Department of Chemical Engineering
State University of New York College of
Environmental Science and Forestry

An Assessment Report on the Undergraduate Collaborative Education Program

On Bioprocess Engineering

Between Beijing University of Chemical Technology (BUCT) and State University of New York – College of Environmental Science and Forestry (SUNY ESF)

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February 20, 2024

Samuel Mukasa, Executive Vice President and Provost, SUNY ESF
February 20, 2024

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Outline

BUCT-ESF cooperation program for Bioprocess Engineering was launched in 2015. The last assessment was completed in 2018. The cooperation between the two institutions have been in a variety of areas, including curriculum improvement, recruitment, and coordination of ESF instructors teaching classes in China.

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SUNY ESF

ESF is one of the premier colleges in the USA focused on the study of the environment, developing renewable technologies, and building a sustainable future. We work to address the Earth's most pressing problems — and students come here because they want to be part of the solution.

Our students, faculty, staff, and alumni make a global impact improving and sustaining the environment. We offer a world-class education among a close-knit community of more than 2,000 scholars with common values and a shared sense of purpose.

Teaching in China

Since the inception of the program highly qualified professors from ESF have taught courses at BUCT in a variety of courses for the program. The courses included required courses in bioprocess engineering. More than 1/3 the number of courses in the program was taught by faculty from ESF. The faculties who taught at BUCT were of the highest caliber with terminal degrees in their fields and with many years of experience in teaching the topics that they were assigned. In the course instruction, BUCT assigned a teaching assistant who worked with the ESF instructor to be the liaison between the students and the instructor. This arrangement worked very well to keep the lines of communication open between the students and the instructor. Also, BUCT assigned student assistants to work with the ESF instructors so that specific needs outside of the classroom such as airport pick-up, coordinating residence, traveling arrangements, and making sure the instructor knows his/her way around the campus, communicating important class-related information to the students, college and/or campus staff. Such an arrangement of cooperation worked very well for both the ESF instructors and BUCT students and administrators.

The mode and means of education in China is quite different from that in the United States. For courses belonging to BUCT the typical style of teaching involves lectures, solving problems from textbooks and examination. Even laboratory activities are prescriptive, meaning all the instructions are given in a step by step process and the student has to follow directions without much thinking and then report results in a systematic manner, not necessarily understanding what was going on. ESF courses are somewhat different in nature. While lectures are still part of the core course structure, assignments contain more open-ended problems and most courses require projects where the theory learned in class has to be applied in practice. While such open-ended approach is challenging both for the instructors as well as students it has enormous rewards. Open ended problems and/or projects provide a greater sense of ownership amongst students. They are usually more engaged in their own learning process and more active in participation.

English Proficiency

English is not the first language for all students in China. It was important that the students achieve proficiency in English before they arrived to ESF. There was tremendous effort on all sides to meet this requirement as much as possible for all students. BUCT offered a number of English classes and prepared the students very well. ESF offered two English writing courses at BUCT. The English writing courses that addressed the writing, technical/scientific writing and presentation skills coordinated its assignments with the technical classes. Typically different types of reports are required in the writing classes, and in many ESF faculty instructed courses technical reports are also required. This would then be reviewed and provided with feedback for

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improvement. The same was done for technical presentations. The improved report or presentation was then delivered as submission in the technical class. By the end of their year at ESF the students made presentations in almost all the classes they were taking. And they did a fantastic job overall.

As the success of English language instruction and training, ESF has subsequently implemented a policy that all students passed the Writing courses no longer need to show any other English language skill test results for entering ESF campus in Syracuse, New York. All the students are evaluated and treated the same as if they were on ESF campus all the time.

Student Support

ESF regularly send staff to BUCT to interact with the students, in addition to the teaching faculty or instructors. The students are informed about the process of transferring into ESF campus in Syracuse, New York and the life expectation in Syracuse.

Pictures above are ESF Associate Director of International Office (Thomas Carter, first row, left), Director of ESF-BUCT Joint Educational Program (Shijie Liu, first row, right), and Associate Director of Admissions (Thomas Fletcher, second row, left) after interaction with the class of 2015.

The "special" attention or support is not stopped after these students come onto ESF campus in Syracuse, New York. For example, to transit the learning in Beijing at BUCT to the learning in Syracuse at ESF, there are supporting structure available for all the students.

Highlights of Student activities and experiences in the classroom at ESF

To help students to settle down in Syracuse, New York, some activities are tailored for these students with and example shown below:

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BUCT Student Experience

- **First and Last Year Students**
  - This is incredibly important to remember and keep in mind at all times. While technically in their last year of the program, these students are in both their first and final years at ESF as the same time. **This is no easy feat for anyone.**
- **Copper Beach Commons (CBC)**
  - All BUCT students are advised to live in Copper Beach Commons. This is a pricy option for the students, but is fully furnished, near campus, and has a shuttle that runs from CBC to ESF.
  - **OIE is working with CBC to help make this situation as suitable for our students as possible.**
- **Grad School Expectations:**
  - As part of the 3+1 Program, BUCT students are expected by BUCT administration to apply for grad school in the U.S. (ESF and elsewhere). **BUCT administration has high hopes that 80% will go on to apply and get accepted into graduate school.** This is key component of their assessment of the success of this program.
- **Range of Academic/English-language Ability**
  - Just as you would see in a cohort of ESF students, some of the incoming students have been very successful academically, whereas others have been challenged. The same goes English language skills. **Some will transition perfectly, but others may need individualized support.**

International Student Orientation

学校情况介绍会

- **International Student Arrival (Wednesday, 8/15, Thursday, 8/16, and Friday, 8/17)**
  - *Airport Pickup* – OIE will pick students up at the airport!
  - *Unpack* – Welcome to Copper Beach Commons!
  - *Shopping and Settling In* – there will be opportunities to go to local stores and malls to purchase items.
- **Orientation Day 1 (Saturday 8/18): Welcome Day!**
  - Welcome to Campus
  - F-1 Regulations Overview
  - American Medical System – Crouse
  - Campus Tour
  - American Classroom Culture/Expectations
  - University Police Safety
- **Orientation Day 2 (Sunday 8/19): About ESF!**
  - Culture Shock and Counseling Services
  - English Language Support Services
  - Student Activities/Affairs/Clubs
  - ESF History/Culture
  - Diversity BBQ
- **Transfer Student Orientation (Friday, 8/24)**
  - Conversation with Dean
  - Registration Tutorial
  - Social Lunch
  - ESF Welcome Convocation

