CASE TEACHING NOTES
for
"Out of the Frying Pan and Into the Grease Fire: A Case Study in Food Science"

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INTRODUCTION / BACKGROUND

This case was developed for a course in Food Chemistry and Analysis, which is taken mostly by food science and dietetics students. The course employs a mixture of lectures, group learning activities, and five case studies. The course content can be divided into six main areas, namely water, carbohydrates, lipids, proteins, other food components, and current issues in food science/chemistry. A case has been developed for each of the main topics, with the exception that the topics of water and carbohydrates together make one case. This case is one of the five cases used in the course and covers the area of lipids.

Students are placed in permanent groups of five at the beginning of the course and the cases are done as in-class group exercises. A case is introduced at the end of each topic and students are expected to use the knowledge that they have gained during the lectures and group learning activities to "solve" the case. In addition, because of the small class size (25 students), it is possible to do the case studies in a computer lab with at least one computer per group, allowing the students to quickly search for specific information on the web if needed.

For this specific case, the basic knowledge the students will need is covered in seven lectures/group learning activities that precede the case. They are: (1) Lipids—Classification/Structure/Nomenclature; (2) Total Fat/Lipid Analysis; (3) Oil Refining and Processing; (4) Lipids—Functional Properties—Crystallization, Emulsion; (5) Methods to Characterize Fat; (6) Rancidity; and (7) Methods to Determine Rancidity. Thus students are familiar with the different fats and the fatty acids they are made of as well as the concepts of the changes an oil undergoes when it is being refined or when it is oxidized.

The case could also be used in a Hotel and Restaurant Management program, although the learning objectives and expectation on students would need to be revised to emphasize the business side of the case.

Primary Learning Objectives:

- Learn about oil temperatures needed for deep fat frying.
- Understand that different oils can be heated to different temperatures before breaking down.
- Understand the concepts of smoke point, flash point, and fire point of oils and the reasons for differences in these parameters among oils.
- Understand the effect of type of oil and the process of oil refining on these parameters.
- Understand the effect of hydrolytic and oxidative rancidity on these parameters.

Secondary Learning Objectives:

- Know how to convert degrees Fahrenheit into degrees Celsius.
- Get an appreciation of the importance of record keeping in the food and food service industries.

BLOCKS OF ANALYSIS

Context

Deep fat frying is a $75 billion dollar industry in the U.S., which includes the value of the oils and the fried food retailed by the food industry and the food service and restaurant industry. Fats and oils at high temperatures of 180°C (350°F) to 200°C (400°F) are used as the medium of heat transfer to cook the food. The oils have to be hot enough to prevent excessive absorption of the oil by the food, but not too hot, which would burn the outside of the food without the inside being fully cooked. The rapid heat transfer causes crust formation on the food and evaporation of water from the food, causing oil incorporation into the food and imparting water and food particles into the oil. At the high frying temperatures, this "contamination" of the oil speeds up oil degradation processes by several magnitudes, rendering an oil, which is otherwise shelf stable for years at room temperature, to degrade within days.

Frying Oils

Fats and oils used in the food industry, at home, or a restaurant are mixtures of triacylglycerides, three fatty acids esterified to a glycerol backbone, extracted from plant sources such as oilseeds (e.g., canola) or animals, such as farm animals (e.g., lard from pigs). The fatty acids are long hydrocarbon chains (16 or 18 carbon chains containing fatty acids are the most common) with a carboxyl group at one end of the chain and a methyl group at the other end. The hydrocarbon chain may or may not have one or more double bonds, called unsaturation. Almost all oils can be used as frying oils, although highly unsaturated oils are less stable and degrade faster than oils with no or fewer double bonds. For that reason, partially hydrogenated oils, which have a decreased degree of unsaturation, have been widely used as frying oils, especially in the fast-food industry. However, health concerns over the *trans* fatty acids, which are generated during hydrogenation, have lead many restaurants, most notably McDonald's in the Fall of 2002, to start using frying oils that are less hydrogenated and have therefore reduced amounts of *trans* fatty acids.

