Elicitation for food microbial risk assessment: a probabilistic approach extending Risk Ranger proposal

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Outline of the presentation

A. Introduction
- Risk assessment
- Need for decision support tools

B. Risk ranger
- Questions (inputs)
- Risk estimates (ouputs)
- Applications and limits

C. The Probabilistic Risk Ranger
- From a unique value to a distribution of values
- The Excel worksheet of Probabilistic Risk Ranger: an interactive tool

A. Introduction

The four step of risk assessment

1. Hazard identification
2. Hazard characterization
3. Exposure assessment
4. Risk assessment

Possible outputs of the risk assessment

"Absolute" estimates for a micro-organism present in a specific food

- Population level: Number of cases of illness per year per population (e.g. 100.000 persons)

- Consumer level: Probability of illness per serving

"Relative" estimates

-Risk reduction for different control measures

- For a given pathogen classification of different food according to (e.g. *L. monocytogenes* in 23 Ready-to-Eat foods FDA 2003)

Need for decision support tools

Depending on

- The question
- The modeled process
- The availability of data
- The delay of response

“Complex”

- using e.g. Monte Carlo simulation, Bayesian inference

→ **“Complex” is not always appropriate**

“Simple” tool to fit some risk managers questions

- Existing tools : RIVM swift QMRA-tool, FDA (P^3ARRT), ACFSE **Risk Ranger**

B. Risk Ranger (RR)

Risk ranger

Ross & Sumner present their tool as:

- a simple calculation tool intended as an aid to determining relative risks from different product, pathogen and processing combinations
- a simple and quick means to develop a first estimate of risk
- a generic but robust model that uses information about all elements of food safety to make risk calculations.
- an help to focus on the factors that contribute to foodborne disease
- a way to explore the effect of different risk-reduction strategies

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A simple, spreadsheet-based, food safety risk assessment tool

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Received 21 June 2001; received in revised form 13 November 2001; accepted 18 January 2002

Risk ranger – 11 questions (inputs)

1. Hazard severity
2. Susceptibility of target population
3. Frequency of consumption
4. Proportion of population consuming the product
5. Size of the population
6. Probability of contamination of raw product per serving
7. Effect of processing
8. Potential for recontamination after processing
9. Effectiveness of the post-processing control system
10. Increase in the post-processing contamination level that would cause infection or intoxication to the average consumer
11. Effect of preparation

A. SUSCEPTIBILITY AND SEVERITY

1 Hazard Severity

- SEVERE hazard - causes death to most victims
- MODERATE hazard - requires medical intervention in most cases
- MILD hazard - sometimes requires medical attention
- MINOR hazard - patient rarely seeks medical attention

2 How susceptible is the population of interest ?

- GENERAL - all members of the population
- SLIGHT - e.g., infants, aged
- VERY - e.g.,neonates, very young, diabetes, cancer, alcoholic etc
- EXTREME - e.g., AIDS, transplants recipients, etc.

B. PROBABILITY OF EXPOSURE TO FOOD

3 Frequency of Consumption

- daily
- weekly
- monthly
- a few times per year
- OTHER

If "OTHER" enter "number of days between a 100g 10

4 Proportion of Population Consuming the Product

- all (100%)
- most (75%)
- some (25%)
- very few (5%)

5 Size of Consuming Population

- Australia
- ACT
- New South Wales
- Northern Territory
- Queensland
- South Australia
- Tasmania
- Victoria
- Western Australia
- OTHER

Population considered: 116 521 267

If "OTHER" please specify: 116 521 267

C. PROBABILITY OF FOOD CONTAINING AN INFECTIOUS DOSE

6 Probablity of Contamination of Raw Product per Serving

- Rare (1 in a 1000)
- Infrequent (1 per cent)
- Sometimes (10 per cent)
- Common (50 per cent)
- All (100 per cent)
- OTHER