SIGN UP NOW
ORIENTATION

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Example of course in Syracuse, New York: **BPE 440 Bioprocess Kinetics and Systems Engineering Lab**

This laboratory exercise is not prescriptive but rather discovery or implementation based, i.e. the students are asked to investigate a chemical or biological process. Each student is assigned to lead an investigation, and participate in other experimentations. In all these cases the approach is to use the intellect and put it into action rather than repeat some ideas learned in a text book. Students learn how to lead an investigation, design an experiment, execute a project, and also how to play a supportive role. While this approach can lead to some frustration and especially hard in the beginning of the lab course, the rewards are without doubt. Through a project based approach students will learn to implement the theory into practical solution to real problems. They will not only learn about the theory and the problem solving on paper but will learn how to implement the solutions on products and as a result will have valuable skills. As some of the course summaries will show the students gained significant hands-on experience in the problems that they had to solve in the project centered courses.

BPE 498 Individual Research Experience

This is a course designed for students on an induvial basis. Students can elect to perform a project with the guidance of a professor from the Department of Chemical Engineering as well as other related departments, such as Environmental Resources Engineering, Chemistry and Biology. Students generally select a project of their own interest and work/partner with a graduate student on a specific project. Students learn the lab skills as well as the fundamental knowledge surrounding the related subject. At the end of the course, students present either a presentation or an essay. Some of these work eventually get published in a scientific journal along with the graduate student and advisor.

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Student Success

ESF and BUCT started a dual degree program, 3+1 BS Bioprocess Engineering program since the Fall of 2010. For past five cohorts of students who graduated from ESF, the majority of students directly entered into graduate school. Table 1. Shows the percentage of graduates entered graduate school right after graduation. One can observe that at least 70% of graduates entered graduation right after graduation, except the cohort graduated in 2021. For this particular cohort, students were not able to come to ESF's Syracuse campus and the instruction had to be completed online owing to the Covid-19 pandemic.

Table 1. Graduate School admission rate at the time of graduation.

Year of graduation	Percentage of students entered graduate school
2023	83.3%
2022	70%
2021	63.6%
2020	74.2%
2019	73.7%

Each year, a special survey was conducted for the experience of "BUCT" students at ESF. Student's experience has been consistently positive.

Picture above, the graduation ceremony (May, 2023). Five BUCT students are clearly in the view.

Picture above, the graduation day photo (May, 2023). 10 BUCT students appeared in this photo.

Sample Student Work

ANTIOXIDANTS AS ACTIVE INGREDIENTS FOR ACTIVE PACKAGING SYSTEM

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BPE 498

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NOVEMBER 27, 2023

Contents

Abstract

With the rapid development of express delivery as 88% people live in cities rather than villages, how to keep the food fresh during delivery and storage has become an important topic (Pew Research Center,2018). One of the most common methods is using antioxidants to make active packaging (AP). Essential oils (EOs) are plant-extracted volatile aromatic compounds that have been the center of attention several types of research owing to their potential in food as natural additives and active ingredients with antimicrobial and antioxidant properties. Ginger, turmeric and plai are some common kind of EOs which have strong antioxidant properties.

Key words: Active packaging, Essential oils, redox reaction.

Introduction

As more and more people choose delivery to get food, the food packaging is getting more and more attention. Nowadays, 30%-40% of food is wasted each year in the USA. According to USDA Economic Research Service estimates, 40% of the loss occurs at Poor storage and care during transportation (Recycle Track Systems,2020). However, the traditional food packaging can't afford people's needs, so the active packaging was born at the right moment. Customers now judge food quality base on the appearance of freshness and the environmental implications of packaging (Rizzo, Valeria ; Muratore, Giuseppe,2021). If using chemical compounds, people will have worries about the safety for people's health and the environment, so people pay attention to biodegradable packaging (European Commission, 2004,2009).

Essential oils (EOs) can be great antioxidants for active packaging as they are from nature. EOs are all from plants so that they will not hurt people's health. Compared with traditional food packaging, the most special thing for active packaging is that can protect the food by having effects with food and active ingredients in packaging (Almenar et al., 2007). EOs can have redox reactions with the surface of food or the environment. Some EOs have hypervalent metal ions so that can have a reduction reaction that can reduce the concentration of oxygen. Some EOs have hydroxyls which can be combined with peroxidants. EOs can be extracted by hydro distillation and steam distillation. In general, EOs can extend the shelf-life of food by having films and coatings on the surface of food. EOs will have redox reactions to making the films and coatings. Distillations can get EOs easily.

In this paper, we will use ginger, turmeric and plai as examples to introduce the theories of EOs antioxidant. From Tongnuanchan (2013), we can find that adding ginger, turmeric and plai can increase the antioxidant of packaging.

This report will focus on the ways EOs as antioxidant ingredients for active packaging.

Active packaging

Active packaging (AP) is a new food technology which plays a positive role in protecting food quality and safety. Compared with traditional plastic packaging, AP will not be harmful to both human and environment. In general, the package has some active ingredients that can have beneficial effects on the environment in the packaging, so that they can extend the product's shelf life. (Almenar et al., 2007).. The active ingredients in AP have the capability to absorb from the packaging and release into the food, thereby preserving its freshness (Ribeiro-Santos et al., 2017). These ingredients may be housed in a separate container or incorporated directly into the active packaging (European Commission, 2004,2009). The adoption of active packaging extends the shelf life of the food, contributing to a reduction in food waste (Dainelli et al., 2008; Ozdemir & Floros, 2004; Suppakul et al., 2003; Vermeiren et al., 2000; Galanakis, 2012). In one word, active packaging is divided into non-migrating and active-release packaging. Non-migrating packaging is designed to remove unwanted components from the environment without direct contact with the product. Meanwhile, active-release packaging uses emitters that allow controlled migration of the desired substance to directly affect the product (Technol,2017)

Additives for AP

There are many kinds of active ingredients which can add in AP, such as such as the use bio nanocomposite materials as packing materials (J.J. Palechor.el, 2021), production of cellulose-containing food packaging, gelatin packaging or coating to enhance food shelf life, intelligent system to monitor and predict packaged food contamination, and novel development of materials for food packaging (A. Rodríguez-Rojas.el, 2019); EOs are extracted from diverse parts of a plant such as seeds, leaves, flowers, buds, bark, wood, root, and so on. They are volatile aromatic liquids and are plant-synthesized secondary metabolites composed of low molecular weight compounds (James S. Chacha.el, 2020). As the Eos are from nature and harmless to human bodies, people pay more attention to adding EOs rather can chemistry into the active packaging.

