Design of experiments: concepts, applications and examples in the food industry

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The main goal in food processing and production is to find a compromise between maintaining key quality characteristics and increasing system performance without increasing production costs and time. Determining the optimal nutritional and functional properties, processing conditions and combination of ingredients can be achieved using design of experiments concepts. Experimental design is a statistical approach in which mathematical relationships can be established between dependent (responses) and independent (factors) variables that influence system characteristics. In experimental design, all investigated (independent) parameters are varied simultaneously and the mathematical models created are usually validated using analysis of variance. The two main applications of experimental design are screening and optimization. This concept of experimental design enables to determine how individual factors and relationships between variables influence the tested responses. The choice of experimental design depends primarily on the objectives of the experiment and the number of investigated parameters. The usual approach is to start with a screening design in order to select which variables are significant and at which levels. For this purpose, a full factorial, a fractional factorial or a Plackett-Burman experimental design can be used. After the initial screening experiments, further investigation must be carried out in which the most important factors are further optimized. Multivariate statistical methods are employed in this context, with central composite design and Box-Behnken as part of the response surface methodology being the most common used. In food analysis and processing, optimal conditions need to determined by optimizing a number of responses simultaneously, and the most commonly used methods are the Derringer desirability function and mixture design. There are many examples of the application of experimental design methodology in food analysis and processing. Examples of the drying process, the preparation of edible packaging and the preparation of functional products based on milk proteins and mushroom extracts will be presented here.