Oil Refining

After extraction in order to make the oils more stable to oxidation, all oils undergo a refining process, which includes the removal of phospholipids, diglycerides and monoglycerides (degumming), free fatty acids (neutralization), pigments (bleaching), and odors (deodorization). Additional refining steps may include decreasing the degree of unsaturation (hydrogenation), separation of fats based on their melting point (fractionation), and removal of waxes (dewaxing). Refined oils are usually bland in flavor and can be stored for extended periods of time.

Oil Degradation

The two main degradation processes for oils are oxidation and hydrolysis. In oil hydrolysis, the fatty acids are hydrolyzed off the triacylglycerides at high temperatures in the presence of water (i.e., frying conditions), yielding free fatty acids, monoglycerides, diglycerides, and glycerol. These breakdown products will speed up the degradation of the remaining triacylglycerides as they allow greater emulsification of water from the food into the oil. In oil oxidation, the carbon atoms next to the double

bonds in the oils are oxidized, which results in a break of the hydrocarbon chain and the formation of volatile compounds, including aldehydes, ketones, alcohols, short chain fatty acids, and other compounds that may introduce an off-odor to the oil. A third type of degradation process, which is the formation of polymers, will darken the color of the oil and can ultimately lead to an increase in viscosity and solidification of the oil. However, this degradation process, while sped up by the frying conditions, is of little importance because the other two degradation processes will render the oil inedible long before polymerization will affect the oil.

Characteristic Oil Parameters

Because oils are mixtures of triacylglycerides containing various different fatty acids, the source of an oil largely determines the characteristics of that oil. Important parameters include chemical measures such as the degree of unsaturation (iodine value), average fatty acid chain length (saponification value) and flash, smoke, and fire point, as well as physical parameters, such as melting point, refractive index, and solid fat index. In addition, important oil quality parameters include the degree of oxidation (peroxide value, anisidine value) and the degree of oil hydrolysis (free fatty acid value). These parameters are all important in determining the stability and shelf life of an oil, which can be determined by accelerated shelf life measurements, such as the active oxygen method.

CLASSROOM MANAGEMENT

The case can be used in a 50-minute class period, unless the assignment given at the end of the case is not used as an out-of-class assignment. While it might be beneficial to present the case to the students prior to class time, it is not a necessity. In the past, the case was used in one class period without students having prior knowledge of the case. Students work in groups of five, with the groups being assigned prior to the class period. Students sit with their group, and the groups cluster around work stations with two to three computers.

The class period is divided into four segments: (1) Presentation of case; (2) Collection of information given in the case; (3) Determination of information needed for "solving" the case that is not given as part of the case; and (4) Collection of that information.

(1) Preferably the case is read to the students by the instructor, as it allows for building anticipation, tension, and expectation. The assignment is given right after the case is read, because it allows students to focus their following inquiries on the task. The case is then handed out to each student. This segment takes about 5-10 minutes of class time.

(2) Groups then have between 5 and 10 minutes to discuss and collect information from the case that will be needed to complete the assignment. Thus, the students within their groups discuss what information will be needed, e.g., not changing the oil according to regulations ought to be a piece of information students identify as significant, while the information that the restaurant manager was in the office at the time the fire broke out is not an essential piece of information. The instructor then asks the students for this information, which is collected on a blackboard, flip chart, or white board. The manner in which the information is collected can be decided upon by the instructor. Past experience has shown that approaching each group separately to ask for one or two pieces of information works well. This segment can be elaborated upon by asking groups in a reciprocal fashion why a selected piece of information is important for the case. This part also takes about 5-10 minutes.

(3) The groups are then asked to consider if any other information might be needed to complete the assignment. This is the section where students need to apply the knowledge they learned earlier in the course in order to (a) decide on the correct information needed and (b) possibly answer some of the

questions. Again, the students discuss this task within their group. As done previously, the instructor then collects that information by writing it on the blackboard. The degree of engaging the students (e.g., "Why do you think that information is important to the case?") depends on the instructor and the available time. This segment will take approximately 10-15 minutes.

