

Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Invention)

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

Team Number: SABC076

Project Title: Antimicrobial Edible Bio-disposables of Kombucha of Fruit Skins with Chitosan Coating

Project Type: Invention

To our best knowledge, there are / / ~~are not~~ * similar works in the market; (if there are,) related product links are as below:

1. Antibacterial disposable absorbent article (International Publication No. Patent WO2012037065A1) It is antimicrobial but Neither edible, biodegradable nor social sustainable as it is alcohol-based
2. Cookie straw (Taiwan Patent TW202000093A.) Edible but neither biodegradable, social sustainable as it used starch as raw material nor antimicrobial
3. Biodegradable antibacterial straw (China Patent CN112876818A) It is biodegradable and antibacterial but not edible as plasticizer is added to strengthen PLA

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

1. Our invention: Antimicrobial edible bio-disposables of Kombucha of Fruit Skins with chitosan-coated (**KFC**): Antimicrobial, Edible, Biodegradable and Social sustainable; Fulfilled some requirements of GB 18006-2008, ISO18188:2016 and COMMISSION REGULATION (EU) 2017/2158.
2. Besides, we discovered a greener way that involved neither 2M nitric acid which is strongly oxidizing nor 16.7M NaOH which is highly corrosive but using vinegar only to obtain chitosan coating (7.1% by mass of Black Soldier Fly **BSF** using vinegar only; cf. 16.6% using 2M nitric acid & 16.7M NaOH).

**Please delete if not applicable. The competition values the originality of works. Students must do enough literature research to ensure that their works are unique and list relevant reference materials before starting research or invention.*

I. Background

The plastic pollution problem worldwide has been deteriorating over decades. However, 72% of plastic waste landfilled or discarded causes long-term pollution to both terrestrial and marine environments.







Hong Kong(HK), being the 10th largest plastic waste producer globally (2010), produces 0.398kg of plastic waste per person per day (Fig1.2.1) [1]. According to the Environment Bureau (EB) of Hong Kong, in 2020, 10809 tonnes of municipal solid waste (MSW) was disposed of at landfills everyday. Among these, around 21.4% (around 2312 tons) were plastic waste, in which 25% of them were dining wares (Fig 1.2.2) [2]. Citizens' preference of takeaways during Covid-19 lockdowns can lead to a potential rise in these figures [3].

With our investigation, it was found that bacteria will grow intensely when they are left without individual packaging. Antimicrobial property is needed to ensure hygienic and reduce waste from packaging.

[1] Ritchie H. & Roser M. (2018). Plastic Pollution. Retrieved from <https://ourworldindata.org/plastic-pollution>

[2] Statistics Unit, Environmental Protection Department. (2021). Monitoring of Solid Waste in Hong Kong Waste Statistics for 2020. Retrieved from <https://www.wastereduction.gov.hk/sites/default/files/msw2020.pdf>

[3] Hong Kong Public Opinion Research Institute. (2022/07/06). 香港民意研究所 管制外賣即棄塑膠餐具意見調查. Retrieved from https://www.pori.hk/wp-content/uploads/2022/07/3_GP_takeaway_freq_rpt_v1_pori.pdf

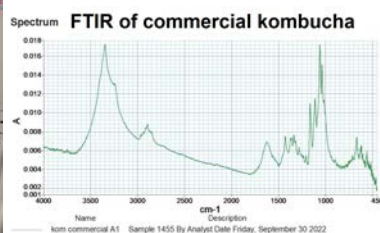
	Drinking water without oral bacterial	KFC	Biodegradable Paper Straw	PLA Straw	Plastic Straw	Biscuit cutlery
Disposables						
No. of bacteria colonies	0	0	110	39	0	N.A.

