Unit
Initial contamination ingredient 1			
Average	M_{N01}	Estimated from self-checks (autocontroles_ing1.csv) and R script (formation_AQR1.r)	$\log_{10}$ (cfu/g)
Standard deviation	S_{N01}	Estimated from self-checks (autocontroles_ing1.csv) and R script (formation_AQR1.r)	$\log_{10}$ (cfu/g)
Concentration in ingredient 1	N_{01}	Normal (M_{N01} , S_{N01})	$\log_{10}$ (cfu/g)
...			
Concentration in the mix	N0	log10($(10^{N01}$ p1+10^{N02} p2))	$\log_{10}$ (cfu/g)
...			
Growth in the mix			
Average temperature of the cold room	M_{T1}	4	°C
SD of storage temperature of raw materials	S_{T1}	1	°C
Storage temperature of raw materials	T_1	Normal (M_{T1} ,S_{T1})	°C
Storage time	t_1	10	hours
Ratkowski model constant	a	0.033	-

Your turn to play

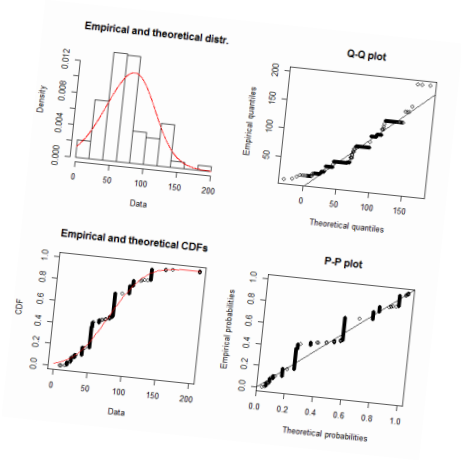
QMRA.xlsx

Measuring the impact on risk of different scenarios:

- Reduction of the initial average N01 contamination by 0.5 $\log_{10}$
- Increase in heat treatment time (t2) from U(5-6) to U(6-7)
- Treatment temperature (T2): increase from 70 to 73°C
- Cooling temperature (T3) from 6°C to 4°C

What control measure do you retain?

$$f(x) = \frac{\beta^{-\alpha} x^{\alpha-1} \exp(-x/\beta)}{\Gamma(\alpha)}$$



Thank you!

