Chapter 8
Conclusion and future scope

8.1 Conclusion

In conclusion, salient features and future scope of the present study with respect to the specific objectives, have been highlighted. Comparison of two pigmented red rice (UA: short kernel) and (LA: long kernel) and one nonpigmented (WR: short kernel) was determined. Phytochemical study of purple passion fruit was also carried using analytical instruments. Foam mat drying of purple passion fruits and characterization of the powder was done. Effect of extrusion parameters on the physicochemical, phytochemical, rheological and sensory properties of passion fruit powder incorporated red rice product were further carried out. Moisture sorption isotherm (MSI) and antioxidant activity study of optimized extruded products was evaluated. Dipeptidyl peptidase-4 (DPP-4) inhibitory activity in rice samples and its product and glucagon-like peptide-(GLP-1) secretion were finally carried out. ICP-MS for the confirmation of arsenic species in rice sample were also further investigated.

The salient findings of the thesis are summarized below:

1. **Physicochemical analysis of pigmented and nonpigmented rice and phytochemical analysis of purple passion fruit**

   - The length of UA was 5.37±0.24 mm (short type) and short and medium type grain produced higher head rice yield (HRY)
   - UA has low porosity (%) when compared with LA and WR. Low porosity had greater resistance to water-vapor escape during the drying process, which may lead to the need for higher power to drive the aeration fans
   - Texture profile analyzer (TPA) of cooked rice data revealed that the cooked UA rice had higher hardness value than the cooked LA and WR
   - Highest water uptake properties was found in UA (3.65±0.01 %) and hence, optimal cooking time (31.16±0.01 min) was also highest in UA
   - Mineral contents of rice cultivars (UA,LA and WR) reveals presence of eleven elements in three cultivars *viz.,* Al, Ca, Cu, Cr, Fe, K, Mg, Mn, Mo, Na and Zn

- ❖ Anthocyanin content of the colored rice cultivars (UA 12.79±0.001 and LA 11.47±0.001 mg/100g) compared to white rice (1.34±0.001) further reinforced its potential for high value addition
- ❖ It is prudent to summarize that these pigmented untapped rice cultivars of Arunachal Pradesh, India have enormous potential in the field of pharmaceutical industry vis-a-vis its health benefits
- ❖ pH and ˚Brix of passion fruit pulp were 3.2± 0.15 and 16.09 ± 0.10, respectively
- ❖ FT-IR and RP- HPLC analyses of the rice cultivars deciphered the presence of seven phenolic compounds *viz.,* quinic, salicylic, quercetin, apigenin, ferulic, gallic and caffic acid which are paramount for functional foods.

2. **Foam mat drying of purple passion fruits fruit and characterization of the powder**
   - ❖ A preliminary trial was conducted to identify the effect of whipping time and methyl cellulose on foam density of passion fruit pulp
   - ❖ Foam density (FD) of the mixture was constant and minimum, up to 3 min of whipping and the highest foam density was observed at 4 min whipping
   - ❖ Increase of methyl cellulose concentration in fruit pulp, decreased FD and was proportional up to a certain value and the lowest FD (0.9615 g/cm^3) was observed at 3% methyl cellulose
   - ❖ The foam mat drying of passion fruit pulp was successfully carried out using CCD followed by response surface methodology
   - ❖ The *L**, *a*,* and *b** values of the foam mat dried powder differed significantly with respect to fruit pulp
   - ❖ The DPPH scavenging activity and vitamin C content decreased in powder (60.53±0.21% and 35.19± 0.20 mg/100g) compared to the raw passion fruit pulp (70.53±0.03 %) and (60.53±0.21 mg/100g)
   - ❖ Total phenolic content (TPC) content of passion fruit powder (210.11±0.23 mg GAE/100g) increased over raw fruit pulp (206.29 ±0.10 mg GAE/100g)

- ❖ RP-HPLC analysis revealed presence of various important bioactive compounds.

