

List of Publications

- **Devi, L. M., & Badwaik, L. S. (2022).** Variety difference in physico-chemical, cooking, textural, pasting and phytochemical properties of pigmented rice. *Food Chemistry Advances, 1*, 100059. **(Published)**
- **Devi, L. M., Das, A. B., & Badwaik, L. S. (2023).** Effect of gelatin and acacia gum on anthocyanin coacervated microcapsules using double emulsion and its characterization. *International Journal of Biological Macromolecules, 235*, 123896. **(Published)**
- **Devi, L. M., Das, A. B., & Badwaik, L. S. (2023).** Ultrasound-assisted extraction of anthocyanin from black rice bran and its encapsulation by complex coacervation. *Food Hydrocolloids for Health.* **(Under review)**
- **Devi, L. M., & Badwaik, L. S. (2023).** Development of anthocyanin-loaded coconut water jelly and its characterization. *Food Measurement and Characterization.* **(Under review)**

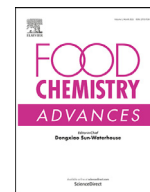
Participation of National/international Conference

- **Devi, L. M., & Badwaik, L. S.** Antioxidant properties and health benefits of pigmented rice grown in Manipur. Poster presented in the International Conference on Technological Innovations for Integration of Food and Health: A Focus on North-Eastern India (TiiFH-2019), 14th-16th February, 2019, Tezpur University, Tezpur, Assam.
- **Devi, L. M., & Badwaik, L. S.** Evaluation of physico-chemical, cooking and phytochemical properties of pigmented rice grown in Manipur. Poster presented in the Indian Convention of Food Scientists and Technologists (ICFoST-2020), 30th January 2020-1st February 2020, Tezpur University, Tezpur, Assam.
- **Devi, L. M., & Badwaik, L. S.** Effect of ultrasound-assisted extraction on phytochemicals and antioxidant activity of pigmented rice bran extract. Poster presented in the International Conference on Sustainable Approaches in Food Engineering and Technology (SAFETy), 24th-25th June 2021, Tezpur University and University of Georgia, U.S.A.
- **Devi, L. M., & Badwaik, L. S.** Development of anthocyanin microcapsules from black rice bran and its nutraceuticals-based coconut water jelly. Poster presented in the

International Conference of Rice Bran Oil (ICRBO) organized by The Solvent Extractors' Association of India (SEA), Hyderabad, India, 21st-23rd April 2023.

Awards/achievements

- Stood **1st Prize in J R Agro Poster Competition Award** for successful innovative approach in “Development of anthocyanin microcapsules from black rice bran and its nutraceuticals-based coconut water jelly” in the 7th International Conference of Rice Bran Oil (ICRBO)-2023 organized by The Solvent Extractors' Association of India (SEA) Hyderabad, India.
- Received **Research and Innovation Grant 2021**, Tezpur University, Assam (Ref. No.: DoRD/RIG/10- 73/1592-A; Dated 07.01.2021; SI No. 04).



Variety difference in physico-chemical, cooking, textural, pasting and phytochemical properties of pigmented rice

Lourembam Monika Devi, Laxmikant S. Badwaik*

Department of Food Engineering and Technology, School of Engineering, Tezpur University, Napaam, Assam 784028, India



ARTICLE INFO

Keywords:

Pigmented rice
Elongation ratio
Hardness
Amylose content
Viscosity
Phytochemicals