The use of EOs in AP

In active packaging, EOs can be films or coatings. EOs and the oxygen and water will have reactions and then the films will have (Krochta, 2002). The films will exist between the food and the packaging. The coatings are films formed in the product. The EOs will have reactions with the surface oil or protein of the food and then the surface will become dry, so that there will be a coating to protect the food.. The films and coatings can protect the food from water, oxygen, oil and so on. They also can reduce bruising and breakage (Krochta, 2002). Until now research, films and coating will not hurt people's health (Krochta, 2002).

Use ginger, turmeric and plai as examples. From Tongnuanchan (2013), we can find that adding ginger, turmeric and plai can increase the antioxidant of packaging. Tongnuanchan (2013) added Eos into the Gelatin firm.so that there will have a bilayer film (Figure 3). DPPH and ABTS radical scavenging activity can be the standard for antioxidants. The HDDP number is higher, the antioxidant is better. Table1 shows the difference between adding EOs and no EOs.

P. Tongnuanchan et al. / Journal of Food Engineering 117 (2013) 350–360

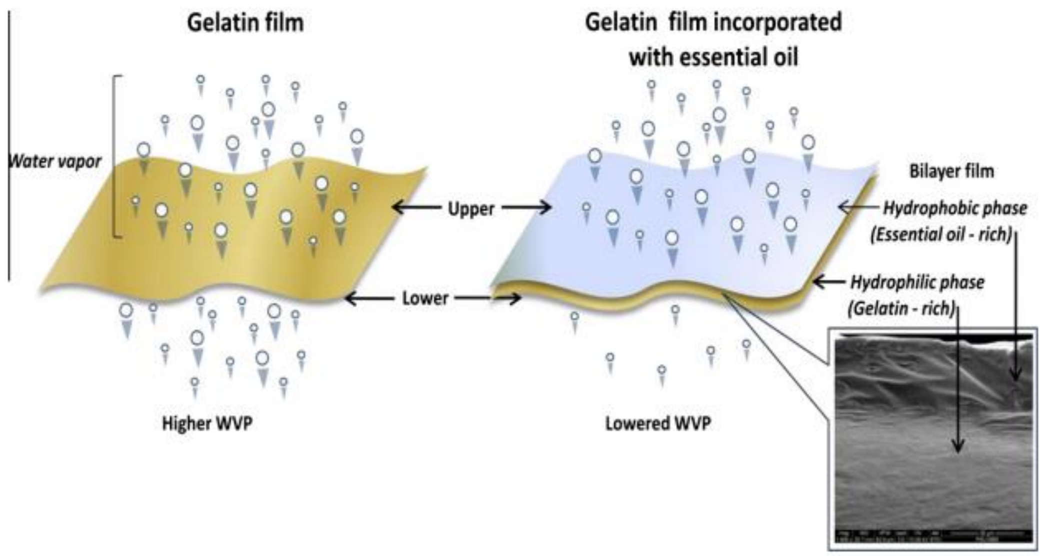

Figure 3 The gelatin film and EOs

Antioxidant activity of films from fish skin gelatin incorporated with ginger, turmeric and plai essential oils at different levels.

Essential oils	Level of incorporation (% based on protein content)	Antioxidant activity (μmol Trolox equivalents (TE)/g dried film)	
		DPPH	ABTS
Control	Without essential oil	0.07 ± 0.08f[a]	0.49 ± 0.31i
Ginger	25	0.26 ± 0.13f	3.47 ± 0.03h
	50	0.66 ± 0.12e	6.97 ± 0.20g
	100	1.30 ± 0.13c	13.43 ± 0.22d
Turmeric root	25	0.72 ± 0.09de	8.96 ± 0.11f
	50	1.41 ± 0.13c	16.52 ± 0.25c
	100	1.97 ± 0.10b	20.26 ± 0.14a
Plai	25	0.95 ± 0.12d	8.68 ± 0.17f
	50	1.90 ± 0.12b	12.34 ± 0.31e
	100	2.39 ± 0.02a	19.51 ± 0.14b

Different letters in the same column indicate significant differences ($p < 0.05$).
[a] Mean ± SD ($n = 3$).

Table 1, the difference of DPPH between adding EOs and no EOs.

The greatest challenge of food packaging is monitoring the compounds from packaging to food, which can be poisonous (Andre, Castanheira, Cruz, Paseiro, & Sanches-Silva, 2010; Cruz, Sanches Silva, Sendon García, Franz, & Paseiro Losada, 2008; Sanches-Silva, Freire, Franz, & Losada, 2008; Sendon et al., 2012). Nowadays more people will be worried about this, so EOs are an important choice for active food packaging as EOs will not be harmful for people’s health until nowadays research.

However, there are still some problems. First, EOs have a strong smell. This smell can limit the use for food. Second, its biological activity is also different due to different qualitative and quantitative of bioactive compounds. The most important problem is the irreproducibility of the active of EOs is a major setback to its use (James S. Chacha, Chigozie E. Ofoedu, Kaijun Xiao, 2020).

Ways to extract EOs.