If "OTHER" enter a percentage value between 0 (none) and 100 2,0000%

7 Effect of Processing

- The process RELIABLY ELIMINATES hazards
- The process USUALLY (99% of cases) ELIMINATES hazards
- The process SLIGHTLY (50% of cases) REDUCES hazards
- The process has NO EFFECT on the hazards
- The process INCREASES (10 x) the hazards
- The process GREATLY INCREASES (1000 x) the hazards
- OTHER

indicates the extent of risk increase 1,00E-03

8 Is there potential for recontamination after processing ?

- NO
- YES - minor (1% frequency)
- YES - major (50% frequency)
- OTHER

If "OTHER" enter a percentage value between 0 (none) and 100 7,60%

9 How effective is the post-processing control system?

- WELL CONTROLLED - reliable, effective, systems in place (no increase in
- CONTROLLED - mostly reliable systems in place (3-fold increase)
- NOT CONTROLLED - no systems, untrained staff (10 -fold increase)
- GROSS ABUSE OCCURS - (e.g.1000-fold increase)
- NOT RELEVANT - level of risk agent does not change

10 What increase in the post-procssing contamination level would cause infection or intoxication to the average consumer?

- none
- slight (10 fold increase)
- moderate (100-fold increase)
- significant (10,000-fold increase)
- OTHER

If "other", what is the increase (multiplic-ative) needed to reach an infectious dose ? 5,E+01

11 Effect of preparation before eating

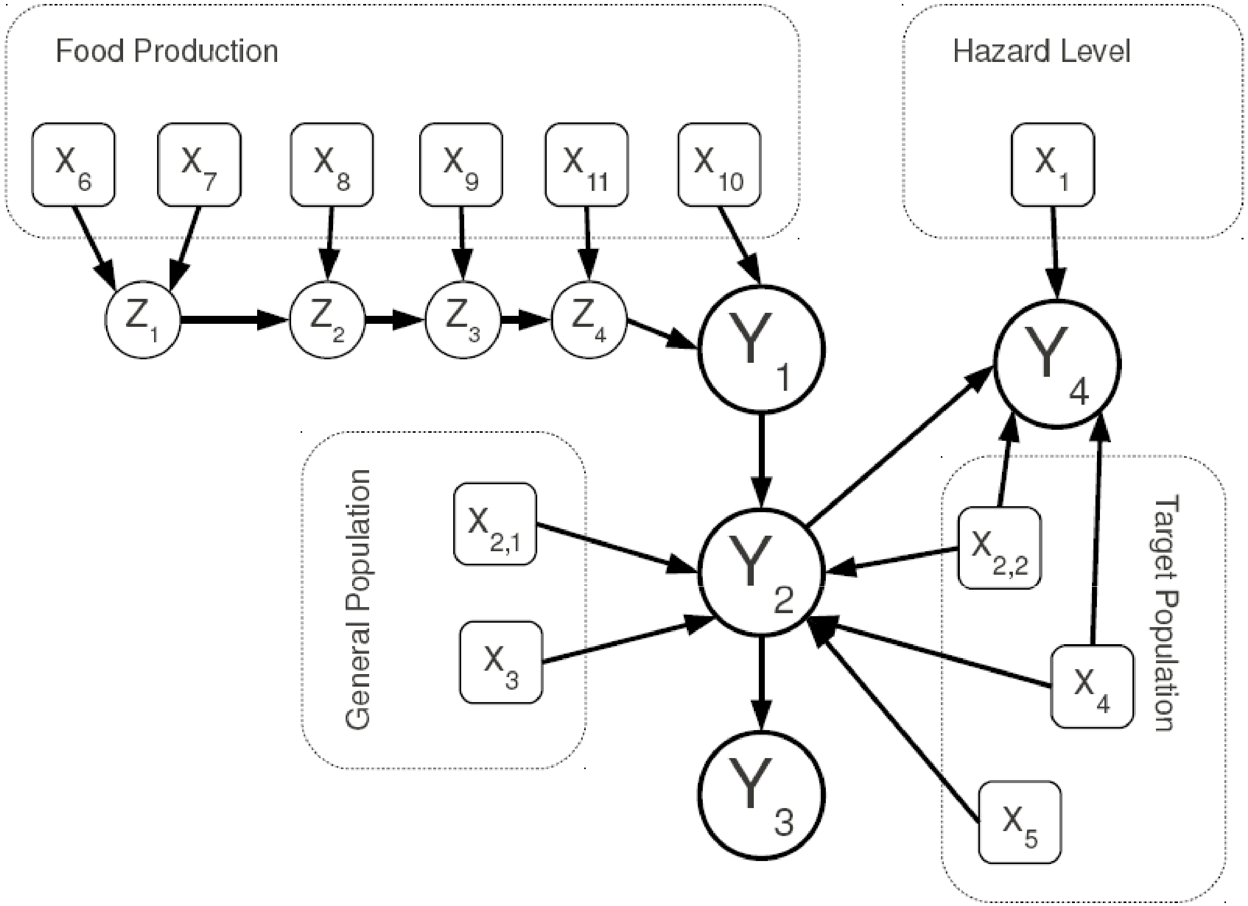
- Meal Preparation RELIABLY ELIMINATES hazards
- Meal Preparation USUALLY ELIMINATES (99%) hazards
- Meal Preparation SLIGHTLY REDUCES (50%) hazards
- Meal Preparation has NO EFFECT on the hazards
- OTHER