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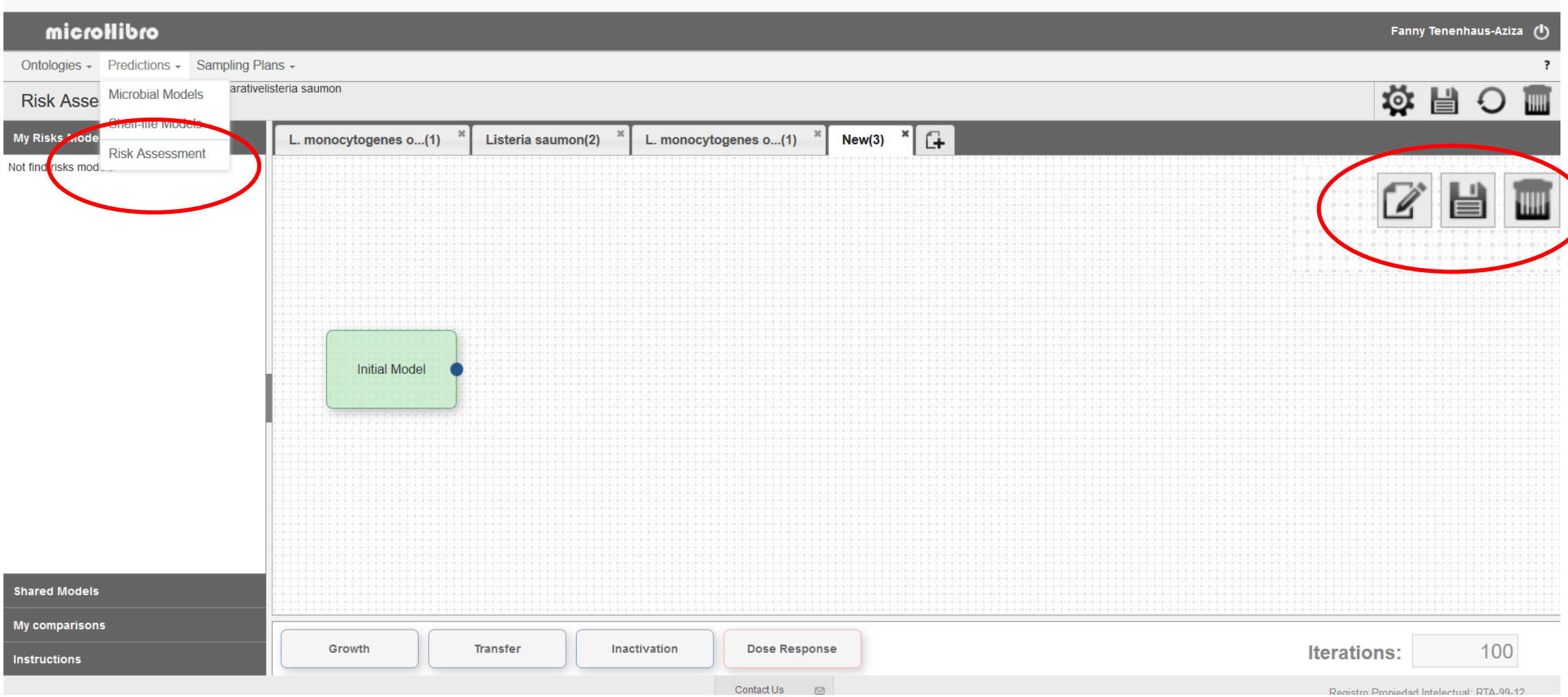
Variables and equations of the AQR model	Abbreviation	Definition	Unit
Initial contamination ingredient 1			
Average	M_{N01}	Estimated from self-checks (autocontroles_ing1.csv) and R script (workshop_variability.r)	log_{10} (cfu/g)
Standard deviation	S_{N01}	Estimated from self-checks (autocontroles_ing1.csv) and R script (workshop_variability.r)	log_{10} (cfu/g)
Concentration in ingredient 1	N_{01}	Normal (M_{N01} , S_{N01})	log_{10} (cfu/g)
Initial contamination ingredient 2			
Average	M_{N02}	-1,3	log_{10} (cfu/g)
Standard deviation	S_{N02}	0,3	log_{10} (cfu/g)
Concentration in ingredient 2	N_{02}	Normal (M_{N02} , S_{N02})	log_{10} (cfu/g)
Preparation of the mix			
Share of ingredient 1	p1	Unif(0.7 - 0.8)	
Share of ingredient 2	p2	1-p1	
Concentration in the mix	N0	$log10((10^{N01}\cdot p1+10^{N02}\cdot p2))$	log_{10} (cfu/g)
Storage of the mix			
Average temperature	M_{T1}	4	°C
SD temperatures	S_{T1}	1	°C
Storage temperature of the mix	T_1	Normal (M_{T1} ,S_{T1})	°C
Storage life of the mix	t_1	10	hours
Growth model parameter	a	0.033	-
Average Tmin	M_{Tmin}	-2	°C
SD of Tmin	S_{Tmin}	0.25	°C
Minimum growth temperature	T_{min}	Normal (M_{Tmin} , S_{Tmin})	°C
Cooking			
Average cooking temperature	M_{T2}	65	°C
SD of the cooking temperature	S_{T2}	2	°C
Cooking temperature	T_2	Normal (M_{T2} ,S_{T2})	°C
Cooking time	t_2	Uniform(5,6)	minutes