1. Hydro distillation. This is the simplest and oldest method to get EOs. This way is putting the plants into the water, and then boil the mixture. The main advantage of hydro-distillation is the extraction from the hydrophobic plants with a high boiling point and the technique is capable of extracting the plant material under 100 ◦C (Sharma et al., 2021). Historically, Avicenna, (980–1037), was the first person who used the alembic-developed extraction. He extracted the first pure essential oil from the rose. Immerse the plant material directly in the water and make the water boil. The extraction device includes a source of heating and has a vessel above the heater, in which we could put plant material and water. The set up also comprises a condenser and a decanter to collect the condensate and to separate EOs from water, respectively (Figure. 1). The extraction's principle is based on azeotropic distillation. In fact, during heating extraction process at atmospheric pressure, water and EOs molecules can form a heterogeneous mixture whose boiling temperature is a lower point close to 100 °C, while for EOs components this point is very high (Asbahani et al., 2015). This way is very easy to implement. However, this way will have some drawbacks. One is the long time that some EOs will be hydrolyzed (Bohra et al., 1994).

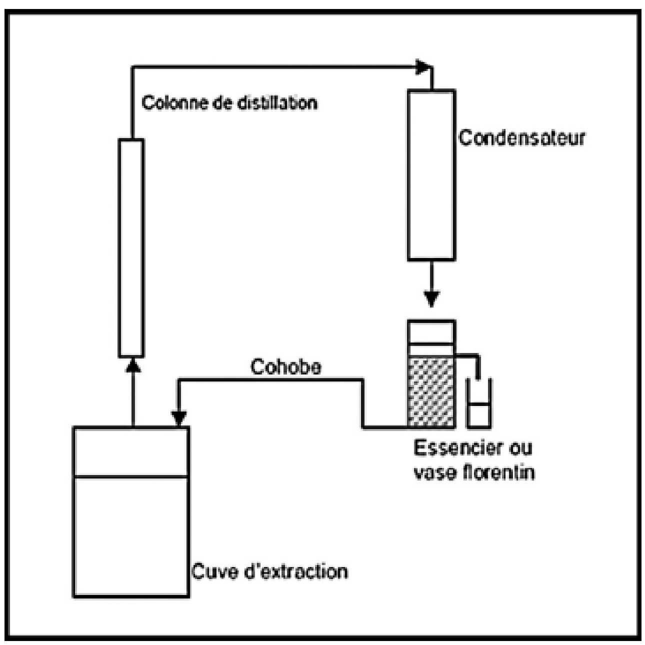

Figure 1. The flow chart of collecting the condensate and separating EOs from water. Source:

2. Steam distillation. Steam distillation is the most widely used method for extracting EOs. Generally, place the plant sample into boiling water and use the steam to heat (Figure 2). The theory of this way to get EOs is the stream can burst and breakdown of cell structure of plant material is the heat, so the aromatic compounds or essential oils from plant material are released (Perineau and others 1992; Babu and Kaul 2005). The temperature of heating must be enough to break down the plant material and release aromatic compounds essential (Tongnuanchan & Benjakul, 2014).

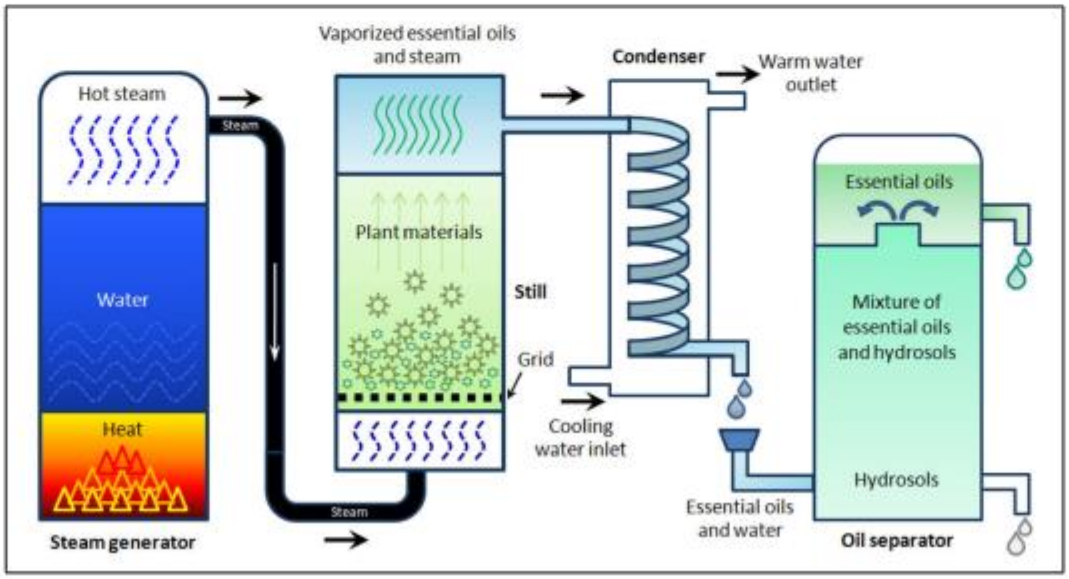

Figure.2 Diagrammatic illustration of steam distillation method. Source:

The theory of EOs as antioxidant

There are two ways to have antioxidants. One is having the strong oxidizing property. For example, hypervalent metal ions can reduce the concentration of oxygen by reduction reaction, so that the oxidation process will be stopped. One is having strong reducing property. For example, hydroxyl can lease the hydrogen atom, combined with peroxide, so that the oxidation process will be stopped. EOs can have strong oxidizing property and reducing property. (Gulcin, 2020)

The ways EOs can be antioxidant is that EOs have hydroxide radical. The hydroxide l radical's hydrogen atom can donate to free radicals, so that EOs have strong oxidability and reductibility (Kumar and others 2005). Also, some EOs have strong reductibility as they have hypervalent iron ions like clove and iganum (Teixeira and others 2013). Then, the internal PH will be changed, and the free chain will be disrupted (James S.el, 2020). EOs also can interact with important microbial enzymes to disrupt the free chain, owing to the hydrophobicity property that allows their permeation through the microbial cell membrane lipids.

Conclusion

In summary, lipid oxidation is the major reason for food loss. EOs are proved that they are nature and harmless for people's health. The EOs also very easy to extract. Therefore, EOs can be great ingredients for active food packaging and reduce the use of chemical compounds. There are abundant factors that will influence the EOs, like the temperature, the kind of EOs, the time of contact. Ginger, turmeric and plai can have good antioxidant when are added in packaging. However, there is a lack of studies on the possible side effects resulting from the prolonged use of EOs in food packaging. In the future, harmless active packaging will be the trend for food packaging.