3. **Effect of extrusion cooking on the physicochemical and phytochemical properties of passion fruit powder incorporated red rice extrudates, rheology of doughs and sensory evaluation of product**

- ❖ The independent parameters were *viz.,* temperature(˚C), screw speed (RPM), feed moisture content (%) and amount of passion fruit powder (%) and dependent parameters were *viz.,* expansion ratio (%), water absorption index (%), total phenolic content (mg GAE/100g) and DPPH scavenging activity (%)
- ❖ During validation, the experiment was conducted at optimized condition and observed experimental values of ER (7.08%), WAI (2.18), TPC (130.10 mg GAE /100g) and DPPH scavenging activity (63.01%) and did not differ significantly
- ❖ DSC thermograph showed an endothermic behavior of extruded products.
- ❖ XRD analysis of samples revealed strong peaks of control sample at 2θ *viz.*, 12.72,18 and 18.82 and for optimized sample were 18.18,20 and 23.50. Weak peaks were also observed at 15, 18.82, 19.82 and 23.5. A and C-type pattern were observed
- ❖ SEM images revealed that the control sample showed a continuous structure and appeared smoother and in optimized products surface became scratched, cracked, and rougher
- ❖ RP-HPLC quantification of compounds like vitamins and anthocyanin in control (C) and optimized (O) extrudates were carried out
- ❖ The Mizrahi and Berk model showed the best fits in both red rice (R^2=0.83) and passion fruit incorporated red rice doughs (R^2=0.87) and explained the shear rheological properties
- ❖ Flow index, n value varied in control sample (0.46 to 0.47) and optimized (0.88-0.89) for Herschel-Bulky and Mizrahi and Berk model, respectively

- The oscillatory rheological properties of rice dough were affected due to the incorporation of passion fruit powder and the storage modulus (G′) was higher than loss modulus (G′′) for rice dough
- Complex viscosity (η*) of doughs were parallel to each other and decayed linearly with increase in frequency.

4. **Moisture sorption isotherm (MSI) and antioxidant activity study of optimized product during storage**

- No significant changes in the total phenolic content (mg GAE/100g of dry solids) during 120 days of storage of extruded product
- The MSI shape of the graph resembled more of Sigmoid S-shaped curves of type II types at given temperatures between water activity and EMC data
- Initially, slow increase in EMC was observed until 0.6 a_w. After that abrupt increase in graph was observed
- At 25 ˚C, Langmuir model described and predicted the EMC of product, 35 and 45 ˚C Peleg model predicted as most suitable model to practice MSI study of optimized extrudate.

5 **Assessment of the antidiabetic potential of red rice and rice-based products**

- The most effective extractant was *n*-hexane, resulting in yields of ≥ 0.82 %
- Rice bran (RB) was the most potent at inhibiting DPP-4 activity when compared with other samples
- RB was the most potent at inhibiting DPP-4 activity by 70.48±1.06 %, followed by UA (42.55±0.84 %), PRR (35.91±1.27 %), WR (29.14±1.23 %), O (25.49±1.86 %) and then C (13.55±3.97 %)
- DPP-4 inhibitory activity was found to be retained in the ethanol:water extracts of both extruded products C (Control) and O (optimized), albeit at reduced levels
- *n*-hexane extracts were able to potently stimulate GLP-1 secretion.

- In particular, PRR, C (control) and O (optimized) enhanced secretion of GLP-1 3.14-fold ($p<0.01$), 3.48-fold ($p<0.001$) and 6.06-fold ($p<0.001$), respectively
- DMA content was in the order of UA (0.010mg/kg) > WR (0.005mg/kg) > RB, PRR, O (0.003 mg/kg) > C (0.002mg/kg). As V (i-As) content (ranging from 0.026 – 0.176 mg/kg) was found significantly higher proportions and was in the order of RB > C > UA > O > WR > PRR.

Future scope of the present investigation

- Cost calculation and feasibility of developed product may be considered before coming to the market.
- Bioavailability of prepared extruded products can be carried out.
- Reduction of As V (i-As) species which is carcinogenic in nature content from rice bran can be further investigated at molecular level.

