Food Physics
(FDSC 597E)
Spring 2004

John Coupland
Assistant Professor of Food Science
Penn State

Syllabus

10:00-11:30 (discussion) and 1:00-2:30 (lecture) Tuesdays
202 Borland

Objectives: This course will explore the physical principles important to the formation of food structure and how that structure can lead to the functional properties important to food quality. The important topics will be considered first in a discipline-based manner using model systems to explain the underlying principles before moving on to more realistic food examples. In conjunction with this, the students will use reading from the primary literature as examples of the applications of the topics. Finally, students will be asked to extend what they have learned in an independent project.

Course outline: The typical format will be two 90 min meetings a week. The first (afternoon) meeting will be largely lecture format and is provided as a way to rapidly communicate the underlying theory of the topic under consideration. At the end of this period a guided reading assignment will be provided. The second meeting will start with a short (10 min) written test on the factual material from the lecture and key points from the reading assignment. We will then proceed to a student-led discussion on the paper(s). In the final part of the semester we will move to a more open project where students will be asked to research and present applications or extensions of the class material. Attendance is required at all class meetings.

Textbook: There is no required text for this class but I recommend:

- McClements, D.J. (1999). *Food emulsions. Principles, practice, and techniques*, Boca Raton: CRC Press.
- Dickinson, E. (1992). *An introduction to food colloids*, Oxford: Oxford University Press.
- Walstra, P. (2003). *Food physical chemistry*

Grades: Credit will be available as follows:

Short, in-class tests	55
Leading discussion sessions	20
Participation in discussion sessions	110
Exam 1	20
Exam 2	20
Project work	50
Total	**275**

Letter grades will be assigned based on the percentage total score according to the typical PSU system, i.e.: 100.0-93.0=A, 92.9-90.0=A-, 89.9-87.0=B+, 86.9-83.0=B, 82.9-, 0.0=B-, 79.9-77.0=C+, 76.9-70.0=C, 69.9-60.0=D, 0-59.9=F.

Discussion Sessions
The morning session each week will be a discussion around one or more papers relevant to the previous lecture material (see below). My goal here is to (i) improve your ability to critically evaluate primary literature, (ii) provide illustrations of the points raised in the lecture classes, (ii) widen your knowledge of the techniques, approaches and investigators active in the field.

Discussion requires your active and informed participation. It is essential you read the paper thoroughly before coming to class. A good approach to take is to try and understand (i) what the authors were trying to do in the context of their introduction, (ii) what measurements did they make and how are these measurements sensitive to the physical properties of the system, and finally (iii) how did they deduce an understanding of the underlying principles from their measurements. Try not to get too hung up on details not central to the goals of the class (e.g., poorly presented figures, limited statistical treatment of the data) but instead focus for the relationships between your theoretical understanding of the system, their observations and their conclusions. In most cases I will provide at least one additional reference for optional background reading and you will receive a reading guide of bigger picture questions to think about. Each discussion will start with a brief written test on some factual points raised in the paper and in the previous lecture.

Each discussion will be led by one or more students. You will be expected to lead two discussions over the course of the semester and your performance as a leader will be evaluated as a contribution to your overall grade. When you are leading a discussion you must meet with me on Wednesday or Thursday following class to briefly discuss your impressions of the paper and the supporting materials and to work together to come up with 3-5 discussion points that you will forward to the class on Friday. At the start of the discussion give a brief presentation (10 min) on the background, goals, experimental design and measurement techniques then lead the class in a discussion of the important questions. When leading a discussion you should have read both the paper and supporting materials.

Research Projects
As part of this class I will ask you to move beyond the material taught to a deeper treatment of a current research question in food physical chemistry. You will be expected to select a significant question current in the literature either from the examples given below or in collaboration with me. The question may be related but should not be central to your thesis research and should incorporate some fundamental aspect of food physical chemistry. Write a clearly-structured essay (<5000 words) explaining the question under consideration and, making extensive use of the primary literature explore the opinions, controversies and implications of the question. Your essay should demonstrate your ability to critically evaluate and integrate ideas and data (so a citation is good – a meaningful citation where actual ideas are detailed and used is better). Illustrations and Figures are strongly encouraged. You will also present your project to the class as a 20-min talk.

There are 50 points available for your project. A timeline for the activities along with available credit is provided below. I am happy to look over any of your work at any reasonable time before deadlines to provide formative criticism.

Before Spring break	**Objectives.** Agree project title and meet with JC to present your opinions of the major questions involved	
On 3/23 or 3/30	**Proposal.** Present to class your general impressions of	5
Before 4/3	**Outline.** Present written outline (topic headings) for your essay to JC	5
On 4/20 or 4/27	**Presentation**. 20-min in-class presentation.	10
Before 5/1	**Report.** Submit report	30

Suggested Project Questions.

1. Why does Rick Ludesher consider the glass transition a limited concept in Food Science?
2. What was Micha Peleg's criticism of the Tg approach?
3. What alternatives are proposed to the Avrami model for fat crystallization?
4. Pieter Walstra argued secondary nucleation is important in fat crystallization. Describe his argument and critically evaluate it in terms of available literature data.
5. What are the arguments around Alex Marangoni's fractal modeling of fats?
6. Describe efforts to quantitatively describe the colloidal forces important in food emulsions
7. Emulsion polymerization is commonly used in polymer manufacture. What is this process and what are the analogies between it and the proposed models for lipid oxidation in emulsions?
8. How does high hydrostatic pressure alter the thermodynamic considerations in food physics? Illustrate your discussion with examples.
9. Critically discuss the importance of "Some thermodynamic considerations in food formulation" by Vladimir Tolstoguzov
10. Tom Eads describes his Trends in Food Science and Technology article as the first in a series. Tom has since retired from academia; write a short version of a follow-up article in this series for him.
11. What has Doug Goff been extracting from winter wheat and why?

