# A **process design** to increase the efficiency of **batch oil deodorizers**

Daniela S. Laoretani and Oscar A. Iribarren

- Batch deodorization is used for small production capacities (e.g., 50 to 100 tons/day) of edible oil or, due to its flexibility, in plants where the type of oil to be processed is frequently changed. However, the times required to process a batch are quite long, with high stripping steam consumption per ton of treated oil.

- A processing alternative that strongly improves the efficiency, is to couple the batch deodorizer to a continuous desorption column: The steam exiting the batch deodorizer is fed to the bottom of the column, while the oil contained in the batch vessel is recycled through the top of the column and then returned to the vessel.

- An efficient (and practical) mechanical design is in progress to implement this alternative, in which a small packed column section is placed inside the batch deodorizer vessel, and the oil from the bulk batch holdup is raised to the top of the column section by steam lifting.

## BATCH DEODORIZATION

Batch deodorization treats the oil in a closed container with direct steam injection through a distributor, to strip the undesirable components. This is attractive in several respects: It is easy to design and to operate, has a low investment cost, and is very flexible for product changeovers. However, it also has disadvantages: The times required to process a batch are quite long (e.g., 8 to 12 h, which implies a low productivity) due to poor vapor-liquid contacting efficiency, and the stripping steam consumption per ton of treated oil is high (Gavin, 1981; O'Brien, 2009). At industrial scale, the stripping steam requirement for batch deodorizers is about 2 to 4% of the oil to be treated, whereas continuous and semi-continuous deodorizers need 0.75 to 1.5%, and continuous thin-film systems can operate with as little as 0.3 to 0.6% steam (Carlson, 1996).

## SEMI-BATCH PROCESSING

Laoretani and Iribarren (2017) explored a processing alternative aimed at improving the efficiency of batch deodorizers, coupling them to a small continuous desorption packed column: The steam exiting the batch deodorizer was fed to the bottom of the column, while the oil contained in the batch vessel was recycled through the top of the column and then returned to the vessel. This strongly increased the efficiency of separation, reducing stripping steam consumption and processing time. This processing alternative is depicted in Figure 1, and was assessed through a case study of soybean oil with an initial content of 5% free fatty acids (FFA) to be stripped up to a product specification of 0.05% FFA, at 210°C, and a pressure of 5 mmHg. Batch sizes of 10,000 kg were considered, and a steaming rate of 3 kg/h steam per 100 kg of oil being treated was applied, as recommended by Gavin (1981), to get an appropriate contact between the phases.

The process was optimized using Douglas (1988) "profit" as objective function, which takes into account revenues, labor, operating (stripping steam, heating and cooling utilities, and electricity), and annualized capital (the deodorizer, the column, and a pump) costs. The optimization variables were

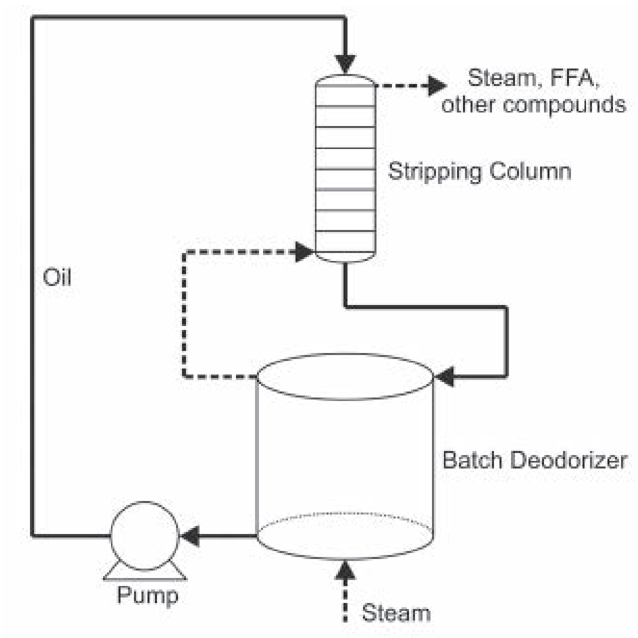


**FIG. 1. Semi-batch process proposed in Laoretani and Iribarren (2017)**

the number of equilibrium stages in the column and the flow rate of oil recycled. To illustrate the effect of the number of stages, Figure 2 depicts depletion of FFA vs. stripping time for 0 (no column at all), 1, 2, 3, 4, and 5 equilibrium stages in the column. It can be seen that just one stage improves the performance of the deodorizer significantly, after which the impact is more modest; the optimal is at about 4 stages.