Reference temperature	T_{ref}	70	°C
Mean reduction time at Tref	M_{Dref}	1	minutes
SDreduction time at Tref	S_{Dref}	0,01	
Decimal reduction time at Tref	D_{ref}	Normal (M_{Dref} , S_{Dref})	minutes
Value of z	z	8	°C
Cooling			
Storage temperature of the cooked food	T_3	Normal (6,1.5)	°C
Shelf life	t_3	140	hours
Consumption			
Parameter scale of the Gamma law	param1	Estimated from the survey (portions.csv) and R script (workshop_variability.r)	
Parameter rate of the Gamma law	Param2	Estimated from survey (portions.csv) and R script (workshop_variability.r)	
Quantity consumed in the tray	portion	Gamma (param1, param2)	g
Dose response			
Dose-response parameter	r	1.10^{-10}	
Equations			
Growth rate during storage of the mix	μ_1	$(a\cdot(T_1 - T_{min}))^2$	h^{-1}
Contamination before cooking	N_1	$N_0 + \log10(\exp(\mu_1 \cdot t_1))$	$\log_{10}$ cfu/g
Contamination after cooking	N_2	$N_1 - (t2.10^{(T2-Tref)/z})/Dref$	$\log_{10}$ cfu/g
Growth rate during storage of cooked food	μ_3	$(a\cdot (T_3 - Tmin))^2$	h^{-1}
Contamination after storage	N3	$\min(9, N2+\log_{10} (\exp(\mu_3 \cdot t_3)))$	$\log_{10}$ cfu/g
Dose ingested	dose	$10^{N3}\cdot$ portion	cfu
Risk for 1 batch	risk	((1-exp(-r• dose))	Probability
Mean risk	mean_risk		

Connexion

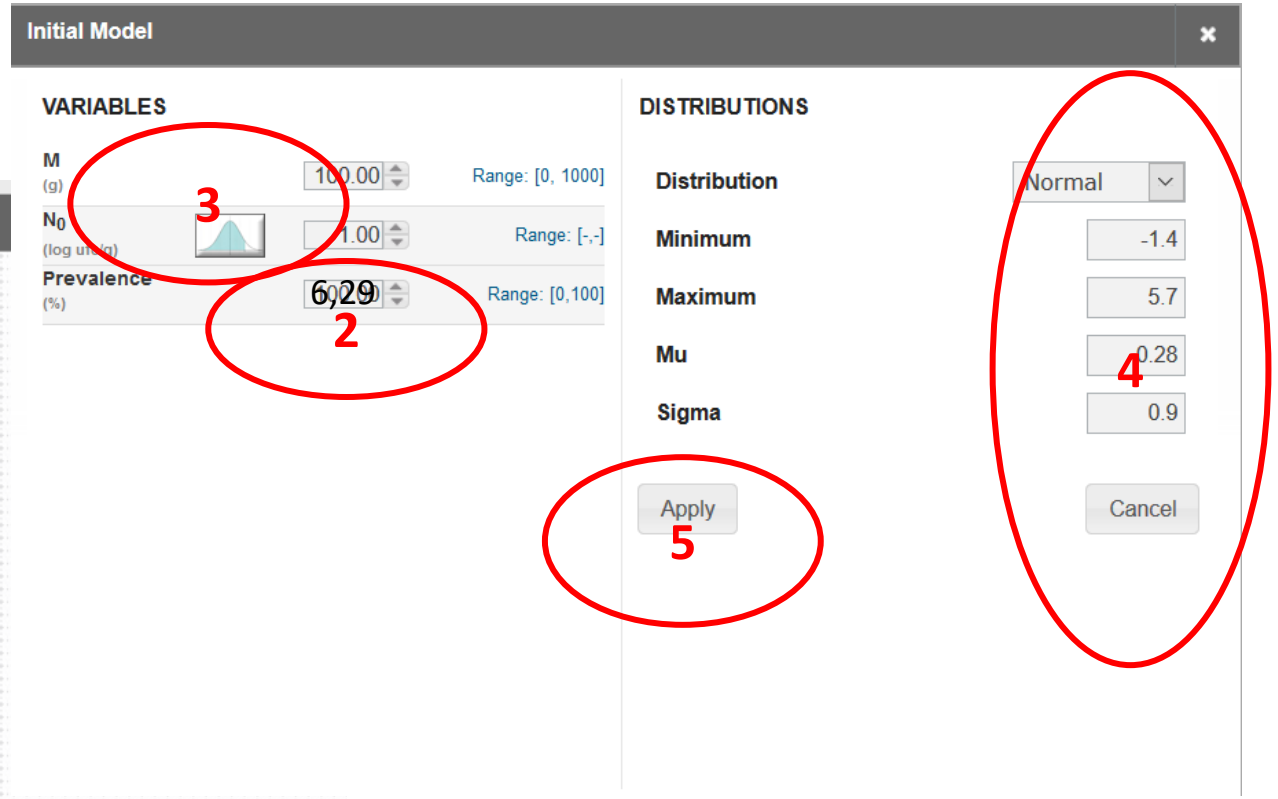

Herramienta de Evaluación Cuantitava del Riesgo Microbiano
microHibro
Autenticación
Usuario
Clave
Idioma
Español
Enviar
¿Ha olvidado su contraseña?
Registrate aquí
Limitación de responsabilidad
Optimizado para Mozilla Firefox 25, Internet Explorer 10 y Google Chrome 30 o superiores

