Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Investigation)

(Word Limit: 1,600 words, Pages: 3 pages only)

Team Number: JBBC089

Project Title: A Study of the effect of basic cooking methods on the rate of racemization of amino acids (消旋匿跡)

Project Type: Investigation

***To our best knowledge, there are similar works in the field*; related research links are as below:**

Ito, H.; Kikuzaki, H.; Ueno, H. Effects of Cooking Methods on Free Amino Acid Contents in Vegetables. *J. Nutr. Sci. Vitaminol. (Tokyo)* 2019, *65* (3), 264–271. https://doi.org/10.3177/jnsv.65.264.

The enhancement our project made / the difference with related research are:

The above research is focusing on the change of the amount of different amino acids of the vegetables separated by acid hydrolysis of protein and C-18 column chromatography under different cooking method. Our project is focusing on the rate of racemization of amino acid determined by self-made polarimeter and its potential effect to human health. Parameters including pH environment and the presence of glucose are examined.

I. Background

Cooking at home has been more common than ever since the social distancing measures against COVID-19, and more cooking methods have been introduced and developed since then. The public is introduced to many different cooking methods. However, inappropriate cooking methods may jeopardize people's health as they would facilitate the formation of poisonous or carcinogenic compounds from normal food ingredients.

The main component of nutrition includes fat, carbohydrates and protein. L-amino acids(A.A.) found in food are proved to be able to change into D-amino acids with the presence of water or base through racemization. The above process is called racemization. Some D-amino acids are reported to be less nutritional and more cancerous. We will test the effect of temperature, pH value and presence of glucose to the rate of racemization. We want to find out the best cooking method to reduce racemization and thus reduce nutritional loss and cancerous growth.

The above change from L-enantiomer to D-enantiomer of amino acids can be measured by polarimeter through the change of optical rotation. Therefore, a polarimeter is designed to fulfill our experimental need.

II. Objectives

1. To find out the best cooking method
2. To provide health suggestions to the public about effect of different cooking methods to human health

III. Hypothesis

Different cooking methods can induce different degrees of racemization. Conditions, such as high temperature alkaline medium and the presence of glucose, are expected to increase the rate of racemization, and potentially posing negative effects on human health. Lower pH is expected to decrease the rate of racemization and potentially can be a solution to reduce the negative effects.

IV. Methodology

Polarimeter

We have designed our own polarimeter for obtaining the optical rotation, which highly reduces the cost of the experiment. The latest prototype of the polarimeter is python-coded with raspberry pi.

Materials and experimental set-up

Materials	Quantity
Raspberry pi	1
3D printed shell	1
Laser	1
Polarizer	2
Plastic tube	1
Light sensor	1
Servo	1

We used the following setup to simulate different cooking methods

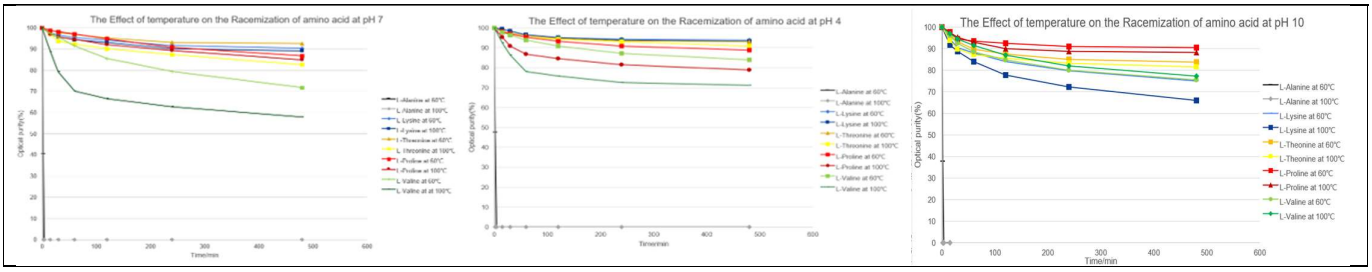
- Water bath(slow cooking and boiling)
- Autoclave (Baking)
- Microwavable sample vials (microwave cooking)