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北京化工大学（BUCT）和

纽约州立大学环境科学与林业学院（SUNY ESF）

就生物工程本科合作教育项目之
评估报告

Shijie Liu，北京化工大学与纽约州立大学环境科学与林业学院
——生物工程项目主任兼教授

2024 年 2 月 20 日

Samuel Mukasa, 纽约州立大学环境科学与林业学院
——常务副校长兼教务长

2024 年 2 月 20 日

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概述

北京化工大学与纽约州立大学环境科学与林业学院（BUCT-ESF）——生物工程合作项目于 2015 年启动。上次评估于 2018 年完成。两所大学之间的合作已经推广到各个领域，包括课程改进以及纽约州立大学环境科学与林业学院（ESF）赴中授课讲师的招聘和协调。

SUNY ESF

纽约州立大学环境科学与林业学院（SUNY ESF）是美国最早致力于环境研究、开发可再生技术和建设可持续未来的少数几家院校之一。我们试图解决这个星球上最迫切的问题，而学生们之所以来到这里，是因为他们希望投身于解决这一问题的事业中。

我们的学生、教师、员工和校友在改善和维护环境方面产生了全球性的影响。我们提供世界一流的教育，我们有 2000 多名学人，他们有共同的价值观和使命感，构成了一个关系紧密的集体。

赴中授课

自该项目启动以来，来自纽约州立大学环境科学与林业学院（ESF）的资深教授已经在北京化工大学（BUCT）教授该项目下的各种课程。这些课程包括生物进程工程领域的必修课程。超过 1/3 项目课程由纽约州立大学环境科学与林业学院（ESF）教师提供授课。在北京化工大学（BUCT）的授课人员均具有各自领域最高学位的最高水准，并在其任教课程方面拥有多年经验。在教学期间，北京化工大学（BUCT）指派了一名助教，与纽约学院讲师合作，专门负责学生与讲师之间联络。助教的这种安排非常有效，保证了学生和教师间的顺畅沟通。此外，北京化工大学（BUCT）还安排了一些学生担任纽约学院教师的生活助理，以满足其在课堂外的各种具体需求，如到机场接机，协调居住事宜，旅行安排，确保讲师知道校园周围交通，以及向同学、学校和相关工作人员传达与教学相关的重要信息。此类合作安排对纽约州立大学环境科学与林业学院（ESF）讲师和北京化工大学（BUCT）学生和管理人员来说，都非常有效。

中国的教育模式与方法和美国大相径庭。北京化工大学（BUCT）课程教学具有代表性风格，包括授课、解决课本和考试中的问题。即使是实验室活动，也有其严格的规定，这意味着所有的指令都是一步一步给出的，学生甚至不用过多思考，只需遵循指令，然后以系统的方式报告结果即可，理解思路却显得不那么重要。相反纽约州立大学环境科学与林业学院（ESF）的课程性质有所不同。虽然讲课依然是核心课程结构的一部分，但是，作业中包含更多开放性问题，大多数课程都要求将在课堂上学到的理论应用到实践中。虽然这种开放式方法对讲师和学生来说哦都是一大挑战，但却也能带来巨大回报。开放式问题和/或项目让学生产生更强的主人翁意识，促使他们更多地参与到自己的学习过程中，并在过程中更加地积极主动。

英语水平

英语并不是所有在华学生的第一语言。在到达纽约州立大学环境科学与林业学院（ESF）之前，学生必须熟练掌握英语。为尽可能让所有学生满足这一要求，各方都付出了巨大的努力。北京化工大学（BUCT）为学生们开设了许多英语教学课程，帮助学生们

做好入学前的准备工作。纽约州立大学环境科学与林业学院（ESF）在北京化工大学（BUCT）提供了两门英语写作课程。教授写作、技术/科学写作和演讲技巧的英语写作课程实现了与技术课程的作业协调。通常，写作课程会要求各种不同形式的报告，并且，在很多纽约州立大学环境科学与林业学院（ESF）教员指导课程中，还要求技术报告。随后，

通过对此进行审查并提供反馈，进行改进。针对技术演示也采取同样做法。然后，在技术课堂上，改进后的报告或技术展示被作为提交材料进行提交。在纽约州立大学环境科学与林业学院（ESF）学习年度结束时，学生在几乎所有参加的课程中都进行了演讲。他们总体表现非常出色。

随着英语教学和培训的成功，纽约州立大学环境科学与林业学院（ESF）随后实施了一项政策，即所有通过写作课程的学生不再需要出示其他任何其他英语语言技能测试成绩，便可进入纽约州立大学环境科学与林业学院（ESF）纽约州雪城校区学习。所有学生都会接受评估，并被一视同仁，就好像他们一直在纽约州立大学环境科学与林业学院（ESF）校园里一样。

学生支持

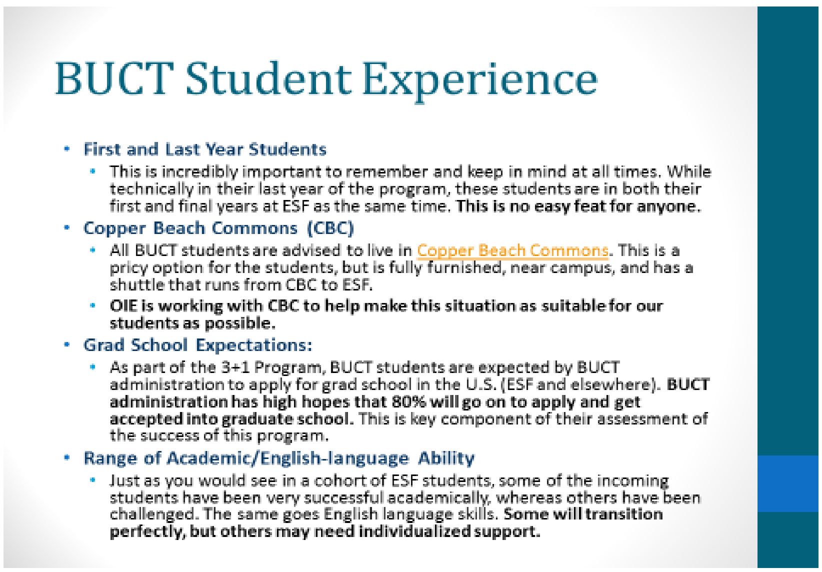
除了全体教员或讲师外，纽约州立大学环境科学与林业学院（ESF）还会定期派员工到北京化工大学（BUCT）与学生进行互动。通过互动，学生将会了解到转入纽约州立大学环境科学与林业学院（ESF）纽约州雪城校区的流程，以及在雪城的预期生活情况。