Create a model

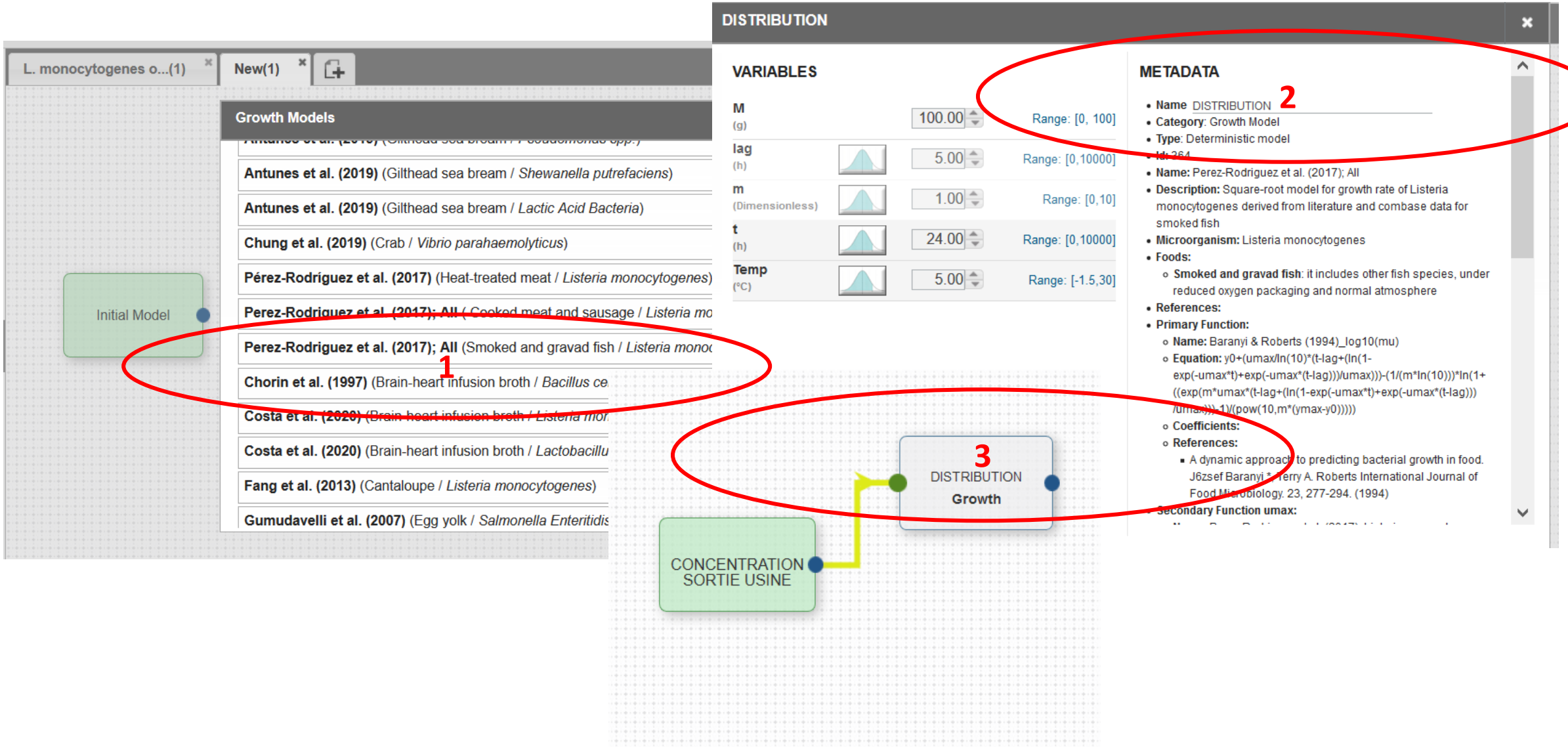


Initial prevalence and concentration

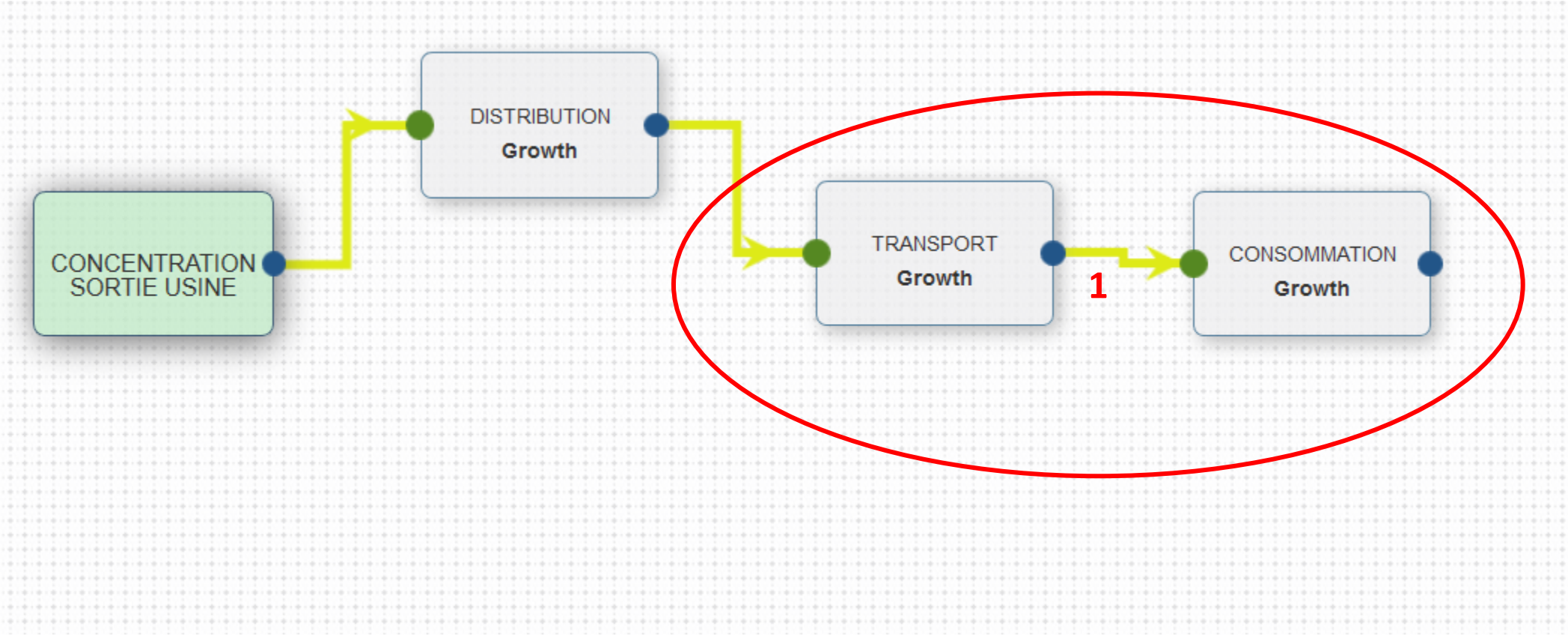
- Contamination prevalence = 6,29 %
- Initial conc at factory (log CFU/g)
  - Max = 5,7
  - Mean = - 0,28
  - SD = 0,9
  - Min = -1,4