Literature Resources

Food Science Journals

- CRC Critical Reviews in Food Science and Technology (TP368.C46, Paterno)
- Food Hydrocolloids (TP453.C65F673, Paterno)
- JAOCS. (TP1.A644, Paterno)
- Journal of Food Science (TX1.F65, Paterno)
- Journal of the Agricultural and Food Chemistry (S583.J66, Paterno)
- Trends in Food Science and Technology (TP368.T74, Paterno)

Physical Chemistry Journals

- Advances in Colloid and Interface Science (QD1.A356, Physical Sciences Library, 230 Davey)
- Colloids and Surfaces A. (QD549.C65, Earth & Min Sci Library, 105 Deike)
- Current Opinion in Colloid and Interface Science (QD549.C87, Earth & Min Sci Library, 105 Deike)
- Journal of Colloid and Interface Science (QD549.J67, Physical Sciences Library, 230 Davey)
- Journal of Physical Chemistry B. (QD1.J663, Physical Sciences Library, 230 Davey)
- Langmuir (QD506.L3, Physical Sciences Library, 230 Davey)

Books: Aside from those listed above, the following are all useful:

- Dickinson "Colloids in Food" (1982)
- Dickinson and McClements "Advances in Food Colloids" (1996)
- Grosburg and Khabkhlov "Giant Molecules" (1997)
- Hartel "Crystallization in Foods" (2001)
- Hunter, "Foundations of Colloid Science" (1986)
- Israelachvilli "Intermolecular and Surface Forces" (1992)
- Macosko "Rheology: Principles, measurements, and applications" (1994)
- Shaw "Colloid and Surface Chemistry" (1991)
- Sjoblom "Encyclopedic Handbook of Emulsion Technology" (2001)

Timetable

	Discussion (10:00-11:30 AM)	Lecture (1:00-2:30 PM)
1/13	--	Introduction
1/20	"Molecular-origins of structure and functionality in foods" Eads TM, Trends Food Sci. Tech., 5 (5): 147-159 (1994). • Coupland	Solutions: Enthalpy and Entropy
1/27	"Quantitative assessment of phase composition and morphology of two-phase gelatin-pectin gels using fluorescence microscopy" Nordmark TS, Ziegler GR, Food Hydrocolloids, 14 (6): 579-590 (2000). • (2)	Gelation
2/3	"Globular protein gelation - theory and experiment" Clark AH, Kavanagh GM, Ross-Murphy SB, Food Hydrocolloids, 15 (4-6): 383-400 (2001). • (2)	Phase transitions
2/10	"Comparison of experimental techniques used in lipid crystallization studies", Wright AJ, Narine SS, Marangoni AG, J. Am. Oil Chem Soc., 77 (12): 1239-1242 (2000). "The Avrami index and the fractal dimension in vegetable oil crystallization" Toro-Vazquez JE, Dibildox-Alvarado E, Charo-Alonso M, Herrera-Coronado V, Gomez-Aldapa CA, J. Am. Oil Chem Soc., 79 (9): 855-866 (2002) • (3)	The glass transition
2/17	"Glass transitions in frozen sucrose solutions are influenced by solute inclusions within ice crystals" Goff HD, Verspej E, Jermann D, Thermochem. Acta, 399 (1-2): 43-55 (2003) • (2)	Interfaces
2/24	"Surface pressure isotherms, dilatational rheology, and Brewster angle microscopy of insoluble monolayers of sugar monoesters", Garofalakis G, Murray BS, Langmuir, 18 (12): 4765-4774 (2002). • (2)	Emulsions

3/2	"Production and characterization of O/W emulsions containing cationic droplets stabilized by lecithin-chitosan membranes" Ogawa S, Decker EA, McClements DJ, J. Ag. Food Chem., 51 (9): 2806-2812 (2003). "Influence of environmental conditions on the stability of oil in water emulsions containing droplets stabilized by lecithin-chitosan membranes", Ogawa S, Decker EA, McClements DJ, J. Ag. Food Chem., 51 (18): 5522-5527 (2003) • (3)	**Part 1 exam**
3/9	**Spring Break**	
3/16	Rheology (lecture)	Visit to Cannon Instruments
3/23	"Rheological characterization of a gel formed during extensive enzymatic hydrolysis" Doucet D, Gauthier S.E., Foegeding E.A., J. Food Sci., 68(5), 711-715 (2001). • (1) & project discussion (1)	Rheology (II)
3/30	"Thermoreversible gelation of caseinate-stabilized emulsions at around body temperature" Eliot C, Dickinson E, Int. Dairy J., 13 (8): 679-684 (2003) • (1) & project discussion (2)	Chemical reactivity in dispersions
4/6	"Ability of surfactant micelles to alter the partitioning of phenolic antioxidants in oil-in-water emulsions", Richards MP, Chaiyasit W, McClements DJ, Decker EA, J. Ag. Food Chem., 50 (5): 1254-1259 (2002) *(or alternative)* • (2)	Sensory consequences
4/13	"Sensory and instrumental textural characteristics of acid milk gels" Pereira RB, Singh H, Munro PA, Luckman MS, Int. Dairy J., 13 (8): 655-667 (2003) • (2)	Review session
4/20	**Part 2 exam**	**Project presentations**
4/27	**Project presentations**	**Project presentations**