Deodorisation and Physical Refining of Fats

Ray Cook
Eborotec Ltd. York, UK.
www.ebortec.co.uk
1890’s Population explosion in USA and Europe fuels demand for butter substitutes

Simple boiling methods adopted to improve flavour of seed oils
1927 Scientist invents steam deodorising of hot oil under vacuum.
Alton E Bailey
(1907 – 1953)

- Introduces scientific basis for the process of deodorisation and fatty acid distillation.
- Introduces concept of flavour evaluation and identification.
- Develops the Bailey semi continuous column deodoriser, providing workhorse for the refining industry for next four decades.
Bailey Semi Continuous Deodoriser 1954 (Girdler - Votator)
Steady progress in the 60’s and 70’s

- Major improvements in sparge tray design
- General introduction of high temperature deodorisation by thermal heating fluids or electric heaters.
- Introduction of single shell deodorisers.
- Development of horizontal deodorisers.
- Better heat recovery systems.
Important inventions in the 1970’s

Votator High Efficiency Stripping Tray
Patent No US 3,693,322

Simon Rosedown Thermosyphon
Patent No US 3,999,966
What can go wrong – Will go wrong

- Heating fluid incident in Japan in 1968 causes many deaths resulting, ultimately, in worldwide ban on mineral oil heaters and the development of HP closed loop steam boilers.
- Deodorisers over simplified by multi stage heat recovery resulting in poor flavour profiles.
- Early single shell designs failed to prevent extreme damage by air leaks in hot oil.
- Problems associated with thermally induced isomerism not recognised until the late 1990s.
Modern Continuous Deodorizing (With acknowledgement to Crown Ironworks Inc)
Modern Semi-Continuous “Diflow” Deodorizer (With acknowledgments to Crown Ironworks Inc)
ABSTRACT
A combined vertical column and shallow tray semicontinuous deodoriser for edible oils and fats comprising a column (40) of discrete vessels and a deodorising vessel (43) disposed within or valve-connected thereto. In the operation of the device, heated oil from a vessel (32) is supplied to deodorising vessel (43) wherein it is circulated by steam injection at (43) through a lift tube (29), between a plurality of vertically separated self-draining shallow trays (26, 27, 28). The entire oil content of deodorising vessel (43) is circulated throughout approximately once a minute for a period in the region of eight to ten minutes to strip free fatty acids and other volatile components from the oil by falling curtain and steam sparge techniques, and then the oil batch is discharged to a heat recovery vessel (24) and a cooling vessel (15) before product discharge.

10 Claims, 7 Drawing Sheets
Development of physical refining in 1980’s and 90’s

- Initially motivated by palm oil industry’s demands for improved refining yield.
- Major environmental advantages by avoiding soap stock splitting.
- Improvements in degumming technology allow physical refining of liquid oils by 2000.
- Introduction of packed column technology reduces energy costs.
- Separation and recovery of distillates using multiple condensers
Continuous Deodorizing with Packed Column

(With acknowledgements to Crown Ironworks Inc)
What is Deodorisation?

FREE FATTY ACIDS

C14

C16

C18

KETONES

PESTICIDES

ALDEHYDES

STEROLS

HEAT BLEACHING

MONOGLYCERIDES
Vapour pressures of pure free fatty acids
Physical laws affecting distillation rate

- **Raoult’s Law**
  For a given temperature the partial pressure of a constituent in a solution, is a function of it’s molar concentration and it’s vapour pressure in pure form.
  This is particularly significant when ffa is high, e.g. in crude Palm oil, 5% ffa equates to a molar concentration of ~14%

- **Dalton’s Law**
  The molar ratio of the vapours issuing from the oil being deodorised equals the ratio of their partial pressures.
  In this respect the introduction of a carrier gas, such as steam or nitrogen can assist the mass transfer of the volatile compounds.
Factors which affect the rate of mass transfer of volatile compounds

- Vapour pressure of volatile compound
- Molar concentration of volatile compound
- System temperature
- System pressure
- Amount of steam used to carry volatiles
- Efficiency of transfer to steam bubble
- Bubble size and number
- Design of deodorisation equipment
Bailey’s simplified steam stripping equation

Where $V_a$ & $V_o$ are the initial and final molar concentrations of ffa. $P_t$ is the system pressure & $P_a$ is the vapour pressure of the ffa. $S$ represents the moles of steam required.

$$S = \frac{P_t}{E \times P_a} \times \ln \frac{V_a}{V_o}$$
Negative Considerations During Deodorisation

- Thermal degradation > off flavours
- Hydrolysis
- Rearrangement isomerism
- Thermally induced trans isomerism
- Polymerisation through air leaks
- Colour fixation of phosphatides
- Loss of tocopherols
Geometric isomerism
(Mainly affecting Linolenic acid)
Illustration of effect of Time and Temperature on formation of Geometric Isomers in Rapeseed Oil
Combined heating & stripping tray
(Minimum time and temperature > minimum trans)

Ebortec patent No GB 2,354,770
Freeze Condensation
(with acknowledgement to the Graham Corporation)
Deodorizing Using Ice Condensing Vacuum Systems

Alternating Ice Condensers

Ice build-up in Condenser
Thank you for listening