If "other", enter a value that indicates the extent of risk increase 1,00E-01

RISK ESTIMATES

probability of illness per day per consumer of interest *(Pinf x Pexp)*	2,50E-05
total predicted illnesses/annum in population of interest	5,31E+04
RISK RANKING (0 to 100)	**49**

Risk Ranger – 11 inputs for 4 outputs



$Y_1 = min(1, \max(X_6 X_{7,} X_8) \times X_9 X_{10} X_{11})$
$Y_2 = min(1, Y_1 X_{2,1} X_3)$
$\mathrm{Y}_3 = 365 \times Y_2 X_{2,2} X_4 X_5$
$\mathrm{Y}_3 = 100 + \log_{10}(Y_2 X_{2,2} X_4 X_1)/17.56$

Risk ranger – 3 main outputs

RISK ESTIMATES		
probability of illness per day per consumer of interest (*Pinf* x *Pexp*)	9.86E-08	Y_2
total predicted illnesses/annum in population of interest	1.08E+04	Y_3
RISK RANKING (0 to 100)	60	

Y_4 : scale 0-100

0: 1 case per 10 billion people per century

100: every member of the population eats a meal that contains a lethal dose of the hazard every day

The scale is logarithmic: an increment of six in the rating corresponds to ~10-fold increase in risk

Risk Rangers users

Sumner & Ross 2002 (seafood)

FAO/WHO 2004 (fish products)

AECL 2005 (Eggs and egg products)

Pointon et al. 2006 (Meat)

Mataragas et al. 2008 (Poultry and porks products)

Perni et al. 2009 (steam meals)

Tian & Liu 2009 (ready-to-eat foods)

Afssa 2010; Guillier et al. 2011 (fish products)

Sosa Mejia et al 2011 (steam meals)

Risk Ranger - Advantages and drawbacks

Advantages:

- Lets consider all the factors of food production (processing, distribution, and preparation)
- Incorporates the principles of risk assessment
- Easy to use (Excel, dropdown menus, ...)

Drawbacks:

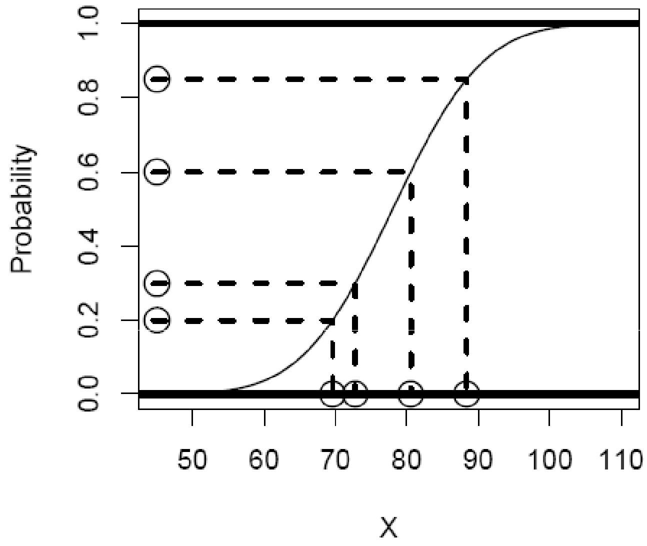
- Simplification (dose response, sources of contamination ...)
- “Arbitrary“ weighting factors (severity, sensitivity)
- Interpretation by the expert of some questions
- **How does the expert answer to questions**?
  - Most probable values given?
  - Worst case scenarios?

C. The Probabilistic Risk Ranger (PRR)

Introducing randomness in the ancestor (input) nodes

Assessing variability on X:

How many quantiles?



What distribution?