(4) The last segment consists of the gathering of the missing information. Depending on the previous knowledge of the students, the time left, the level of the class, and the resources available (e.g., computer availability) this can be done by either allowing students to search the web on their own and/or using books that are made available and/or handing them some or all of the URLs provided below and/or handing out printouts of the information provided by those websites.

As time permits, or depending on the preference of the instructor, this information can then also be listed on the blackboard, or this task can become part of the assignment that is to be completed by the students on their own. In the past, the information was not listed on the board, but briefly talked about by being interspersed with concluding remarks so that it became part of the written assignment of preparing the report by Chief Tipton to the insurance company.

Websites used in class for the case:

- Is It Time for an Oil Change?
  By Beth Macintosh, Office of Research, University of Guelph
  http://www.uoguelph.ca/atguelph/01-02-28/articles/oil.html

- Cooking Up Healthful Foodservice Foods
  By Andrea Platzman, R.D., Contributing Editor, *Food Product Design*
  http://www.foodproductdesign.com/archive/2000/0500fa4.html

- Guidance on the Use and Handling of Frying Fats and Oils
  Food Safety Authority of Ireland
  http://www.fsai.ie/industry/guidance_frying_oils.htm

- Deep-Fat Frying
  By Rosana Moreira, Texas A&M University
  http://baen.tamu.edu/users/rmoreira/pdfindex/Deepfat.pdf

- Your Guide to Better Deep Fat Frying
  Goodman Fielder Food Services
  http://www.gffoodservice.com.au/dir085/gffsinternet.nsf/Content/Your+Guide+to+Better+Deep+Frying

- Frying Oils: A Big Factor in Cooking Fires
  Agralite Electric Cooperative
  http://www.agralite.coop/news/article27.htm

- Frying Up a Storm: Useful Life of Frying Oils
  OChef.com
  http://www.ochef.com/888.htm

- Frequently Asked Questions (FAQ) About Fats and Oils
  Institute of Shortening and Edible Oils
  http://www.iseo.org/faq9.htm

- Smoke Point for Cooking Oils
  Care2.com: The Environmental Network for Healthy Living and a Healthy Planet
  http://www.care2.com/channels/solutions/home/143

Note: In addition, the "Glossary of Terms" and "Common Test Methods and Related Terms" on the Institute of Shortening and Edible Oils website at http://www.iseo.org/ffo_10-end.htm#glossary were copied from the site and then printed out and given to the students as supplemental case materials to help them in their discussions and in writing the assignment.

REFERENCES

- Belitz, H.-D., and W. Grosch. 1999. "Lipids." Chapter 3 in *Food Chemistry*. Berlin: Springer, pp. 152-236

- Blumenthal, M.M. 1996. "Frying Technology." Chapter 11 in *Bailey's Industrial Oil & Fat Products*. Vol. 3, *Edible Oil & Fat Products: Products and Application Technology*. 5th edition, Editor: Y.H. Hui. New York: Wiley Interscience, pp. 429-483.

- Duncan, S.E. 2000. "Lipids: Basic Concepts." Chapter 6 in *Food Chemistry: Principles and Applications*. Editors: Christen, G.L., and J.S. Smith. West Sacramento, CA: Science Technology System, pp. 79-96.

- Gunstone, F.D. 1996. *Fatty Acid and Lipid Chemistry*. London: Blackie Academic & Professional.

- Orthoefer, F.T., and R. Sinram. 1996. "Oil Processing and Quality Assurance." Chapter 7 in *Bailey's Industrial Oil & Fat Products*. Vol. 4, *Edible Oil & Fat Products: Processing Technology*. 5th edition, Editor: Y.H. Hui. New York: Wiley Interscience, pp. 391-410.

- Schmidt, K. 2000. "Lipids: Functional Properties." Chapter 7 in *Food Chemistry: Principles and Applications*. Editors: Christen, G.L., and J.S. Smith. West Sacramento, CA: Science Technology System, pp. 97-113.

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