Extraction and encapsulation of phytochemicals from edible flower for application in food system

A thesis submitted in part fulfillment of the requirements for the degree of

Doctor of Philosophy

Indrani Chetia

Registration No.: TZ202261 of 2020

Department of Food Engineering and Technology

School of Engineering

Tezpur University, Tezpur-784028

Assam, India

April, 2025

CHAPTER 7

Summary, conclusions and future scope

7.1. Summary and conclusions

The research work delivered the scientific evidence and helped to aware consumers' regarding the health beneficial properties edible flowers such as Nongmangkha, Night jasmine, Drumstick and Pumpkin and showed the utilization of edible flower to develop functional food products. Indeed, novel extraction technique was employed such supercritical fluid extraction technique and ultrasound pretreated-microwave assisted extraction technique to find out the optimal extraction parameters for the extraction of polyphenolic compounds and antioxidant activity. The study for Ultrasound pretreated-microwave assisted extraction technique, this analysis represented the quadratic model to predict the maximum extraction of TPC, TFC and antioxidant activity due to the effect of sonoporation and microwave heating as ionic conduction and bipolar rotation generate heat and as a result cell wall disruption and release of target compounds were occurred in solvent from the cells of flowers. Also, to make the flower extract safe from outer environmental factors such as light, pH, temperature and various storage conditions etc. along with simulated gastrointestinal digestion affects to decrease the levels of polyphenols or bioavailability of it or the quality of a polyphenolic compounds of the flower extract; ion gelation technique was applied to maintain the quality of flower extract. This provided the optimal combination of sodium alginate with calcium chloride to achieve better encapsulation of flower extract and stood out to have better physicochemical properties in terms of color, encapsulation efficiency, antioxidant activity, TPC, TFC, and gastro intestinal release of TPC than the crude extract of flower. The development of functional food products such as gummy and RTS beverage by using edible flower extract encapsulates showed successful formulations. The nutritional properties also observed to be higher. This indicates that the encapsulated flower extract was suitable for easy to use focusing on the effective delivery of bioactive compounds in our body by incorporating in the food system like gummy and RTS beverage. It can be a solution for the functional food product development, nutraceuticals, pharmaceutical and chemical industry.

Certain points of conclusions from the thesis are summarized below:

- This study showed the presence of various nutritional compounds, minerals, phenolic compounds and antioxidant activity of the investigated edible flowers i.e., Night jasmine, Nongmangkha, Pumpkin and Drumstick.
- Mineral analysis revealed the presence of potassium, sodium, iron, zinc, copper, and manganese in varying concentrations in the selected edible flowers, with potassium being the most abundant mineral among them.
- HPLC analysis of phenolic compounds showed to the presence of various phenolic compounds in edible flowers such as gallic acid, resorcinol, caffeic acid, p-coumeric acid, ferulic acid etc.
- Among the flowers studied, Nongmangkha had the highest TPC, TFC confirming its superior phytochemical profile.
- Ultrasound pretreated- Microwave assisted extraction technique proved to be more effective than conventional methods for extracting phytochemicals from Nongmangkha flowers.
- HPLC confirms that the Ultrasound pretreated- Microwave assisted extract of Nongmangkha flower had higher phenolic compounds concentrations than conventional methods enhancing its functional potential.
- The cell viability taste for the flowers indicates the non-cytotoxicity nature (up to a specific amount) of edible flowers make them ideal for food and nutraceutical applications.
- Encapsulation using ion gelation technique effectively protected and retained the phytochemical properties of flower extracts.
- *Invitro* digestion showed encapsulated extract had the highest phenolic release in the intestinal phase, following a controlled release pattern.
- Encapsulated flower extract demonstrated excellent physical properties, including color retention, solubility, and antioxidant activity making them suitable for food applications.
- Functional food products (Gummy and RTS beverage) were successfully developed by incorporating encapsulated flower extract which nutritional value, particularly TPC, TFC and antioxidant activity of the products.

7.2. Future scope

The future scope of the present research paved a way for novel use of edible flowers not only in food industry but also in pharmacological industry, nutraceutical area. To emphasize on it, develop scalable extraction and encapsulation methods for industrial applications. As the flowers contain bioactive compounds so the study for antinational compounds in a depth study could help the consumers to utilize edible flowers safely. Conducting some in vivo trials to assess the bioavailability and health benefits of the functional foods can help to understand more. Exploring other encapsulation techniques can also help to develop other food formulations such as baked goods, dairy products and other food system.