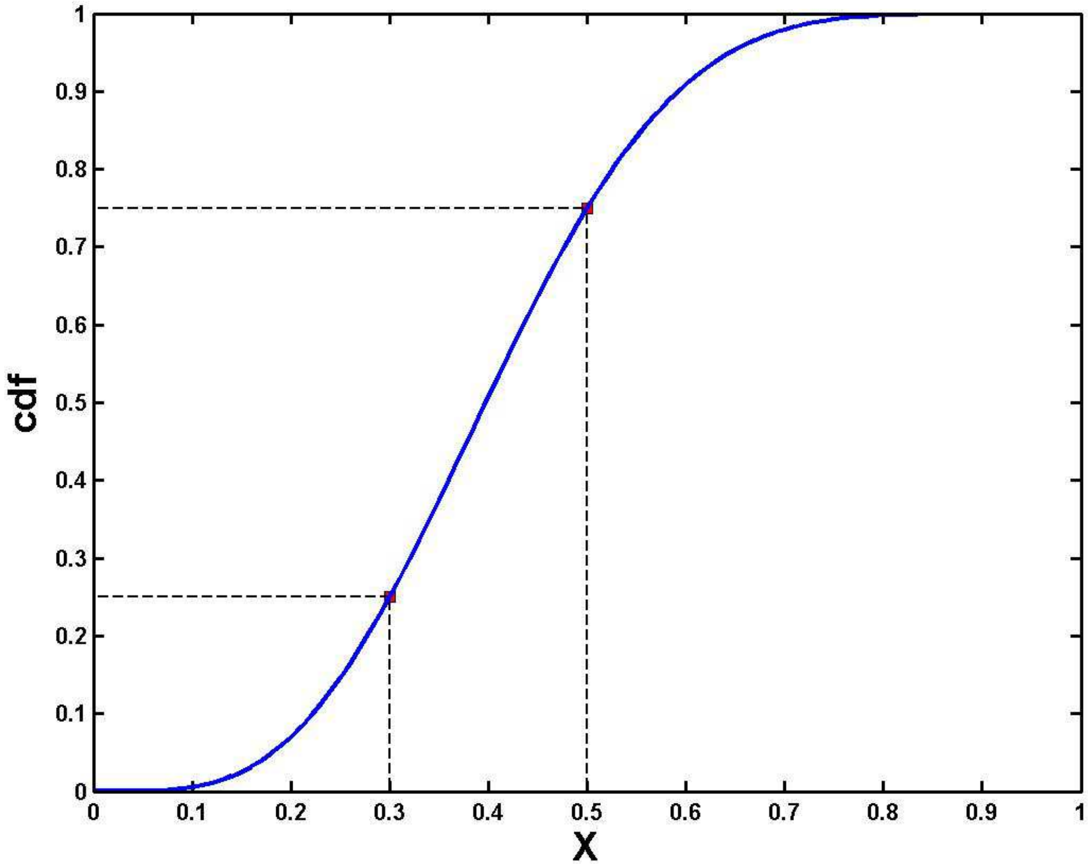
- Normal
- Triangular
- Beta
- …

Introducing variability in the ancestor (input) nodes

Assessing variability on X with beta distribution and two elicited quantiles (q_l and q_u):

- For two probabiliy levels (α_l=0.25 and α_u=0.75)

- Using numerical procedure of van Dorp & Mazzuchi (2000) for estimating Beta parameters