II. Objectives

1. To combat the above problem, we aim to use edible kombucha of fruit skins with chitosan coating (**KFC**) as antimicrobial bio-disposables to ease the burden. **KFC** are not only eco-friendly alternative materials to replace plastics disposables such as plastic straws but also antimicrobial so that natural resources are saved from making wrapping materials for disposables.
2. To discover a greener way by using vinegar only to obtain antimicrobial chitosan coating from shells of **BSF** that neither involves the use of 2M nitric acid which is strongly oxidizing nor 16.7M NaOH which is highly corrosive.

III. Methodology

1. Structural determination of **KFC** before and after roasting using FTIR



2. Counting bacterial colonies of drinking water with oral bacteria soaking with different chitosan coating and commercial disposables
3. Counting bacterial colonies of drinking water kept in roasted cups and straws of **KFC**
4. 3.4 Investigating the possibility of using untreated (without using 2M nitric acid & 16.7M NaOH) **BSF** shells as the source for **KFC** antimicrobial coating
5. Investigation of the food safety of roasted **KFC** as edible bio-disposables by determining the concentration of acrylamide using UV-VIS spectrometer



6. Detection of surface protein allergens using 3M Clean-Trace ALLTEC60
7. Comparing the biodegradability of different roasted **KFC** and other disposables
8. Testing and certification of antimicrobial edible cups of roasted **KFC** based on GB 18006-2008
9. Testing and certification of antimicrobial edible straws of roasted **KFC** based on ISO18188:2016 (Section 5.3) and DJS 348:2019 (Section 5)



IV. Design of Invention

Antimicrobial edible bio-disposables of **KFCs** should be eco-friendly alternatives materials to replace plastics such as plastic straws. About 3300 metric tonnes of food wasted were produced daily in HK and half of US produce were thrown away as they were not 'perfect'. Fruit skins actually could be the raw material to produce kombuchas. Kombuchas obtained from brewing fruit skins in sugar solution are edible and biodegradable. When kombuchas were roasted at 120°C for 30 mins, the strength of kombuchas and waterproofness would be enhanced. Chitosan has antibacterial and antifungal properties which qualify it for food preservation. In this investigation, edible roasted kombuchas with different chitosan coating were tested and certified based on GB 18006-2008, ISO18188:2016 and COMMISSION REGULATION (EU) 2017/2158 on the presence of acrylamide in food, so they should be edible and safe for consumption, biodegradable with high tensile strength, show good water proofness and would not cause any allergic effect.



V. Application / Market Need

- Domestic science about restaurant equipment.
- Edible disposables of grilled kombucha should be eco-friendly alternatives materials to replace plastics such as plastic straws. According to the HKSAR government, 2,320 tonnes of plastic were sent to Hong Kong's landfills daily in 2019. Single-use plastic cups and straws were among them. To ensure hygiene of disposables and to reduce wastes from packaging at the same time, antimicrobial edible biodisposable of **KFCs** is in urgent need.
- Limitation: Laboratory analysis of acrylamide In practice, laboratory analysis of acrylamide [29] is conducted using Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS) technique, while UV-vis spectrometry is only an alternative workable method.

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)

Bio-disposables of **KFC** meet the 12th sustainable development goal (SDG) of the United Nations - Ensure sustainable consumption and production patterns, in 2 ways.

Firstly, roasted **KFC** can replace plastic as disposable. Hence achieving Target 12.5 by substantially reducing waste generation through plastic prevention. Together with its biodegradability, antimicrobial edible bio-disposables of **KFC** can

ensure sustainable development.

