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OPTIMIZATION USING RESPONSE SURFACE METHOD IN TEMPERATURE AND PH OF A FOOD SUPPLY CHAIN

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ABSTRACT

To develop a framework for automated optimization of stochastic simulation models using Response Surface Methodology. The framework is especially intended for simulation models where the calculation of the corresponding stochastic response function is very expensive or time-consuming. One of the most challenging tasks in today's food industry is controlling the product quality throughout the food supply chain. In this paper, we integrate food quality in decision-making on production and distribution in a food supply chain. We provide a methodology to model food quality degradation in such a way that it can be integrated in a Response surface model used for production and distribution planning. The resulting model is applied in an illustrative case study, and can be used to design and operate food distribution systems, using both food quality and cost criteria.

KEYWORDS: Response Surface Method & Food Supply Chain

INTRODUCTION

Optimization is the choice of a best alternative from a specified set of alternatives. As reported by Evans (1982), Aris (1964) defines the optimization as, ‘‘getting the best you can out of a given situation.’’ Optimization opens up the possibility of achieving the best case among the possible alternatives (Evans, 1982). Achieving optimization, therefore, requires some way of describing the potential alternatives and deciding to choose the best alternative (Norback, 1980; Evans, 1982). The continuous optimization problems are reported to be difficult to solve due to the possible nonlinear and distributed nature of the system dynamics and presence of explicit and implicit constraints on both control variable and objective function (Banga et al., 2001). There have been numerous methodologies recommended for this problem in the literature (Erdo_gdu and Balaban, 2003).

Response surface methodology (RSM) is a collection of mathematical and statistical techniques for empirical model building. By careful design of *experiments*, the objective is to optimize a *response* (output variable) which is influenced by several *independent variables* (input variables). An experiment is a series of tests, called *runs*, in which changes are made in the input variables in order to identify the reasons for changes in the output response. Originally, RSM was developed to model experimental responses (Box and Draper, 1987), and then migrated into the modeling of numerical experiments. The difference is in the type of error generated by the response. In physical experiments, inaccuracy can be due, for example, to measurement errors while, in computer experiments, numerical noise is a result of incomplete convergence of iterative processes, round-off errors or the discrete representation of continuous physical phenomena (Giunta et al., 1996; van Campen et al., 1990, Toropov et al., 1996). In RSM, the errors are assumed to be random.

LITERATURE REVIEW

RSM has been very popular as a tool for optimization study in food engineering in recent years. This method was successfully employed for applications in developing probiotic candies, with maximum viability using the multi start SQP (Chen et al.,2008), in optimizing the pistachio nut roasting process (Kahyaoglu, 2008), in maximizing the thermo tolerance of *Bifido bacterium bifidum*gellan-alginate micro particles (Chen et al., 2007), in search for the maximum cell immobilization conditions, for the production of palatinose (Mundra et al., 2007), in finding the optimum formulation of cassava cake (Gan et al., 2007), in optimizing the extraction process of crude polysaccharides from boat-fruited sterculia seeds (Wu et al., 2007), in finding the optimal combination of the coating materials for probiotic microcapsules (Chen et al., 2006), in obtaining the optimal manufacturing conditions of dairy tofu (Chen et al., 2005), in maximizing the viability of probiotics in a new fermented milk drink using genetic algorithms (Chen et al., 2003), in developing new edible gels with fibrinogen plasma protein (Chen and Lin, 2002), and in finding the optimum producing conditions of the dairy product Kou Woan Lao (Weng et al.,2001). A recent review paper (Bas¸ and Boyaci, 2007) discussed the applications and limitations of RSM.

METHODOLOGY

There are number of minimizing variability. A reduction in variability can mean Minimization of dispersion in product temperature and Minimization of dispersion in product quality levels or any combination of these. The constraints on the optimization can be the requirement to achieve certain values for mean (or minimum) levels of product temperature or safety or quality at the end of the process. This focuses on two specific systems. Both approaches illustrate how them selection of the process temperature can be influential in controlling the level of product dispersion. In food manufacturing, using a time invariant process temperature, a choice is available between using high process temperatures that give a short process duration or lower process temperatures that require a longer time to achieve the process end point.