Introducing uncertainty in the ancestor (input) nodes

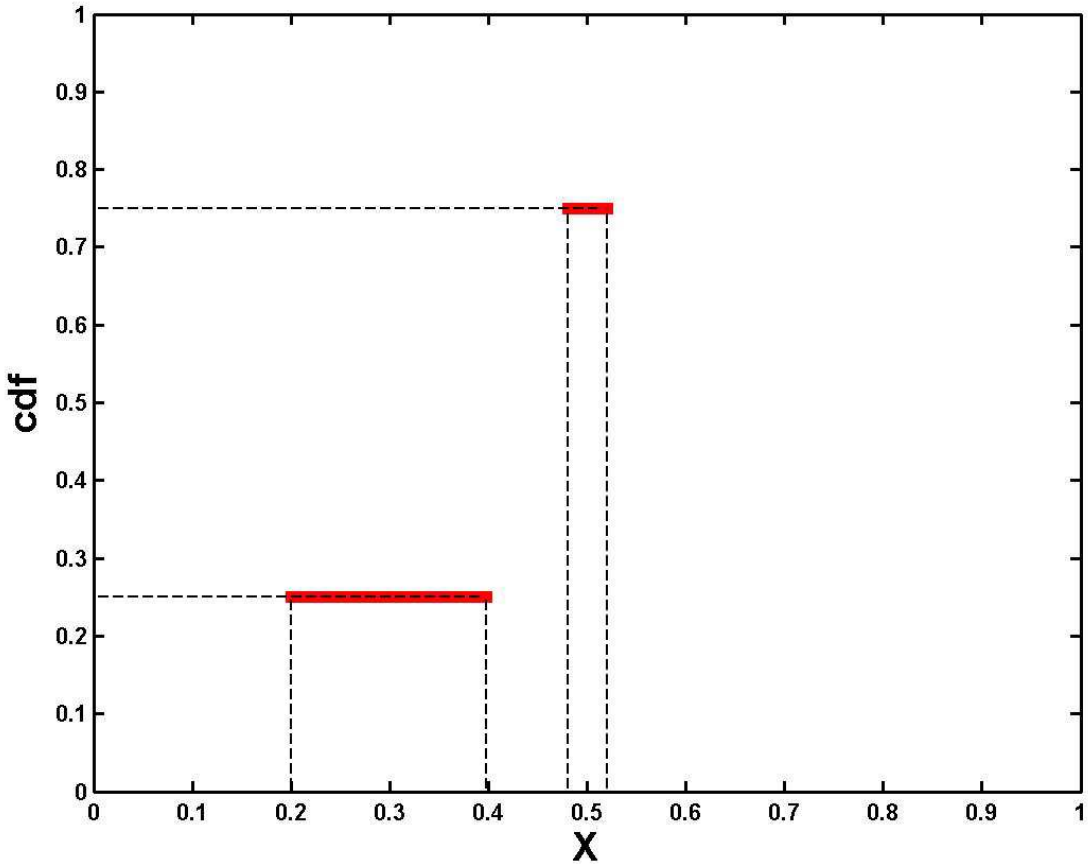
Is the expert confident in both quantiles he gave (q_l and q_u)?

- d_l, d_u associated degrees of confidence of the user in her/his assessment about the variability quantiles (q_l, and q_u)

- d_l, d_u can vary from

1 (poor confidence)

10 (perfect confidence)



Introducing uncertainty in the ancestor (input) nodes

When d_l or d_u < 10 (not perfect knowledge), then q_l and q_u are described by Uniform distributions

- $q_l \sim Unif(Q_{l1}, Q_{l2})$ and $q_u \sim Unif(Q_{u1}, Q_{u2})$

$$Q_{l1} = q_l - (1-d_l/10) \cdot (q_l - X_{min}) \text{ and } Q_{l2} = q_l + (1-d_l/10) \cdot (q_m - q_l)$$

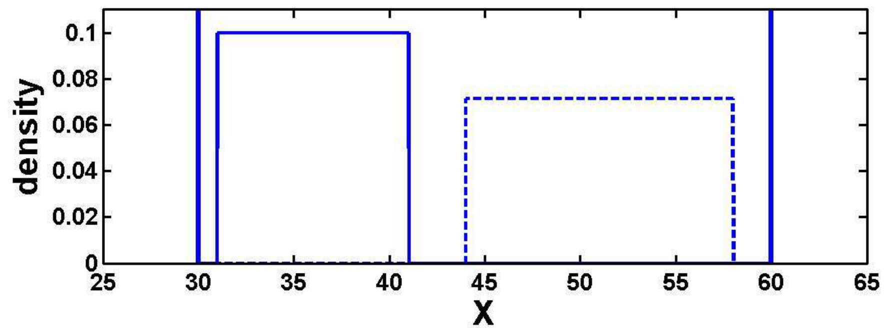
$$Q_{u1} = q_u - (1-d_u/10) \cdot (q_u - q_o) \text{ and } Q_{u2} = q_u + (1-d_u/10) \cdot (X_{max} - q_u)$$

