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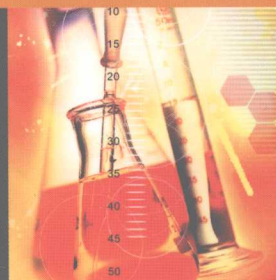
• 高等学校专业教材 •

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# FOOD CHEMISTRY LABORATORY MANUAL

欧仕益 黄才欢 吴希阳 编著

食品化学实验手册



 中国轻工业出版社

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## PREFACE

Food chemistry, which deals with the composition and properties of food and chemical changes during handling, processing and storage, is an important subject for students majoring in Food Science and Engineering or Food Safety and Quality. And food chemistry experiments are essential part of this subject. The goal of this course for students is to make scientific measurements of some important chemical reactions occurring in foods, thus eighteen experiments have been designed in this manual to illustrate some of chemical and physical principles discussed in lectures. To satisfy the requirements of bi-linguistic teaching, this Food Chemistry Laboratory Manual is edited in English.

This manual is intended for students who have previously taken laboratory courses in chemistry and biochemistry. This course provides opportunities to improve experimental design and practical laboratory skills and can also be a useful reinforcement for other specialty courses. More importantly, food chemistry experiments very often do not work according to plan. In chemistry laboratories the chemicals are pure, the conditions are controlled and a "right answer" in theory can be expected. However, in food chemistry we often have more complex starting materials and many side-reactions can occur in parallel under non-ideal conditions. Not surprisingly, the data obtained can be confusing and hard to interpret. This course is intended to develop students' skills to solve food research problems and to conduct critical analysis of the data in a complex food matrix. When attending this course, students are required to: (1) Come to the lab prepared; read the experiment in advance and have an idea of the results you expect. (2) Make good scientific observations; what is the appearance of your samples before, during and after the reaction? What are their sensory characteristics? Do you think your measurement technique is capable of giving meaningful results from the

samples? (3) Thoroughly record your observations: rigorously record the data required and also note your other observations. Remember that your experimental notebook is not just a record of the experiment, but also must be a complete guide for another scientist to repeat your results and can be a legal document in a court of law or patent application. (4) Be imaginative and creative: with your detailed observations you can formulate or refine your scientific theory based on what you expected and what actually occurred in the experiments.

To successfully complete this course you will be also required to: (1) Understand the important reactions in food chemistry and their consequences in food systems. (2) Develop an expertise with the analytical methods to used measure these reactions. (3) Report data and observations in an appropriate format. (4) Design and conduct an experiment to study simple food chemistry systems.

## 前 言

食品化学是研究食品的化学组成、理化性质及其在生产、加工、贮运过程中的化学变化的一门科学,它是食品科学与工程、食品质量与安全专业的一门专业基础课。为满足一些院校采用双语教学的需要,特编制这本英文《食品化学实验》教材,设计了18个实验,使学生有机会对理论课所学的知识进行实验研究,以加深对理论知识的理解并培养其从事科学研究的能力。

此前,同学们已经修读过几门化学类课程的实验课,而食品化学实验课将能训练你们从事应用科学研究的技能并加强对后续专业课程的学习能力。食品化学实验课不像我们已经学过的基础化学实验课,它使用的是组成复杂、含量多变的实验材料而非纯净的化学试剂,某些情况下你得不出你想要的“正确”结论,而是一些难以解释的结果。因此,本课程将培养你解决科学研究问题并从一些看起来是“杂乱无章”的结果中做出正确判断的能力。要获得这些科研素养,必须满足如下要求:(1)实验前的预习:了解你需要做什么和可能获得的结果。(2)做个细致的观察者:如观察样品的颜色、气味、形状,分析所采取实验方法能否获得有意义的结果等。(3)详细记录:不仅记录实验课程要求的数据,而且要记录其它观察结果。(4)丰富的想象力:对你预期的实验结果和其它发生的实验现象都能进行科学解释。

要圆满地完成本课程,你还必须达到以下要求:(1)掌握食品化学的重要化学反应及其产生的结果(如主要产物,颜色、气味变化等)。(2)熟悉相关实验方法及其原理。(3)认真完成实验报告,并准确地报告你的实验现象和实验结果。(4)能进行实验设计研究一些简单的食品化学问题。