以上照片是纽约州立大学环境科学与林业学院（ESF）国际办副主任（Thomas Carter，第一排，左），北京化工大学与纽约州立大学环境科学与林业学院（BUCT-ESF）联合教育项目主任（Shijie Liu，第一排，右）和招生办副主任（Thomas Fletcher，第二排，左）与2015 级学生互动后的照片。

这些学生在进入纽约州立大学环境科学与林业学院（ESF）纽约州雪城校区学习之后，“特别”关注或支持并不会停止。例如，在将北京化工大学（BUCT）的学习转移到雪城纽约州立大学环境科学与林业学院（ESF）的学习过程中，配套有针对所有学生的辅导体系。

纽约州立大学环境科学与林业学院（ESF）课堂上的学生活动和课堂体验的突出表现

为帮助学生在纽约雪城安顿下来，ESF 专门为他们量身定制了一些活动，如下所示：



ESF
纽约州立大学
环境科学与林业学院
化学工程系

纽约州雪城校区课程案例：**BPE 440 生物进程动力学与系统工程实验室**

该实验室操作不是规定性的，而是基于发现或实施展开，即：要求学生调查化学或生物学过程。每个学生都被指派牵头进行调查，并参与其他实验。在所有这些情况下，能采用的方法就是动脑思考并付诸行动，而不是重复教科书中所学到的一些想法。学生要学习如何带头调研，设计实验，执行项目，以及如何发挥支持作用。虽然这种方法可能会对学生造成挫折，并且在实验课程开始时会格外困难，但是，回报也切实可观。通过项目依托式方法，学生将会学会将理论应用于解决实际问题的实际解决方案。他们不仅会学习理论知识和解答考试中的问题，还会学会如何针对产品实施解决方案，从而获得宝贵的技能。同样，一些课程总结还会显示出学生在项目导向课程中在解决问题方面的重要实践经验。

BPE498 个人研究体验

这是为学生个别设计的课程。学生可选择在有关教授的指导下实施某个项目，这些教授来自化学工程系和其他相关系别，如环境资源工程系，化学系和生物系。通常，学生会选择符合自身兴趣的项目，并在具体的项目中与研究生合作/协作。学生学到了实验室技能和相关科目的基本知识。在课程结束时，学生须提交一份演示文稿或一篇论文。这些作品中的一部分将在有关科学杂志上发表，与研究生和顾问的研究成果一并公之于众。

学生成功经验

自 2010 年秋季以来，纽约州立大学环境科学与林业学院（ESF）和北京化工大学（BUCT）开始了双学位课程“3+1 生物进程工程项目”。最近五年来，在毕业于纽约州立

大学环境科学与林业学院（ESF）的学生中，多数直接进入了研究生院。表 1.显示了毕业后直接进入研究生院的毕业生所占比例。从中可以看出，除 2021 年的毕业生外，其他年份至少有 70%的毕业生在毕业后直接进入了研究生院。由于新冠疫情的影响，2021 年的毕业生未能进入纽约州立大学环境科学与林业学院（ESF）纽约州雪城校区，教学是在线上进行的。

表 1.毕业时，研究生院的录取率。

毕业年份	进入研究生院的学生所占比例
2023	83.3%
2022	70%
2021	63.6%
2020	74.2%
2019	73.7%

纽约州立大学
环境科学与林业学院
化学工程系

每年对北京化工大学（BUCT）学生在纽约州立大学环境科学与林业学院（ESF）的学习体验进行一次特别调查。学生的体验始终是积极的。

上图是毕业典礼日合影（2023 年 5 月）。来自北京化工大学（BUCT）的五名学生很清晰。

上图是毕业日合影（2023 年 5 月）。照片中有来自北京化工大学（BUCT）的 10 名学生。

学生作品示例

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活性包装系统中的活性成分

（抗氧化剂）

Sarah Liu

BPE 498

Dr. Ericka Redmond

2023年11月27日

目录

摘要

今天，多达 88%的人们生活在城市里，快递业随之迅速发展。因此，运输储存过程中的食物保鲜问题成为一个重要的话题（皮尤研究中心，2018 年）。最常用的一种保鲜方法是使用抗氧化剂制作活性包装（AP）。精油（EO）是从植物中提取出的挥发性芳香族化合物，具有抗菌性和抗氧化性，有可能用作食品天然添加剂和活性成分，相关人士已展开多种重点研究。生姜、姜黄和 Plai 属于常见精油，具有很强的抗氧化性能。

关键词：活性包装，精油，氧化还原反应。

简介

随着越来越多的人们选择外卖餐饮，食品包装日益受到人们的关注。如今，美国每年的食物浪费率高达 30%~40%。据美国农业部经济研究处估计，40%的食物浪费是由于运输过程中储存和保护不当造成的（回收跟踪系统，2020 年）。传统的食品包装已无法满足人们的需求，因此活性包装应运而生。现在，顾客会根据食品外观的新鲜度和包装的环境影响来判断食品的质量（Rizzo，Valeria；Muratore，Giuseppe，2021 年）。化合物包装会影响人体健康、污染环境，因此人们开始关注可生物降解类包装（欧洲委员会，2004 年，2009 年）。