ABSTRACT

Three different varieties of pigmented rice namely Chakhao Amuba (Black), Chakhao Angangba (Red), Chakhao Poreiton (Purple) and a non-pigmented Chakhao Angouba (White) rice grown in Manipur, India were investigated for their physicochemical, phytochemical, cooking, textural and pasting properties. Thousands kernel weight, bulk density and length/breadth ratio for all varieties varied in the range of 16.69 to 21.17g, 0.59 to 0.65g/mL and 2.87 to 3.25, respectively. All pigmented rice showed significant amount of total phenolic content, flavonoid content and antioxidant activities. Black rice showed the highest phenolic content (12.70 mg GAE/g), Red rice showed highest flavonoid content (6.12 mg catechin/g) and DPPH % inhibition (92.62 %). Highest anthocyanin content was observed in the black rice variety (9.13 mg Cyanidin-3-glucoside/g). Cooking time was found highest (31.33 min) in Purple rice which can be correlated with the amylose content. Maximum amylose content was recorded in purple rice (6.44g/100g). Water uptake ratio was found in the range of 2.03 to 2.71. Highest amylose content rice (Purple rice) has the highest hardness value (173.18 N) which is positively correlated with the amylose content. The colour values were reduced after cooking of rice which may be due to degradation in monomeric anthocyanins due to heat treatment. Red rice showed the highest pasting temperature, peak, hold and final viscosity compared to other rice varieties.

Introduction

Rice (*Oryza sativa* L.) is considered as a staple food in South East Asia and is the most popular cereal crop, consumed by over half of the world population (Wei & Huang, 2019). Pigmented rice grain varied from deep-purple (black) to brown-reddish (red) in their covering layers, due to the accumulation of natural pigments in the seed coat called anthocyanin, water soluble flavonoids. It has a typical nutty flavour, aroma which turns into deep dark purple when cooked. It is stickier than the white rice when cooked and takes longer time to cook. Such pigmented rice are commonly known as 'Chak-hao' in Manipur, India, meaning 'delicious rice' (Chak = rice and ahaoba or hao = delicious). The major contributor of aroma is due to the presence of volatile compound 2-acetyl-1-pyrroline which was first isolated and identified by Buttery et al. (1983). Chakhao Poreiton (Purple) and Chakhao Amubi (Black) are two main aromatic rice varieties grown in Manipur.

Pigmented rice is a main source of various bioactive compounds which have anti-inflammatory properties, anti-diabetic and also inhibit new blood vessels formation which enhances tumour growth (Mahanta & Sikia, 2016). This rice also contains many phytochemicals and having a beneficial effect on health. The whole grains are major resources of various biologically active compounds such as phenolic acids, antioxi-

dants, vitamins, phytates, tocopherols, and carotenoids and due to this multiple biological activities of black and other pigmented rice varieties, there has been an increase in demand. One of the primary functional components of pigmented rice is anthocyanins (Delgado-Vargas et al., 2000), which are derived from the flavylium ion or 2- phenyl benzopyr- rilium. Again phenolic acids are present in both free and bound form. The black rice bran's extract showed inhibitory effects on *in vitro* allergic reactions (Choi et al., 2007). Pigmented rice bran (black and red) extracts inhibit α - amylase and α -glucosidase activity which also help in delaying of digestion and absorption of carbohydrates leading to suppression of postprandial hyperglycaemia in the diabetic person. Nutrient content of these rice varieties have gained consumers interests for utilization in nutraceuticals and has enticed the food industries. Although the phytochemicals available in whole rice grains are minute quantity, they provide various health benefits in minimizing the risks of many diseases such as heart and cardiovascular diseases, type II diabetes, obesity, and some types of cancer (Shao et al., 2015). Again the rice bran is an underutilized coproduct produced in the process of milling. During the last decades, research conducted has shown that it contain a complex unique naturally occurring antioxidant compounds (Moldenhauer et al., 1998).

* Corresponding author.

E-mail address: laxmikantbadwaik@gmail.com (L.S. Badwaik).