# 目 录

实验室规则 .....	1
实验报告 .....	2
第1章 水分活度 .....	4
第2章 乳糖 .....	11
第3章 糖的性质 .....	21
第4章 淀粉胶 .....	26
第5章 食品胶体 .....	33
第6章 油脂的酸败 .....	40
第7章 蛋白质的功能性质 .....	46
第8章 面筋的制备 .....	55
第9章 食品中赖氨酸的测定 .....	59
第10章 豆奶蛋白中 -SH 和 -S-S- 基团的测定 .....	67
第11章 非酶褐变 .....	72
第12章 酶促褐变: 多酚氧化酶的动力学模型 .....	78
第13章 烫漂作用 .....	91
第14章 蔬菜中色素的分离 .....	95
第15章 pH 和磷酸盐对肉类蛋白水合作用的影响 .....	101
第16章 高效液相色谱法测定咖啡因 .....	107
第17章 食品风味物质的感官评定 .....	115
第18章 项目工作目标 .....	123

## CONTENTS

LABORATORY REGULATIONS .....	1
LABORATORY REPORTS .....	2
<b>CHAPTER 1</b> WATER ACTIVITY .....	4
<b>CHAPTER 2</b> LACTOSE .....	11
<b>CHAPTER 3</b> PROPERTIES OF SUGARS .....	21
<b>CHAPTER 4</b> STARCH GELS .....	26
<b>CHAPTER 5</b> FOOD HYDROCOLLOIDS .....	33
<b>CHAPTER 6</b> RANCIDITY OF OIL .....	40
<b>CHAPTER 7</b> FUNCTIONAL PROPERTIES OF PROTEINS .....	46
<b>CHAPTER 8</b> PREPARATION OF GLUTEN .....	55
<b>CHAPTER 9</b> DETERMINATION OF AVAILABLE LYSINE IN FOODS .....	59
<b>CHAPTER 10</b> DETERMINATION OF -SH AND -S-S- GROUP CONTENT IN SOYMILK PROTEIN .....	67
<b>CHAPTER 11</b> NON - ENZYMATIC BROWNING REACTION .....	72
<b>CHAPTER 12</b> ENZYMATIC BROWNING; KINETICS OF POLYPHENOLOXIDASE .....	78
<b>CHAPTER 13</b> BLANCHING EFFECTIVENESS .....	91
<b>CHAPTER 14</b> SEPARATION OF PIGMENTS IN VEGETABLES ...	95
<b>CHAPTER 15</b> EFFECT OF pH AND PHOSPHATES ON HYDRATION OF MEAT PROTEINS .....	101
<b>CHAPTER 16</b> DETERMINATION OF CAFFEINE BY HPLC .....	107
<b>CHAPTER 17</b> SENSORY ASSESSMENT OF FLAVORS .....	115
<b>CHAPTER 18</b> PROJECT WORK .....	123



## **LABORATORY REGULATIONS**

(1) Consuming food or beverages is not allowed in Food Chemistry Laboratory Classes.

(2) Do not pipette any liquid by mouth.

(3) Untied long hair and inappropriate footwear such as sandals are not allowed.

(4) All sharp objects, such as broken glasses, must be discarded into designated container.

(5) Solid food waste should be wrapped with plastic garbage bags before being disposed into the waste bin.

(6) Work on volatile chemicals must be performed in ventilating fume hood.

# LABORATORY REPORTS

The following documentation is requested for all laboratory reports:

## 1. Title Page

Must include: course title, subject title, experiment title, author's name, group number & group members, date (performing experiment and submitting report).

## 2. Introduction and Aims

Describe the basic science relevant to the work and your goals/hypotheses for the study. Cite references to support your basic science (e. g. lab manual, textbooks and journals) and list your references at the end of the text. Do not copy section contents from this manual or other materials. Plagiarism will not be tolerated.

## 3. Experimental Procedure

Describe what you did and how you did it. Very often this section can be abbreviated to: "The experiment was conducted as described in the *Food Chemistry Laboratory Manual* (Ou et. al, 2007)." But be sure to list any changes or expanded descriptions to procedures. The method section should be written in a past impersonal form with passive voice (e. g. "A standard protein solution was prepared by weighing 20.0 g of soy powder..." not "I prepared a standard protein solution by weighing 20.0 g of soy powder...").

## 4. Results

Experimental data can be presented in tabular or graphical form or both. All tables, graphs and figures should be numbered in sequence and titled accurately. Data and title that appear in tables, graphs and figures should be complete and self-explanatory so that a reader can then interpret the results without referring to the text for necessary information.

## 5. Discussion

The discussion section may include a statement of the results reported in

the tables and figures. Students need to: (1) Account for and interpret observations, results and their implications referred to each table and figure in your discussion; (2) Compare the actual results to those predicted by theory; (3) Discuss other observations and experimental errors; and (4) When questions are included in experiments, incorporate answers to these questions in the discussion.

## 6. Conclusion

Summarize your observations, results, and conclusions previously presented in the discussion section. The conclusions may be presented as a series of numbered statements, which include only pertinent information based solely on data within the report.

