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## Risks of false decisions on conformity of a sausage with a mass balance constraint

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**Abstract.** A technique for evaluation of risks in a sausage conformity assessment is developed. Measurement uncertainty, correlation and mass balance constraint are considered. A multivariate Bayesian approach and a Monte Carlo method are applied. Risks in assessment of sausage "Braunschweigskaia" are evaluated as a case study. R code for the risk evaluation is provided as electronic supplementary material.

A multivariate Bayesian approach, taking into account measurement uncertainty, correlation and mass balance constraint of the regulated contents of sausage components, was applied for evaluation of risks of false decisions on conformity of a sausage chemical composition [1, 2].

A dataset of measured contents of fat, protein, moisture and salt, regulated in sausage "Braunschweigskaia", was used for the risks evaluations as a case study. There were data on chemical composition of 83 batches of the sausage, produced in Russia according to standardized technical conditions (GOST 55456-2013) during about three years at two similar factories. Each factory tested a sausage batch at its laboratory for conformity assessment to the standard GOST 9792-73 before the product is placed on the market. Analysis of variance (ANOVA) of the dataset showed insignificance of the difference in the contents of the sausage components between the two factories during the three years of the production, indicating that the technological process was well standardized and stable.

The marginal distributions of contents of fat, protein, moisture and salt were approximated by normal probability density functions (pdfs). However, since these components contents were limited by the mass balance constraint, the prior multivariate distribution describing the dataset was numerically simulated starting from a multivariate truncated normal pdf on the  $[0\%, 100\%]^4$  domain and the subsequent closure of the sum of the generated contents to 100 %. The observed correlations and the spurious one, caused by the mass balance, were taken into account in the prior multivariate model. Distribution of the measured values was modelled by a multivariate truncated normal likelihood function taking into account associated measurement uncertainties, and therefore the closure operation did not apply here.

Based on Monte Carlo simulations of the product of the prior pdf and the likelihood function, a total global consumer's risk of 0.006 and a total global producer's risk of 0.017, characterizing the production process in general, were evaluated. The difference in the risk values indicated a clear preference of the consumer's interests over the producer's interests. The total specific consumer's and producer's risks, related to a specific sausage batch, were evaluated using normal approximations in the Bayesian model. The obtained risk values were much more significant when measured contents approached their tolerance/specification limits set in the standard GOST 55456-2013 or exceeded them.



**References**

- [1] Pennecchi FR, Di Rocco A, Kuselman I, Hibbert DB, Sega M 2020 *Measurement* **163** 107947
- [2] Pennecchi FR, Kuselman I, Di Rocco A, Hibbert DB, Semenova AA 2021 *Food Control* **125** 107949