Effect of gelatin and acacia gum on anthocyanin coacervated microcapsules using double emulsion and its characterization

Lourembam Monika Devi, Amit Baran Das, Laxmikant S. Badwaik^{*}

Department of Food Engineering and Technology, School of Engineering, Tezpur University, Napaam, Assam, India

ARTICLE INFO

Keywords:

Anthocyanin
Dual emulsion
Coacervation
Microstructure
Thermal stability

ABSTRACT

The present study was aimed to develop a stable microencapsulated anthocyanin from black rice bran using double emulsion complex coacervation technique. Nine microcapsule formulations were prepared using gelatin, acacia gum and anthocyanin at ratios of 1:1:0.5, 1:1:0.75 and 1:1:1 respectively. The concentration of gelatin and acacia gum used were 2.5, 5 and 7.5 % w/v. Subsequently, the coacervated microcapsules were obtained at different pH (3, 3.5 and 4), freeze-dried and evaluated for their physicochemical properties, morphology, Fourier transform infrared spectroscopy (FTIR), X-ray diffraction pattern (XRD), thermal behaviour and stability of anthocyanin. The results obtained for encapsulation efficiency of anthocyanin with high values (72.70 to 83.65 %) indicated that the encapsulation process was effective. The morphology of the microcapsule powder was analysed and exhibited round, hard, agglomerated structures and relatively smooth surface. The thermal degradation behaviour of microcapsules displayed endothermic reaction confirming the thermostability of the microcapsules where the peak ranged from 83.7 to 97.6 °C. The stability studies in terms of retention of total anthocyanin content were observed at different storage conditions; both under refrigerated condition (7 °C) and at room temperature (37 °C). The results indicated that the microcapsules obtained through coacervation can be an alternative source to develop stable nutraceuticals.

1. Introduction

Antioxidants such as anthocyanin are sustainable natural pigments found in leaves, roots, fruits, flowers of plants, and some cereal grains. Anthocyanins (ANCs) are the largest group of water-soluble flavonoids, profoundly colored materials, that impart red, purple, and blue colors [1]. These compounds are also used as food colorants; providing a brilliant red color to many foods. Consumers are increasingly interested in developing natural colorant alternatives to synthetic colors in food applications [2]. Again, artificial pigments are becoming unacceptable in food and beverages due to their negative health and environmental effects [3]. Fruit such as blackberries, and gooseberries comprise the natural source of antioxidants that effectively inhibit free radical formation [4]. They can either suppress or inhibit the oxidation of lipids, including fats, oils, and fatty acids [5]. Also, burgeoning studies have reported its importance in terms of nutritional and medicinal aspects. These compounds are very promising and are also known to possess a wide range of potential nutraceuticals and promote health characteristics such as anti-microbial, anti-cancer, antidiabetic, antiproliferative,

anti-inflammatory activities, etc. [6]. Antioxidants are also used as a food component to maintain the lipid components from quality deterioration. Due to their multiple physiological functions, consumers demand has been addressed for commercialization for food fortification and its nutraceutical applications [7].

Functional components present in food (specially antioxidants) are non-conventional biomolecules possessing the extend to regulate one or more metabolic pathways in the body that results to health promotion [8]. They are also known to be available in rice varieties, which deliver many health-beneficial properties. It is also reported that rice bran contains several bioactive compounds which includes γ -oryzanol, vitamin E (α -tocopherol, γ -tocopherol, and δ -tocopherol) [9]. Colored rice such as black and other pigmented rice bran varieties are known to provide antioxidant activities [10,11]. They contain significant amounts of phenolic acids such as gallic acid, protocatechuic acid, p-hydroxybenzoic acid, vanillic acid, chlorogenic acid, caffeic acid, syringic acid, p-coumaric acid, ferulic acid, and sinapic acid, and flavonoids (kaempferol) [10,11]. They are also known to contain color pigment 'anthocyanins', especially cyanidin and peonidin-3-glucoside [10,11] that are

^{*} Corresponding author at: Department of Food Engineering Technology, Tezpur University, Napaam, Assam 784028, India.

E-mail address: laxmikantbadwaik@gmail.com (L.S. Badwaik).