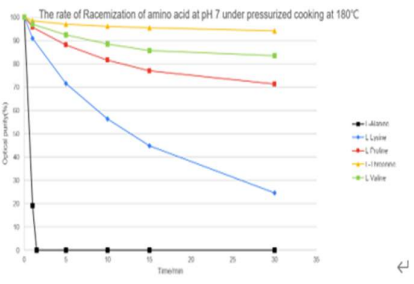
Procedures

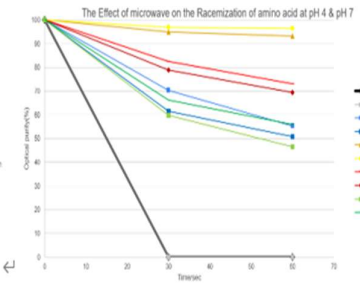
1. Dissolve amino acid in pH buffer with concentration according to the full report.
2. Add 2 mL of the pH 4/ 7 buffer to the solution to fill up the solution to 10 mL
3. Transfer the A.A.s into the polarimeter and test for the optical rotation of the amino acid.
4. Transfer the A.A.s solution into a 10 mL measuring cylinder.
5. Put the A.A. solution in one of the following set-ups for the designated time.
    a. Water Bath
        A water bath is designed to simulate boiling and slow cooking method. Measuring cylinders containing A.A.s were half-immersed in water and heated to 60℃ or 100℃.
    b. Autoclave
        Autoclave is used to simulate the ultra-high temperature of disinfection (UHT, which seats at a round 150℃), frying, and baking method. The A.A.s will be stored in an autoclave for testing and the pressurized can will be heated in an oven.
    c. Microwave
        Microwave sample vials are used in the experiments regarding microwave heating. The solution is cooled down naturally as a safety precaution of immediate cook-down.
6. Cool down the A.A.s solution under cool running water for 3 minutes to get an accurate reading of volume.
7. Add up the A.A.s solution to 10 mL with distilled water.
8. Transfer the A.A.s into the polarimeter and test for the optical rotation of the A.A..
9. Repeat steps 6-9 to extend the testing time.

Each experiment has been repeated for three times and Q-test has been performed to find out the outlier. Only the average of each dataset has been reported in plotting graph.

V. Results







We can observe a higher rate of racemization under a higher temperature, alkaline environment and the presence of glucose. The effect of microwave heating is distinct, for example, L-Lysine, which is equivalent to 8 hrs of cooking under 100°C(A detailed explanation can be found in the full report)

VI. If your team will compete the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. *(Word limit: 300 words)*

Good health and wellbeing is one of the United Nations Sustainable Development Goals. It stresses the importance of health to the sustainability. Cooking methods is proved to be highly related to cancer, one of the top killers in the world, is a major treat to the goal. Cooking methods are also proved to cause nutritional loss in food. As more and more cooking methods developed nowadays, the effect of these methods remains unclear.

Our project shows that racemization undergoes under all cooking method, and our main goal is to minimize the effect of racemization to health. We found out racemization undergoes at the highest rate under high temperature, alkaline environment. Therefore, we suggest slow cooking and acidic dishes to minimize the effect of cooking method to human health. Glucose present environment is also found to have a higher rate of racemization. We would suggest that the presence of glucose will also increase the rate of racemization.

Thus, our project can potentially reduce the number of cancer cases by reducing the amount of cancerous material in food. This reduces the pressure of the public health system.

VII. If your team will compete the Social Innovation Award, please list the target group or social issue the project focuses on, and provide justification for competing for this award. *(Word limit: 300 words)*

Frozen and microwave food are common for the public nowadays as its conveniency. Delicious food can be supplied in a matter of seconds. Frozen food is also an option for them with limited budget.

However, they are exposed to a huge health risk, which should be reminded. Preparation of these food usually involve high temperature heating, which highly increase rate of racemization. For example, rate of racemization of L-Lysine is distinctly higher under microwave heating environment than other cooking methods. Frozen food is usually alkaline dishes, which further increase the rate of racemization. This causes nutritional lost and can be cancerous.

Therefore, slow and acidic cooking method is suggested for them which can balance between convenience and health. Prepared slow cooking food is recommended in this case to reduce the effect cooking methods to human health.

Furthermore, our project can provide health suggestions for the choose of cooking methods. This reduces the cancerous material in food and thus potentially reduce the number of cancer patients, which relieves the pressure of public health system in Hong Kong.

VIII. Conclusion

1. High-temperature cooking and cooking with a high concentration of glucose should be avoided on all A.A.s. We would recommend slow cooking, especially for food high in lysine such as oysters, to prevent nutritional loss and the formation of cancerous materials.
2. Acidic cooking can reduce the rate of racemization in most case, while alkaline cooking can increase the rate. Acidic cooking is considered as a solution to reduce the rate of racemization, thus reducing the potential negative health hazard on humans. On contrast, alkaline cooking increase rate of racemization and should be avoided.