Secondly, source of chitosan used in antimicrobial coating can be extracted from Black Soldier Fly (**BSF**), achieving target 12.2. In the life cycle of **BSF**, **BSF** shells are disposed of after **BSF** has become mature. To make our antimicrobial chitosan coating, shells of **BSF** will be converted into chitosan, hence reducing waste production. Making use of **BSF** supports the development of circular economy and nothing will be wasted. Nowadays, **BSF** larvae are used to consume food wastes. They undergo ecdysis when mature and shells will separate from them without manual operation. The shells can then be used in circumstances due to its high chitin content and can be converted into chitosan, in this case, the chitosan coating on **KFCs**. Since **BSF** is a high value animal protein, the dead or excess individuals can be used as fish feed or food for livestock. **BSF** can also be used as a fertiliser for soil amendments. These can potentially help promote other industries' growth. Biodegradation itself also enhances soil nutrient thus boosting plants growth, leading this whole process self-sustainable. With our discovery that **BSF** shells only treated with vinegar, the chitosan % obtained is still enough to perform the antimicrobial ability. Together with the high DD%, a greener way that involves neither strongly oxidizing 2M nitric acid nor highly corrosive 16.7M NaOH to obtain chitosan as a source for making **KFC** coating is discovered. Chitosan extracted from **BSF** shells are used as coating on **KFC** is a new application of chitosan, benefiting the whole society in terms of sustainable development.



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)

Not applicable

VIII. Conclusion

To conclude, antimicrobial edible bio-disposables of **KFC** represent a brand-new breakthrough to combat plastic pollution. Besides, a greener way that involves neither 2M nitric acid nor 16.7M NaOH but using vinegar only to obtain chitosan coating (7.1% by mass of **BSF**) was discovered. **KFC** bio-disposables met different international standards like GB18006-2008, ISO18188:2016 and Commission Regulation (EU) 2017/2158 on the presence of acrylamide in food. Chitosan coatings on kombucha bio-disposables were excellent antimicrobial agents as no or few oral bacterial colonies were found when bio-disposables of **KFC** with different chitosan coatings were soaked in drinking water with oral bacteria of different dilution factors. With the application of chitosan coating to edible kombucha bio-disposables, antimicrobial kombucha bio-disposables are not only edible and safe for consumption but also greatly reducing natural resources used in catering services. The content of acrylamide of all bio-disposables of roasted **KFC** with chitosan from different sources were as follows: pure chitosan (19.0 μ g/kg), crab chitosan (18.1 μ g/kg), **BSF** chitosan (65.8 μ g/kg), untreated (without using 2M nitric acid & 16.7M NaOH) **BSF** chitosan (133 μ g), Fancl Calorie Cut (146.5 μ g/kg) and Fancl Supplement (224.8 μ g/kg) which were all within the safety limit of acrylamide of food. Antimicrobial edible cups of **KFC** met the standards based on GB18006-2008, so antimicrobial edible cups of **KFC** are suitable for serving as disposable cups. Antimicrobial edible straws of **KFC** also met the standards ISO18188:2016, so antimicrobial edible straws of **KFC** are suitable for serving as disposable straws. Surface protein allergens were not found on roasted hydrogel of chitosan of Fancl Calorie Cut, Fancl Supplement, **BSF**, crab, and pure chitosan using 3M Clean-Trace ALLTEC60 showing that antimicrobial edible bio-disposables of **KFC** are non-allergic in nature. Adding a simple production process and the use of eco-friendly raw materials like fruit skins, antimicrobial edible bio-disposables of **KFC** cups and straws are eligible for marketing. Sustainable consumption and development could also be achieved as **SDG Target 12.2** and **12.5** are met. This eco-friendly alternative with high tensile strength, good waterproofness, the promising marketing of antimicrobial edible bio-disposables of **KFC** would be a great leap forwards to a plastic-free society, ultimately a more sustainable society in the future.

√ **Our project is developed based on previous project and the enhancement is below:**

Previous project: Kombucha of fruit skin as edible bio-disposables

Our invention is an enhancement as follows:

1. Our invention: Antimicrobial edible bio-disposables of Kombucha of Fruit Skins with chitosan-coated (**KFC**): Antimicrobial, Edible, Biodegradable and Social sustainable; Fulfilled some requirements of GB 18006-2008, ISO18188:2016 and COMMISSION REGULATION (EU) 2017/2158.
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