THE SOLVENT EXTRACTORS' ASSOCIATION OF INDIA



International Association
of Rice Bran Oil

in collaboration with

Foodtech Pathshala

as the knowledge partner are proud to present

J R AGRO POSTER COMPETITION AWARD

to

Ms. LOUREMBAM MONIKA DEVI

Dept. of Food Engg. & Technology, Tezpur University, Assam

For Winning the First Award with a Cash Prize of Rs. 10,000 (For a team)

for successful innovative approach in

**Development of Anthocyanin Micro Capsules from Black Rice Bran and
Its Nutraceuticals Based Coconut Water Jelly.**

at the

7th International Conference on Rice Bran Oil -2023

22nd April 2023, Hyderabad, India.

Ajay Jhunjunwala
President, SEA

Ashok Sethia
President, IARBO

Dr. Prabodh Halde
Convenor, ICRBO

Department of Food Engineering and Technology

Certificate Of Achievement



Tezpur
Chapter

This is to certify that

Lourembam Monika Devi

Research Scholar of Food Engineering and Technology has participated
in the Graphical Abstract Competition and secured 2nd position in the
Scholar's Day, held on September 14, 2023, organized by the Department of Food Engineering and
Technology, Tezpur University, Assam, India.

Co-Ordinator

Scholar's Day-2023, FET Dept.

Tezpur University



Head, FET Dept.

Tezpur University

27th Indian Convention of Food Scientists and Technologists

“Raising Agro-processing & Integrating Novel technologies
For Boosting Organic Wellness” (RAINBOW)

30th January 2020-1st February 2020 @ Tezpur University, Tezpur, Assam



Poster Presentation Certificate



This is to certify that the following **POSTER** was presented at **27th ICFoST** organized by AFST(I)-HQ and Tezpur Chapter during 30th January 2020-1st February 2020 at Tezpur University, Tezpur, Assam.

Title : Evaluation of physico-chemical, cooking and phytochemical properties of pigmented rice grown in Manipur

Author (s): Ms. Lourembam Monika Devi, Laxmikant S. Badwaik

(Prof. Sankar Chanda Deka)

Local Organizing Secretary

(Dr. D D Wadikar)

Organizing Secretary

(Dr. Bhaskaran V)

Chairperson





INTERNATIONAL CONFERENCE

on

**Sustainable Approaches in Food Engineering and Technology
(SAFETy-2021)
24th-25th June, 2021**

Certificate

LOUREMBAM MONIKA DEVI

This is to certify that Dr./Mr./Ms. has participated as Poster Presenter at SAFETy-2021, organized by the Department of Food Engineering & Technology, Tezpur University, Assam, India, and Department of Food Science & Technology, University of Georgia, Georgia (US) in Association with AFST(I) Tezpur Chapter during 24th-25th June, 2021.

Title: Effect of ultrasound-assisted extraction on phyto chemicals and antioxidant activity of pigmented rice bran extract

Author(s): Lourembam Monika Devi, Laxmikant S. Badwaik

Dr. Amit Baran Das
Organizing Secretary
TEZPUR UNIVERSITY

Dr. Abhinav Mishra
Organizing Secretary
UNIVERSITY OF GEORGIA

Prof. Nandan Sit
Chairperson
TEZPUR UNIVERSITY

Prof. Manpreet Singh
Chairperson
UNIVERSITY OF GEORGIA



INTERNATIONAL CONFERENCE

on

**Technological Innovations for Integration of Food and Health
A Focus on North-Eastern India
(TiiFH-2019)**

Certificate

This is to certify that **Lourembam Monika Devi** has participated as **Presenter** at TiiFH-2019, organized by the Department of Food Engineering and Technology in Association with AFSTI during 14th-16th February, 2019 at Tezpur University, Tezpur, India.

Title: Antioxidant properties and health benefits of pigmented rice grown in North-Eastern India

Author(s): Lourembam Monika Devi, Laxmikant S. Badwaik


Chairman
TiiFH


16/2/19
Convener
TiiFH


Co-Chairman
TiiFH

AFST(I)