Modelling exposure and concentration

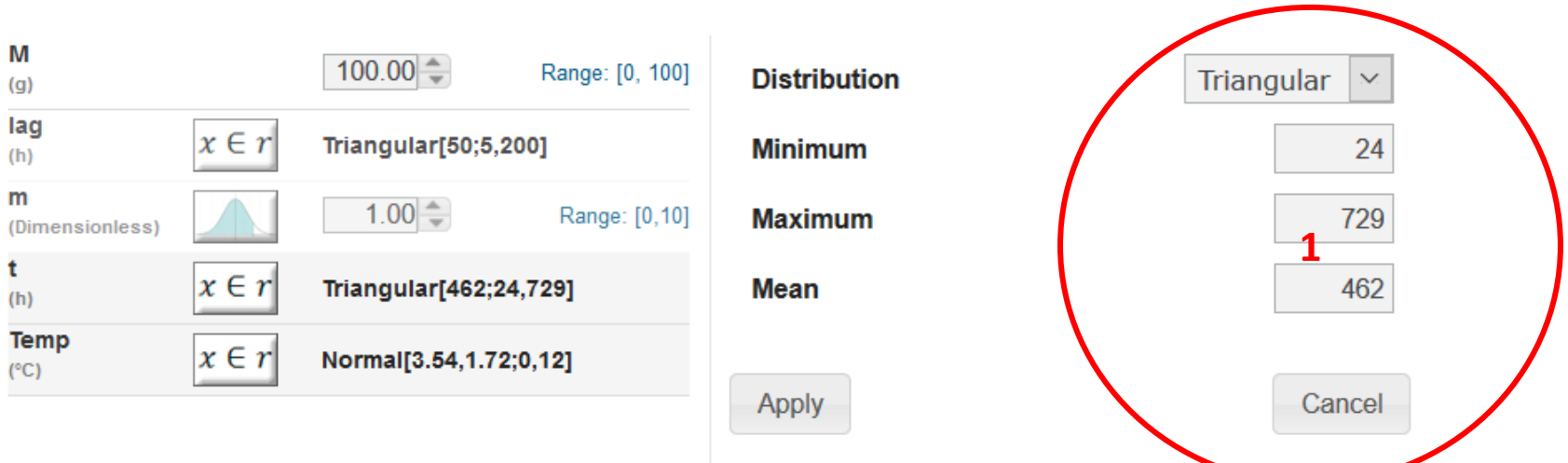


Modelling exposure and concentration

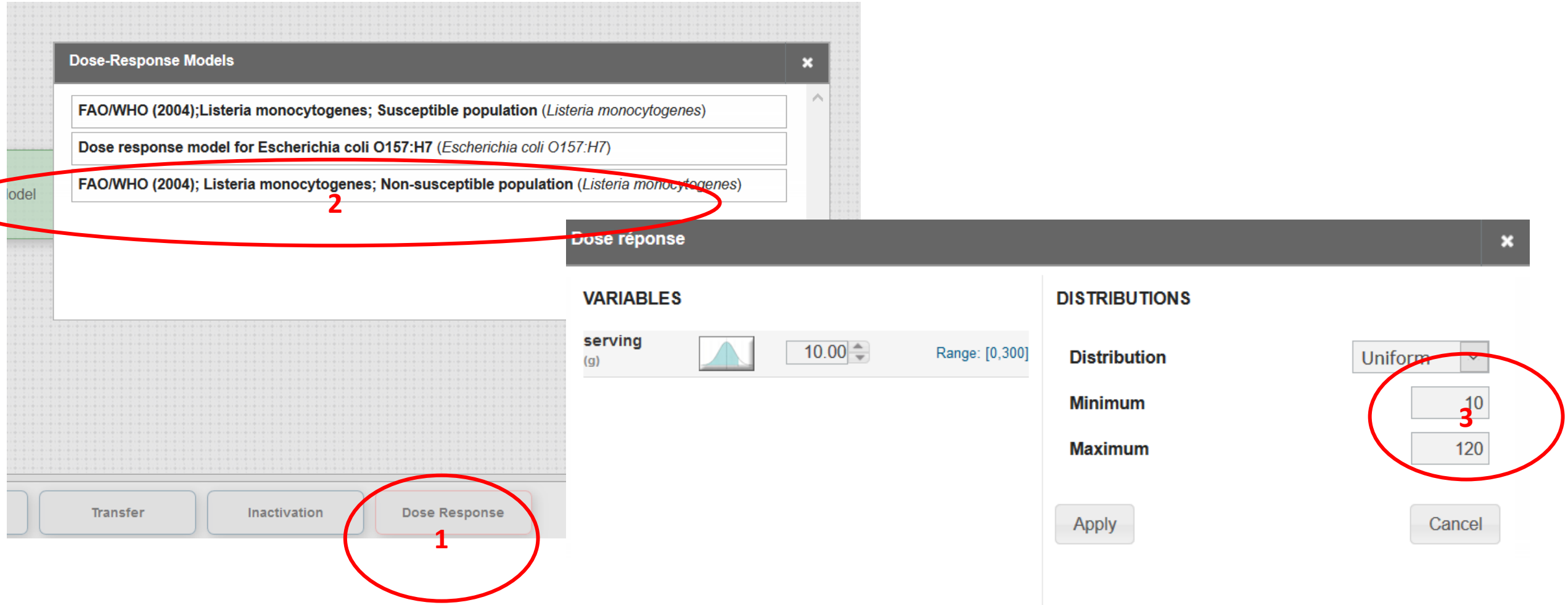


Environmental parameters at each step

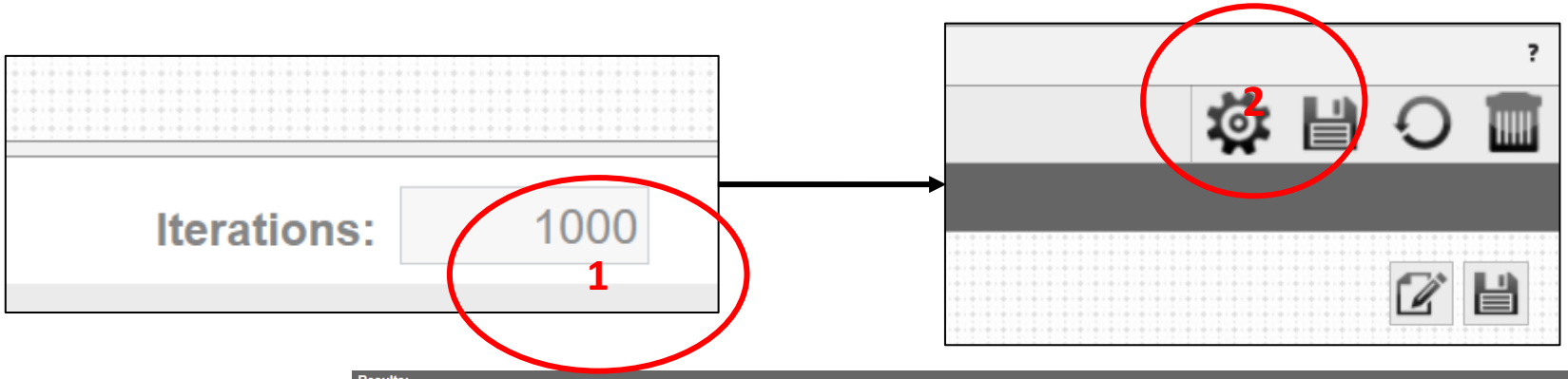
- Durations step (hours):
  - Retail: max = 729 / min = 24 / Mean = 462 **-> TRIANGULAR**
  - Transport: max = 4 / min = 0,5 **-> UNIFORM**
  - Consumption: max = 720 / min = 24 / Mean = 153
- Temperature step (°C)
  - Retail : max = 23 / min = 0 / Mean = 3,54 / SD = 1,72
  - Transport: max = 9,5 / min = 4 / Mean = 7
  - Consumption : max = 17 / min = 0 / Mean = 7 / SD = 2,7 **-> NORMAL**