$$\text{with } q_o = (q_u + q_l)/2$$

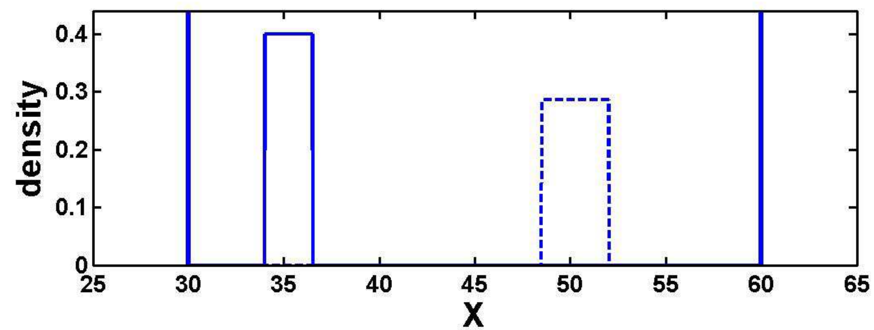
- Example: X defined on [30 60]

q_l=35 q_u=50

d_l=d_u=2

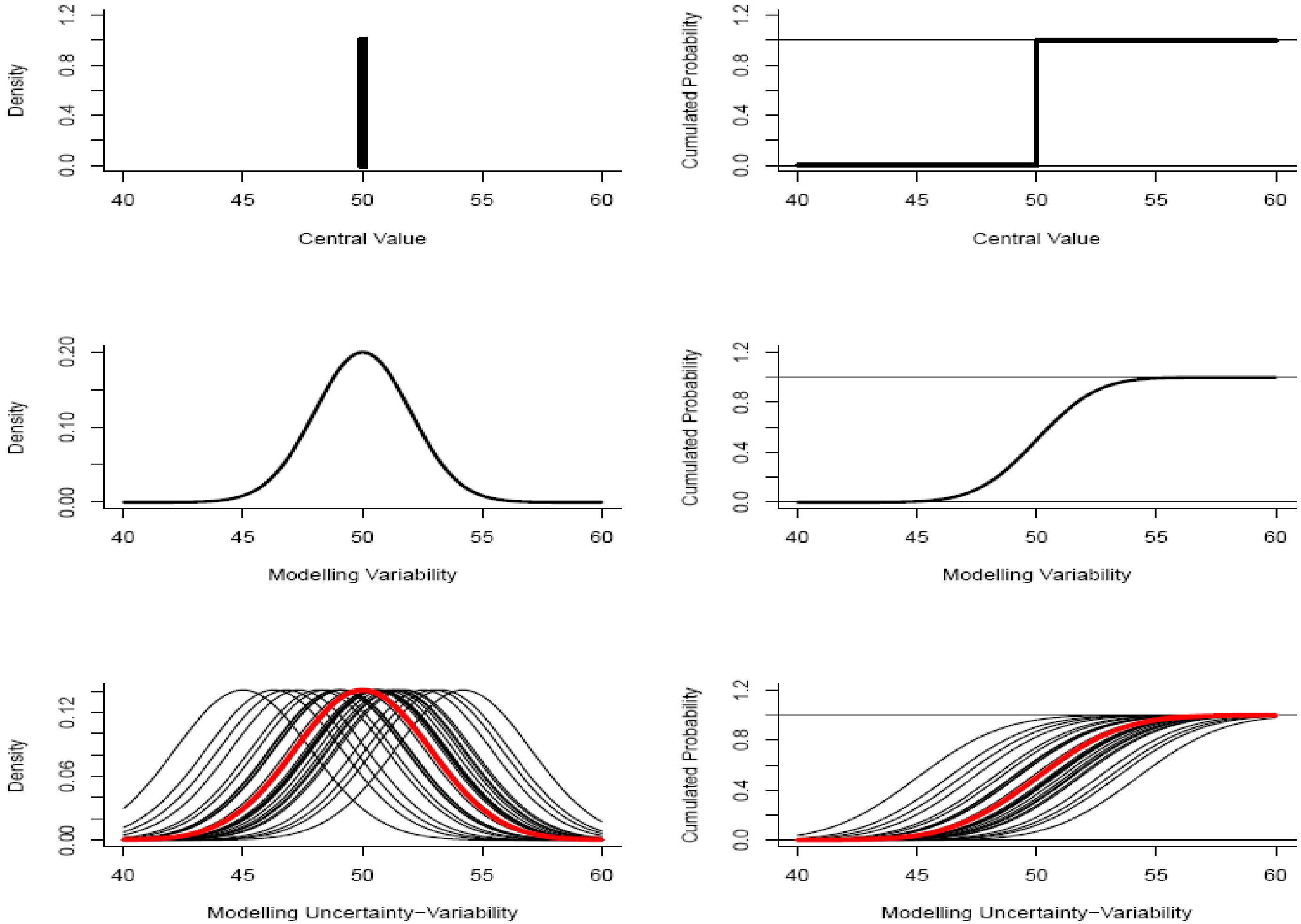


d_l=d_u=8



Introducing randomness in the ancestor (input) nodes