精油取材天然，是活性包装中很好的抗氧化剂。精油均从植物中提取而来，不会损害人体健康。与传统食品包装相比，活性包装有其独到之处，可与食品和活性成分发生反应，进而保护食品（Almenar 等人，2007 年）。精油可与食品表面或环境发生氧化还原反应。某些精油含有高价金属离子，会发生还原反应，从而降低氧气浓度。而某些精油则带有羟基，可与过氧化物结合。可通过水蒸馏法和蒸汽蒸馏法提取精油。一般来说，可通过在食品表面形成精油薄膜和涂层来延长食品的保质期。精油会通过氧化还原反应生成薄膜和涂层。蒸馏法可轻松生成精油。

本文以生姜、姜黄和 Plai 为例，介绍了精油抗氧化剂的原理。Tongunanchan（2013 年）的资料显示，添加生姜、姜黄和 Plai 可以增强包装的抗氧化性。

本报告重点介绍精油作为抗氧化成分用于活性包装的方法。

活性包装

活性包装（AP）是一种新型食品技术，在保护食品质量安全方面发挥着积极的作用。与传统塑料包装相比，活性包装不会对人体和环境造成危害。一般而言，包装中含有一些对环境有益的活性成分，能够延长产品的保质期。活性包装中的活性成分能够从包装中吸收，并释放到食品中去，从而保持食品的新鲜度。这些成分可在单独容器中存放，或直接加入活性包装中（欧盟委员会，2004 年，2009 年）。采用活性包装可延长食品保质期，有助于减少食物浪费（Dainelli 等人，2008 年；Ozdemir 与 Floros，2004 年；Suppakul 等人，2003 年；vermeren 等人，2000 年；Galanakis，2012 年）。简而言之，活性包装分为非迁移型包装和释放型活性包装。非迁移型包装旨在从环境中移除有害成分，以免直接接触产品。同时，活性释放型包装使用释放器控制所需物质的迁移，从而对产品产生直接影响（Technol，2017 年）。

活性包装添加剂

活性包装中可以添加多种活性成分，如利用生物纳米复合材料作为包装材料（J.J. Palechor 等人，2021 年），生产含纤维素的食品包装，延长食品保质期的明胶包装或涂层，监测与预测包装食品污染的智能系统，以及开发新型食品包装材料（A. Rodríguez-Rojas 等人，2019 年）；精油可从植物的不同部位中提取，如种子、叶、花、芽、树皮、木材、根等。精油属于挥发性芳香液体，是植物合成型次生代谢物，由低分子量化合物组成（James S. Chacha 等人，2020 年）。由于精油取材天然，对人体无害，人们更愿意在活性包装中添加精油，用以取代化学物质。

精油在活性包装中的使用

活性包装可采用精油薄膜，也可采用精油涂层。精油、氧气和水会发生反应，薄膜将随之发生反应（Krochta，2002 年）。薄膜将存在于食品和包装之间。涂层则是在产品中形成的薄膜。精油会与食品表面的油或蛋白质发生反应，使食品表面变得干燥，从而产生一层可保护食品的涂层。薄膜和涂层可以保护食品免受水、氧、油等物质的侵害。还可减少擦伤和破损（Krochta，2002 年）。迄今为止，尚无研究发现薄膜和涂层会损害人体健康（Krochta，2002 年）。

我们以姜、姜黄和 Plai 为例予以说明。Tongunanchan（2013 年）的资料显示，添加生姜、姜黄和 Plai 可以增强包装的抗氧化性。Tongnuanchan（2013 年）将精油加入明胶涂层，形成双层薄膜（图 3）。DPPH 和 ABTS 自由基清除活性是衡量抗氧化剂的标准。HDDP 值越高，抗氧化性就越好。表 1 为是否添加精油的效果差异。

图 3 明胶薄膜与精油

鱼皮明胶薄膜中掺入不同含量的姜、姜黄和 Plai 精油后的抗氧化活性。

精油	掺入量（按蛋白质含量百分比计）	抗氧化活性（μmol Trolox 当量（TE）/g 干化膜）	
		DPPH	ABTS
控制生姜 姜黄根 Plai	不含精油 25 50 100 25 50 100 25 50 100	0.07 ± 0.08f[a] 0.26 ± 0.13f 0.66 ± 0.12e 1.30 ± 0.13c 0.72 ± 0.09de 1.41 ± 0.13c 1.97 ± 0.10b 0.95 ± 0.12d 1.90 ± 0.12b 2.39 ± 0.02a	0.49 ± 0.31i 3.47 ± 0.03h 6.97 ± 0.20g 13.43 ± 0.22d 8.96 ± 0.11f 16.52 ± 0.25c 20.26 ± 0.14a 8.68 ± 0.17f 12.34 ± 0.31e 19.51 ± 0.14b

同列中的不同字母表示差异明显（P<0.05）。

[a] 平均值±SD（n=3）

表 1. 是否添加精油的 DPPH 差异。

食品包装的最大挑战是监测从包装侵入到食品的化合物，而这些化合物有可能具有毒性（Andre，Castanheira、Cruz、Paseiro 与 Sanches-Silva，2010 年；Cruz、Sanches Silva、Sendon García、Franz 与 Paseiro Losada，2008 年；Sanches-Silva、Freire、Franz 与 Losada，2008 年；Sendon 等人，2012 年）。现在越来越多的人对此表示担忧，所以精油是活性食品包装的一项重要选择。迄今为止，尚无研究表明精油会损害人体健康。

然而，仍然存在一些问题。首先，精油气味浓烈，此气味会限制其在食品包装方面的应用。其次，根据生物活性化合物的不同定性和定量，其生物活性也会有所不同。最大的问题是精油活性的非再生性，使其用途大打折扣（James S. Chacha，Chigozie E. Ofoedu，Kaijun Xiao，2020 年）。

精油提取方法

1. 水蒸馏法。水蒸馏法是获得精油最简单最古老的方法。这种方法是将植物放入水中，然后将水煮沸。水蒸馏法的主要优点是从高沸点疏水植物中提取物质，此方法能在 100°C 下提取出植物材料。历史上，Avicenna（980-1037）首次使用蒸馏器提取物质，他从玫瑰花中提取出第一种纯精油。具体做法是将植物材料直接浸入水中，然后将水煮沸。所用的提取装置包括一个热源（加热器），在热源上方放置的一个容器，在容器内放入植物材料和水。该装置还包括一