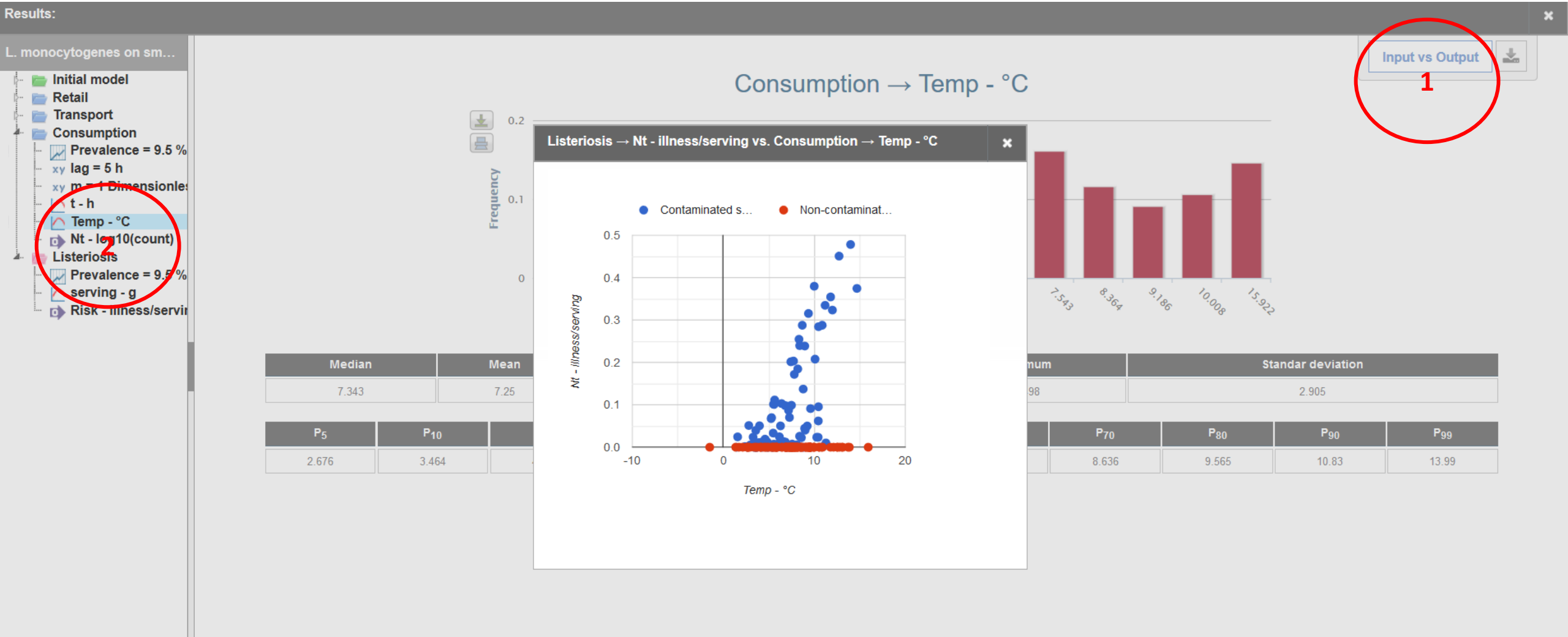
Modèle dose réponse



Launching simulations / model outputs



Entrées vs sorties



Case study : *Listeria monocytogenes* in sausages

Perez-Rodriguez et al. (2017) cooked meat and sausage

Initial contamination

Input variable	Description	Distribution/ model/value	Unit
N_0	Initial concentration	Normal (1.05, 0.44)	Log_{10} CFU/g
P	Prevalence	7.5	%
W	Sausage weight	100	Grams

First storage

At the end of the first storage; in average the mean concentration increase of 0,43 log ufc/g

Second storage

Input variable	Description	Distribution/ model/value	Unit
t_{st}	Storage at the factory duration	Uniform (0, 36)	h
T_{st}	Storage temperature at the factory	5	°C

Retail

Input variable	Description	Distribution/ model/value	Unit
t_R	Storage time at retailing	Uniform (2, 6)	h
T_R	Temperature at retailing	Normal distribution (3.7, 1.78)	°C

Transport

Input variable	Description	Distribution/ model/value	Unit
t_{TR}	Transport to home time	Uniform (0.25, 2)	h
T_{TR}	Transport to home temperature	Triangular distribution (10; 4; 25)	°C

Conservation

Input variable	Description	Distribution/ model/value	Unit
t_H	Household storage time	Normal (103,2, 62,4)	h
T_H	Household temperature	Normal (6.62, 2.56)	°C

Consumption

Input variable	Description	Distribution/ model/value	Unit
S_z	Serving size	Normal distribution (50, 5)	Grams

Dose Response model

Equation:

1−exp(−r × pow (10, dose) × serving)

Questions

- What is the distribution of the risque of listeriosis by portion (median, minimum, maximum) with 1000 iterations ? For sensitive population ? For population > 65 years old?

- If the temperature varies between 0°C et 3°C during transport between retailing and consumer home, what is the impact on the risk of listeriosis?