# CHAPTER 1 WATER ACTIVITY

## 1.1 INTRODUCTION

When water interacts with solutes and surfaces, it is unavailable for other hydration interactions. The term “water activity” ( $a_w$ ) describes the (equilibrium) amount of water available for hydration of materials: a value of unity indicates pure water whereas zero indicates the total absence of “free” water molecules, and addition of solutes always lowering the water activity.  $a_w$  is the effective mole fraction of water, defined as  $a_w = \lambda_w x_w = p/p_0$  where  $\lambda_w$  is the activity coefficient of water,  $x_w$  is the mole fraction of water in the aqueous fraction,  $p$  is the partial pressure of water above the material and  $p_0$  is the partial pressure of pure water at the same temperature (i. e. the water activity is equal to the equilibrium relative humidity (ERH), expressed as a fraction).

$a_w$  is a particular relevance in food chemistry and preservation. It is a critical factor that determines the shelf life of food. While temperature, pH and several other factors can influence organisms growth in a product,  $a_w$  may be the most important factor in controlling spoilage. Most bacteria, for example, do not grow at  $a_w < 0.91$ , and most molds cease to grow at  $a_w < 0.80$ . By measuring  $a_w$ , it is possible to predict which microorganisms will or will not be potential sources of spoilage. Water activity—not water content—determines the lower limit of available water for microbial growth. In addition to influencing microbial spoilage,  $a_w$  can play a significant role in determining the activity of enzymes and vitamins in foods and can have a major impact on their color, taste, and aroma. It also controls the textural characteristics such as crispness and crunchiness (e. g. the sound produced by “crunching” breakfast cereal disappears when  $a_w \geq 0.65$ ).

## 1.2 OBJECTIVE

The objective of this experiment is to learn how to determine  $a_w$  and to demonstrate the impact of various  $a_w$  on the texture and visual sensory quality attributes for foods.

## 1.3 APPARATUS AND INSTRUMENTS

- (1) Desiccators
- (2) Balance
- (3) Water activity system meter
- (4) Texture analyzer
- (5) Souffle cups

## 1.4 REAGENTS AND MATERIALS

1.4.1 Saturated standard solutions: Prepare several different saturated standard solutions in humidity chambers (desiccators) (Table 1.1 ~ Table 1.2).

Table 1.1  $a_w$  for saturated standard solutions

Compound	$a_w$	Compound	$a_w$
NaOH	0.07	NaBr · 2H <sub>2</sub> O	0.58
CH <sub>3</sub> COOK	0.23	NaCl	0.75
MgCl <sub>2</sub> · 6H <sub>2</sub> O	0.33	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	0.82
K <sub>2</sub> CO <sub>3</sub>	0.43	KBr	0.83
Mg(NO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O	0.52	BaCl <sub>2</sub>	0.90
Ca(NO <sub>3</sub> ) <sub>2</sub>	0.56	KNO <sub>3</sub>	0.924

Note: Use distilled or deionized water to prepare solutions. Solutions may be prepared with hot water; however, cool them down sufficiently prior to placing them in chambers.

Caution: The NaOH solution is especially hazardous. Treat all solutions with extreme care.

**Table 1.2 Food products and methods for their evaluation after storage at various humidities**

Food Products	Evaluation Techniques
Soda crackers	Shortometer; texture analyzer-knife probe
Ripened cheddar cheese	Penetrometer-needle point +50g weight; texture analyzer-puncture probe
Cream cheese	Penetrometer-cone; texture analyzer-cone probe
Carrots or celery	Warner Bratzler shear press; texture analyzer-knife probe
Hard candies	Word description; texture analyzer-cylinder probe, tension mode

## 1.4.2 Materials

- (1) Apple
- (2) Cake
- (3) Biscuit
- (4) Foil

## 1.5 PROCEDURE

### 1.5.1 Procedure 1: Determination of water activity

#### 1.5.1.1 Method of equilibrium relative humidity

A piece of food will gain or lose moisture to the environment but not necessarily in a linear manner. At a given level of atmospheric moisture, one food may bind more or less water than the other. The relationship between food water content and atmospheric moisture content is given by a moisture sorption isotherm. We can measure moisture sorption by the mass gained by a piece of dry food on coming to equilibrium with a known humidity. The easiest way to make a known humidity is to use a saturated salt solution. Any solution has some tendency to bind water and thus there is an equilibrium moisture content above it (the water activity  $a_w$ ). Typically the more concentrated a solution, the lower the equilibrium moisture above it. If the moisture is constantly removed, for example leaving a pan of salt water out on a sunny windy day, the solution will dry out. If the solution is left in

a moist environment it will gain water until it has dried out the environment and come to equilibrium again. We use a supersaturated solution (i. e. with crystals left at the bottom) so that when it absorbs moisture from the environment, more crystals dissolve but the solution concentration remains the same. Similarly if the solution is dried by the environment, more crystals form but the solution concentration remains the same. Some examples of the water activities provided by different saturated solutions at 25°C are given in Table 1. 1.