The optimal semi-batch design reduces the stripping time by about 40% (batch conventional 3 h, semi-batch 1.8 h). This leads to an increase in productivity: The original 1,720 batches per year can be increased to 1,845. The batch deodorizer is the same for both alternatives, with a diameter D = 2.5 m and a height H = 5 m (half full with oil); the semi-batch alternative adds a pump of 1 K Watt, and the desorption column has D = 1 m and a height that can contain 4 equilibrium stages (which, with structured packing, is about 2 m).

## ECONOMIC ASSESSMENT

The capital investment is about 25% larger in the semi-batch; the operating costs also increase (mainly because the number of batches increase) by 10%, but revenues increase 40% (due to a larger production), which leads to a net increased benefit of $75,000/yr with the semi-batch. This processing alternative should be attractive for facilities that have already adopted batch technology, and even more so if the raw material to be deodorized is palm oil or bait, where the initial content of FFA is high. In existing plants where deodorization is a bottleneck, the benefit will be more noticeable. In plants where deodorization is not a bottleneck, semi-batch processing may lead to a reduction of labor costs (reducing the number of shifts required), and in the case of a new plant construction project, the cost impact will be mainly due to a lower size of deodorizers.

## References

Carlson, K.F. (1996). In: Hui, Y.H. (Ed.), Deodorization, Bailey's Industrial Oil & Fat Products, 5th Ed., Vol. 4. Wiley Interscience Pub., New York, p. 363 (Chapter 6).

Douglas, J.M. (1988). Conceptual Design of Chemical Processes. McGraw Hill, New York.

Gavin, A.M. (1981). Deodorization and finished oil handling, *J. Am. Oil Chem. Soc. 58*: 175–184.

Laoretani, D.S. and O.A. Iribarren (2017). Enhancing the productivity of batch deodorizers for edible oils, *J. Food Eng. 192*: 72–78.

O'Brien, R.D. (2009). Fats and Oils: Formulating and Processing for Applications, 3d Ed. CRC Press, Florida, pp. 160–162.

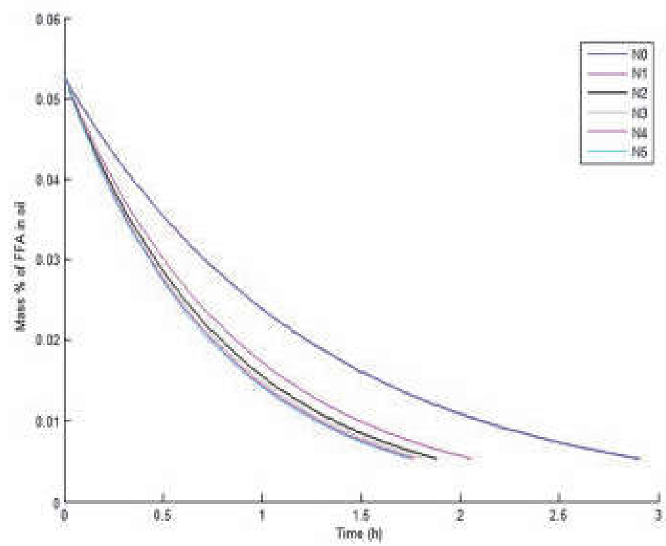


**FIG. 2. Content of free fatty acid (FFA) in oil as a function of deodorization time**

*Daniela S. Laoretani has a Ph.D. in Industrial Engineering from Universidad Tecnológica Nacional–Santa Fe, Argentina. Laoretani holds a postdoctoral position at CONICET, where her area of interest is process design and integration in the agroindustrial supply chain. She can be contacted at danielalaoretani@hotmail.com.*

*Oscar A. Iribarren has a Ph.D. in Chemical Engineering from the University of Massachusetts–Amherst, Massachusetts, USA. He is a senior researcher at CONICET, where his area of interest is process design and integration in the agroindustrial supply chain. He can be contacted at iribarr@santafe-conicet.gov.ar.*