So, we move from deterministic to stochastic (variability and uncertainty) inputs



anses

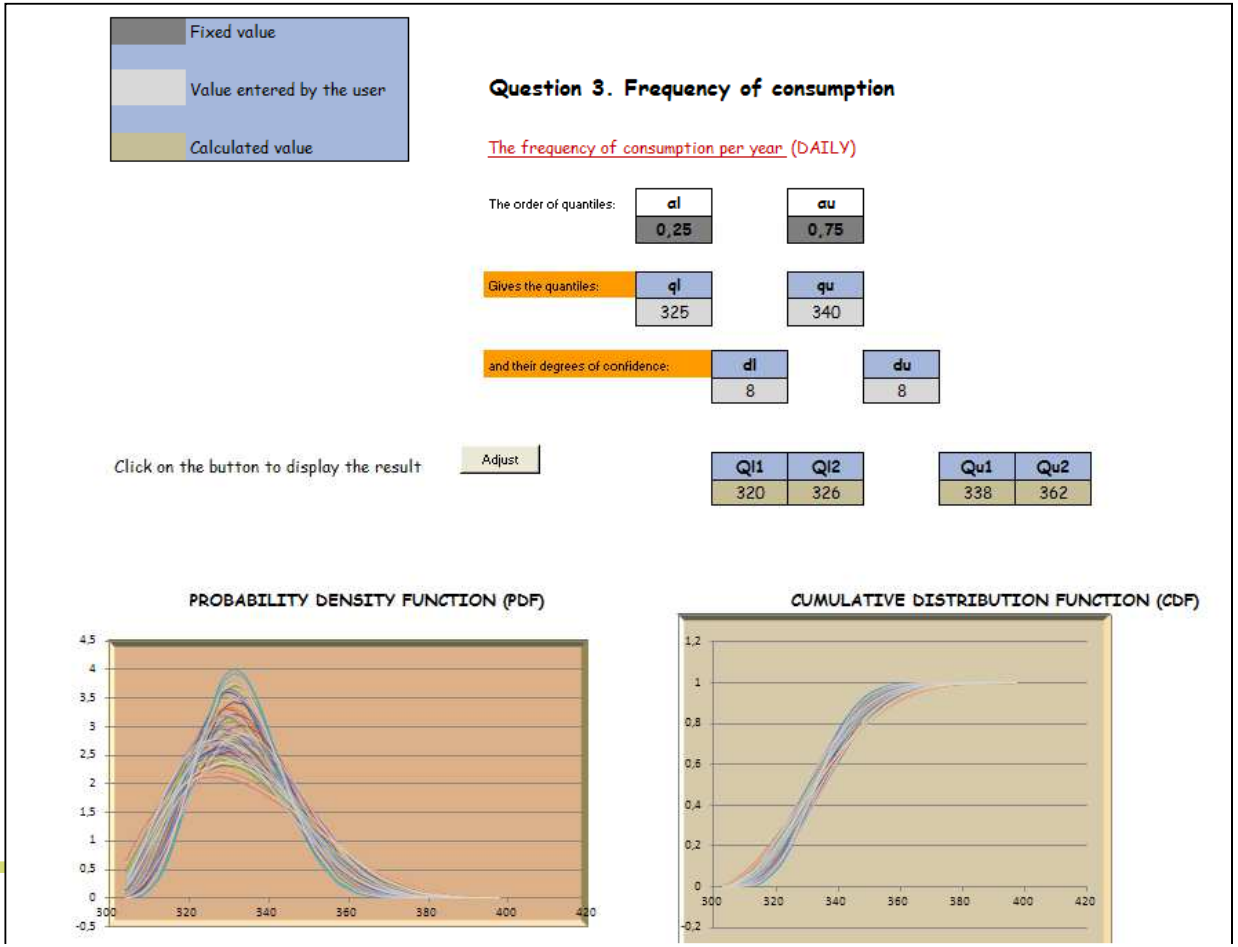
The Excel worksheet of Probabilistic Risk Ranger: an interactive tool

