Prof. Pierantonio Facco

May 21st, 2025

HOMEWORK #2

This is an **individual homework**.
Students **MUST complete the homework in a totally independent manner**.

Objective: *optimization* in food processing manufacturing.

Problem: the food multinational PigmentOne Inc. commercializes food pigments extracted from fruits. The PigmentOne R&D manager would like to understand the optimal conditions to run a process of aqueous extraction of betacyanin and betaxanthin from prickly pear, in such a way as to maximize the extraction of betacyanin and betaxanthin. In particular, the factors of the extraction process considered in the experimental campaign are: temperature [°C] x_1, time [min] x_2, and mass [g] of the fed fruit x_3.

Table 1. *Plan of the experimental design in terms of temperature, time and mass of fruit and responses (extracted betacyanin and betaxanthin) for the process of pigments recovery from prickly pear through aqueous extraction.*

TEMPERATURE [°C]	TIME [MIN]	MASS [G]	BETACYANIN [MG/100 G]	BETAXANTHIN [MG/100 G]
30	20	1	11.89	18.72
30	70	1.5	12.73	22.35
30	120	1	13.04	21.77
50	120	1	13.22	22.57
40	70	1	12.96	22.5
40	70	1	12.96	22.5
40	120	1.5	13.29	24.27
50	70	1.5	12.76	22
30	70	0.5	11.36	18.85
40	70	1	12.96	22.5
50	20	1	11.86	19.62
40	20	1.5	11.54	20.72
50	70	0.5	11.38	21.05
40	20	0.5	11.06	20.02
40	70	1	12.96	22.5
40	120	0.5	11.37	21.47
40	70	1	12.96	22.5

Data from the experimental campaign are available in Table 1 and in the provided file `dataset.mat`: factors are collected in the `X` matrix (and in `Xc` in coded terms), while the corresponding responses are in the `Y` matrix.

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QUESTIONS: solve the problem using Matlab® and Minitab®.

1. What type of design was planned and carried out in PigmentOne?
2. Build the main effect plot and comment on it.
3. Build the interaction plot and comment on it.
4. Build a response surface model:
    a. estimate the regression model and comment on its structure, considering the parameters uncertainty (provide the parameters values in vector `b` of a Matlab® file `surname_homework2.mat` and the parameters' uncertainty in `b_unc`);
    b. discuss the outcome (in terms of regression parameters) considering what were the results of both the main effect plot and the interaction plot;
    c. comment on model fitting and adequacy (provide the coefficient of determination `R2` and the vector `r` of the residuals);
    d. refine and update the model structure, if needed, and determine the updated values of regression coefficients, uncertainty of the coefficients, R^2, and residuals (provide the parameters in vector `b2`, parameters' uncertainty in `b_unc2`, coefficient of determination `R2_2` and the residuals vector `r2`). Comment on the results;
    e. build the response surface plots adding the experimental points and comment it.
5. Identify the optimal formulation which guarantees that the maximum extraction of betacyanin and betaxanthin in the domain of the coded variable [-1,1].
6. Comment on what are the differences you find in the main effect plots, in the interaction plots, and in the response surface models built with Matlab® and Minitab®.
7. Comment on what are the differences you find in the optimal points found with Matlab® and Minitab®.

Deadline:

- 1 week before the final exam.

Deliverables:

- send an **email** to both:
  `pierantonio.facco@unipd.it`
  and
  `edoardo.tamiazzo@phd.unipd.it`
  with:
    1. the solution of the problem in a file: `surname_homework2.pdf` of **maximum 15 pages** (in Times New Roman, 12 pt, line-spacing 1.5) providing the answers and the necessary figures and tables;
    2. a Matlab® file `surname_homework2.mat` with the required mathematical entities;
    3. a Minitab® file `surname_homework2.mpx` with the required solutions.

Homework evaluation:

- correctness and completeness of the provided solution;
- clearness of the presentation.