Optimization to Minimize Temperature Dispersion

The first approach under consideration is selection of process temperature to minimize the dispersion in product temperature at the end of the process. The constraint on the system arises from the fact that the initial temperature of the (average) product, mTi is fixed by the prior processing or storage environment. The final temperature of the (average) product, mTf (the temperature that the product must achieve at the end of the process) is set by specific product end-user requirements. The duration of the process, tp (the elapsed time in which mTi must be changed to mTf) can be adjusted. In summary, the objective of the thermal process is to take the average product and convert its temperature, from mTi to mTf in some tp. Once, the initial product temperature mTi and required final product temperature, mT fare was given or known (and the product thermal rate constant, b can be quantified), then using the simple RSM model, the process time tp is obtained.

Optimization to Minimize Quality Dispersion (Including Ph)

The second approach h aims to minimize the dispersion in product quality at the end of the process. For this case, the only dispersion in the system is in the thermal diffusivity, a or thermal rate constant, b of the product (there is assumed to be no dispersion in initial product temperature or process temperature). This method can use either the Fourier temperature model, the simple thermal model is employed to illustrate the behavior of the system while the calculations of the case study are based on the RSM model.

RESULTS AND DISCUSSIONS

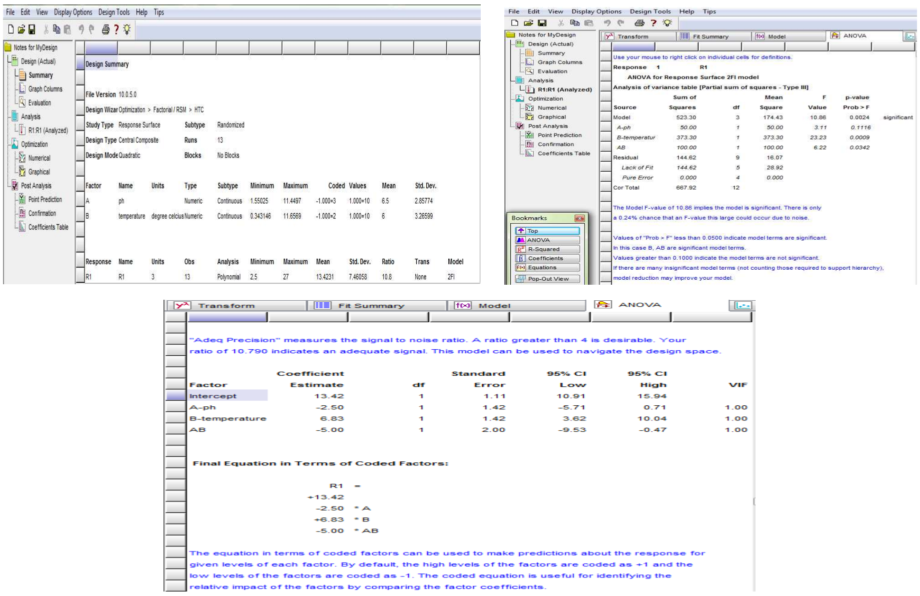

Figure 1: Computer Program for Optimization using Response Surface Method

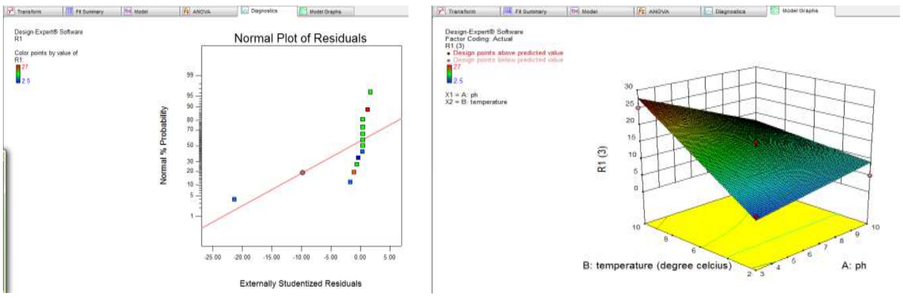

Figure 2: Graphical Representation of the Optimized Model on Temperature and Ph

From the optimization method it was found out that temperature decreases causes the shelf life to increase and the shelf life was increased to 6 days from 2.5 days, with reduction of 1 degree Celsius. Also the ph is reduced as the shelf life of produce increases.

CONCLUSIONS

From analysis of the literature, it can be concluded that a global management of the production process in the food processing industry is generally seen to be of great interest. Global management could be adequately developed from two independent but interconnected systems. Increase in shelf life causes more demand for the product, which can in term reduce cost and quality loss.

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