Large use of Risk Ranger = **implementation in Excel**

Important to keep Excel for Probabilistic Risk Ranger

Advantage: the expert can check graphically (almost instantly), the uncertainty and variability of the elicited variable

The expert can then interactively modify it according to the **consistency** between his/her opinion and that he/she sees on the graphs



The Excel worksheet of Probabilistic Risk Ranger: Y4 output

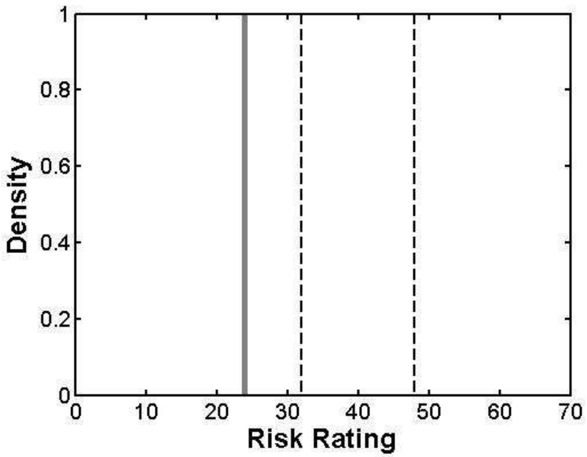
Monte Carlo simulation (two dimensions) for calculation of outputs

Examples of PRR output: here Risk Rating (Y_4)

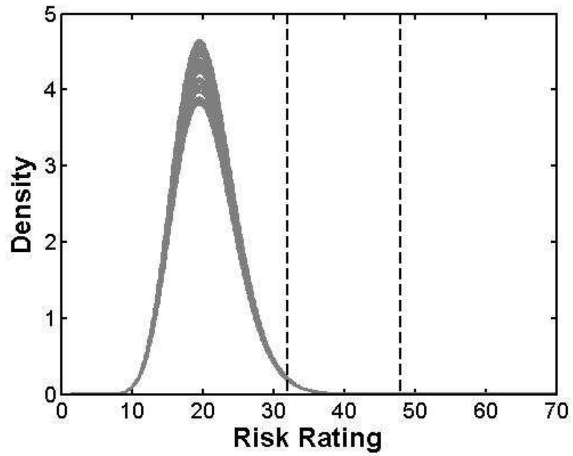
Ross and Sumner assumed **food/hazard combination**:

- <32=minor
- >48=major

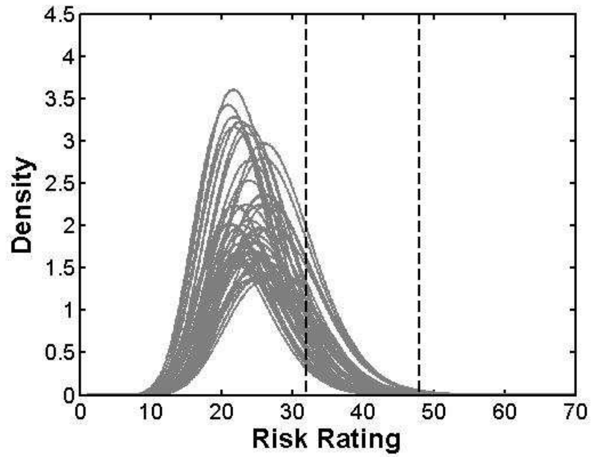
Risk Ranger (deterministic)



PRR (high variability low uncertainty)



PRR (high variability high uncertainty)



Conclusion

PRR remains an easy to use decision support tool (food microbiologist experts)

Visualization of the consequences of values elicited almost immediate : self correction / adjustment

Feedback from first food microbiologist users:

- **Too many levels for degree of confidence (3 levels “not confident”, “quite confident”, “confident” ?)**
- **Let the expert choose probability (now: 0.25 and 0.75; experts would prefer 0.5 and extreme quantiles)**
- **Maybe too long (because of MC2D, solution? P-Box)**

First try planned for pork products on several experts

Thank you for your attention

Thanks to:

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anses