If we put a piece of food in a container with (not in) a solution, the food will gain or lose moisture until it is in equilibrium with solution. Water activity could be measured by placing samples in equilibrium with a number of salt solutions and calculating the one where there is no mass change.

The determination procedures were as follows:

(1) Prepare 6 desiccators containing a saturated solution with the water-activity modifying salt and a support for the samples.

(2) Each student group selects one product and weighs pieces of food product (4 figure precision) onto labeled aluminum foil, carefully place into the desiccators. Three samples per desiccator.

(3) Store for approximately 2 weeks to allow the samples to come to moisture equilibrium. Be careful to keep the jars somewhere safe where they won't be knocked over.

(4) Reweigh each sample. Because the samples will gain or lose moisture rapidly in contact with the lab atmosphere, you will need to weight them quickly. Once completed, return the samples to the desiccator as quickly as possible. Note that you will need the mass of the foil from two weeks ago to make your calculation.

(5) Calculation of  $a_w$ . Calculate weight gain and weight loss of the samples and draw the plot using  $a_w$  of the saturated solutions as abscissa, weight gain or loss as Y-coordinate (Fig. 1. 1), the intersection point of the line with the abscissa is the  $a_w$  value of the sample.

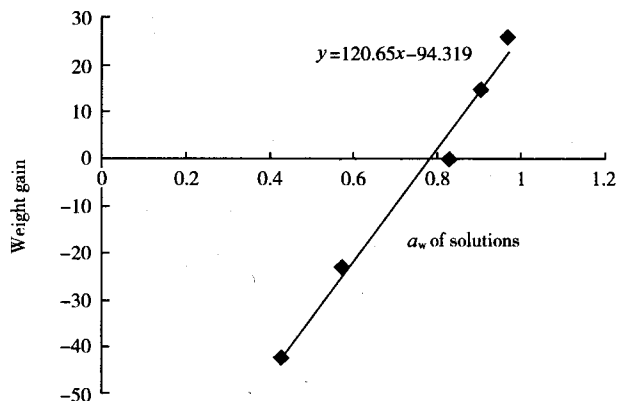


Fig. 1.1 Relationship between Weight Gain and  $a_w$  of the Sample

The  $a_w$  value can be calculated from the regression equation. For example, the regression equation in Fig. 1.1 is  $y = 120.65x - 94.319$ ; when  $y = 0$ ,  $x = a_w = 0.78$ .

#### 1.5.1.2 Method of using water activity meter

The water activity meter has a small chamber where the headspace is in contact with a mirror. The mirror is chilled and eventually reached the dew point of the air (i. e. the temperature when water starts to condense on surfaces). The mirror “fogs up” and the temperature at which this occurs is measured and the relative humidity of the gas (and hence the food) is calculated automatically.

#### 1.5.2 Procedure 2: Effect of varying water activity on the texture and visual sensory quality attributes of foods

(1) Prepare the saturated solutions shown in Table 1.1 in 5 humidity chambers (desiccators).

(2) Place representative samples (at least five of each) in 2-ounce plastic souffle cups and store in evacuated humidity chambers for 2 weeks. Compare to fresh controls.

(3) Evaluate the foods listed in Table 1.2 utilizing the techniques suggested in there.



## 1.6 STUDY QUESTIONS

(1) Was the  $a_w$  determined on the Water Activity meter close to the value expected from the relative humidity of the saturated solutions? What conditions might account for discrepancies?

(2) Are  $a_w$  and product moisture directly related? Discuss.

(3) What are the ramifications of packaging on product shelf life in relationship to  $a_w$ ?

(4) When a cheese and cracker snack food is made for retail distribution, why do the  $a_w$  of the cheese and that of the cracker have to be the same? How does the cheese still maintain its “soft” texture? (Note: consider humectants).

(5) Suggest other tests that could objectively or subjectively evaluate the effect of  $a_w$  on foods.

## 1.7 VOCABULARY

abscissa *n.* 横坐标

aqueous *adj.* 水的,水成的

aroma *n.* 芳香,香气,气味

coefficient *n.* 系数,常数

condense *vt.* 浓缩

crispness *n.* 脆性,酥脆物

crunchiness *n.* 嘎吱嘎吱声

crystal *n.* 晶体 *adj.* 结晶状的

desiccator *n.* 干燥器

dew point *n.* 露点

equilibrium *n.* 平衡

ERH (equilibrium relative humidity) 平衡相对湿度

foil *n.* 箔,金属薄片

moisture sorption isotherm 吸湿等温曲线