个冷凝器和一个玻璃瓶，分别用于收集冷凝液和分离精油（图 1）。提取原理以共沸蒸馏为基础。实际上，在常压加热提取过程中，水和精油分子可形成非均相混合物，沸点较低，接近 100℃，而精油组分的沸点非常高。这种方法很容易实施，但也会有一些缺点。一方面，某些精油水解时间较长（Bohra 等人，1994 年）。

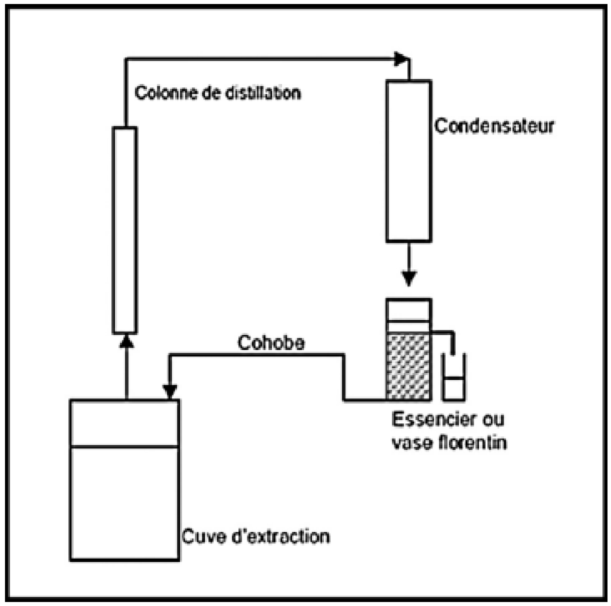
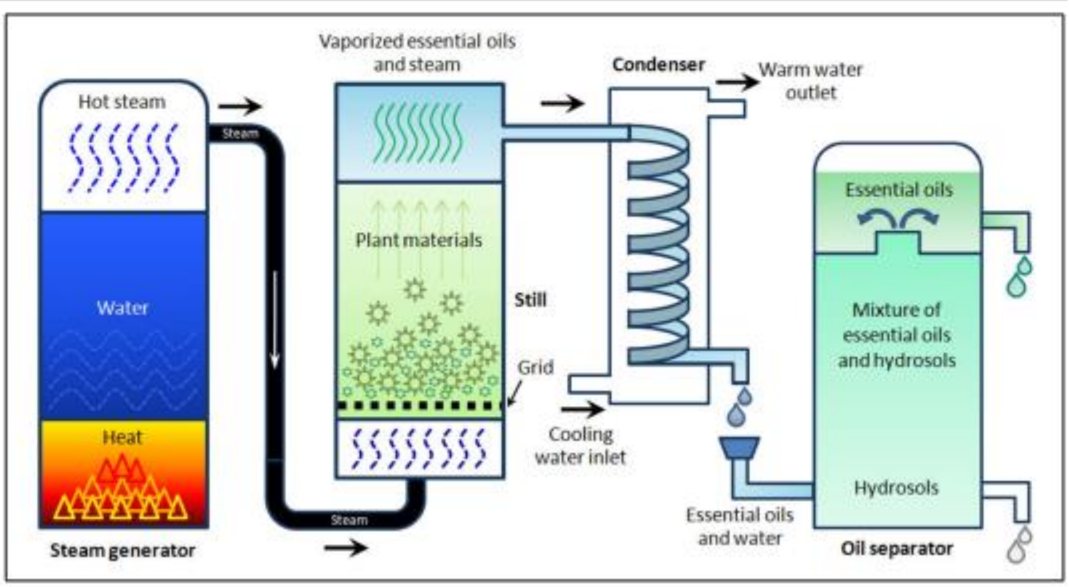


图 1.凝结水收集和精油分离流程图。来源：

2. 蒸汽蒸馏。蒸汽蒸馏法是提取精油最常使用的方法。一般情况下，将植物样品放入沸水中，用蒸汽加热（图 2）。这种方法提取精油的理论是，植物材料的细胞结构被热破坏后，释放出芳香族化合物或精油（Perineau 等人，1992 年；Babu 和 Kaul，2005 年）。加热温度必须足以分解植物材料，并释放出芳香族化合物成分。



Hot steam 热蒸汽	Vaporized essential oils and steam 蒸发的精油和蒸汽	Condenser 冷凝器	Warm water outlet 温水出口
Water 水	Plant materials 植物材料	still 蒸馏器	Essential oils 精油
Heat 热	Steam 蒸汽	Grid 网格	Mixture of essential oils and hydrosols 精油与水溶胶的混合物
Steam generator 蒸汽发生器		Cooling water inlet 冷却水进口	Hydrosols 水溶胶
			Oil separator 油水分离器

图 2 蒸汽蒸馏法图解。来源：

精油抗氧化剂理论

有两种方法可以获取抗氧化剂。一种是取得强氧化性。例如，高价金属离子可通过还原反应降低氧浓度，从而终止氧化过程。另一种方法是取得强还原性。例如，羟基可捕获氢原子，与过氧化物相结合，从而终止氧化过程。精油具有较强的氧化性和还原性（Gulcin，2020）。

精油之所以能成为抗氧化剂，是因为其具有羟基自由基。羟基自由基的氢原子可以转移给自由基，使精油获得很强的氧化性和还原性（Kumar 等，2005 年）。此外，某些精油因为含有丁香和甘菊等高价铁离子，还具有很强的还原性（Teixeira 等人，2013 年）。之后，内部 PH 会发生变化，使自由链发生破坏（James S.等人，2020 年）。由于疏水性可使精油渗出微生物细胞膜脂质，所以精油还可与重要的微生物酶相互作用，破坏自由链。

结论

总之，脂质氧化是食品损失的主要原因。试验证明，精油属于天然物质，对人体健康无害。另外，精油也易于提取。因此，精油可用作活性食品包装的重要成分，从而减少化学化合物的使用。影响精油的因素很多，比如温度、精油种类和接触时间等。在包装中加入生姜、姜黄和 Plai，可发挥良好的抗氧化作用。然而，食品包装中长期使用精油是否有副作用，尚缺乏相关的研究。未来，无害活性包装将是食品包装的趋势。

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