List of Publications

1. Samyor, D., Deka, S.C. & Das, A.B. (2016). Phytochemical and antioxidant profile of pigmented and non-pigmented rice cultivars of Arunachal Pradesh, India, International Journal of Food Properties, 19, 1104–1114

2. Samyor, D., Deka, S.C. & Das, A.B. (2016). Evaluation of physical, thermal, pasting characteristics and mineral profile of pigmented and non -pigmented rice cultivars. Journal of Food Processing and Preservation, 40, 174–182

3. Samyor, D., Das, A, B. & Deka, S, C. (2017). Pigmented rice a potential source of bioactive compounds: a review. International Journal of Food Science and Technology. International Journal of Food Science and Technology, 52, 1073-1081

4. Samyor, D., Das, A.B. & Deka, S, C. (2017). In: Value Addition of Underutilized Crops of India by Extrusion Cooking Technology, Innovative Food Science and Emerging Technologies, Published by Apple Academic Press, Taylor & Francis Group (In press)

5. Samyor, D., Deka, S.C. & Das, A.B. (2017). Effect of foam mat drying on physicochemical and phytochemical properties of passion fruit powder. International Journal of Food Properties (Under Review)

6. Samyor, D., Deka, S.C. & Das, A.B. (2017). Effect of extrusion cooking on the physicochemical and phytochemical properties of passion fruit powder incorporated red rice extrudates. Journal of Food Science and Technology **(**Under Review)

7. Samyor, D., Deka, S.C. & Das, A.B. (2017). Effect of passion fruit powder on rheologicalproperties of gluten free red rice dough. Journal of Texture Studies (Under Review).

Conferences /seminars /workshops

1. Samyor, D., Das, A. B. and Deka, S. C. (2013). Studies on physicochemical properties of some selected underutilized rice cultivars of Arunachal Pradesh. Presented poster at the 7th International Food Convention, IFCON 2013 w.e.f 18-21 December, 2013(venue CSIR-CFTRI, Mysore, India), Organized by AFSTI, Mysore.

2. Samyor, D., Das, A, B. and Deka, S. C. (2014). Pigmented rice- A potential source of bioactive compounds. Presented poster in National conference on

Emerging Technology Trends in Agricultural Engineering. November 7-9, 2014 (ETTAE 2014). Organized by Department of Agricultural Engineering, North Eastern Regional Institute of Science and Technology, Nirjuli, Itanagar, Arunachal Pradesh-791109.

3. Samyor, D., Das, A, B and Deka, S.C. (2015) Effect of different pH and temperature on the stability of anthocyanidin content of red rice. Oral presentation in National Seminar cum Workshop on Innovative Prospects in Food Processing: Integration of Engineering and Biological Sciences 27 -28th March, 2015.

4. Samyor, D., Calderwood,D., Das,A,B., Deka, S,C. and Green,B,D.(2016). Presented e-Poster "Pigmented red rice (*Oryza sativa* L.) contains dipeptidyl peptidase-4 (DPP-4) inhibitory activity which can be incorporated into a healthy cereal product" in 1st International Conference on Food Bio-actives and Health, held on (12-15) Sept. 2016 in Norwich, UK.

5. Samyor,D., Deka,S.C. and Das,A,B.(2016).Presented a poster entitled as "Effect of passion fruit (*Passiflora edulis* Sims.) powder on dynamic oscillatory rheological properties of gluten free red rice (*Oryza sativa* L.) dough" in 2ndYoung Investigator Meeting, Cambridge, U.K on 16th September 2016.

6. Attended Global Challenge Networking Programme Event on :'Productivity'Resaerch Event (Order no. 559920946) held on Monday, 17 October 2016 from 12:30 to 15:00.

7. Attended a one day workshop on 'Research & Innovation actions Writing workshop', Friday 4 November 2016, Queen's University Belfast, United Kingdom.

8. Attended one day event on 'What Works Research'? Views from research, policy and practice, Tuesday 15 November 2016, 11.00am – 4.00pm, The Great Hall, Queen's University Belfast, UK.

9. Samyor,D., Deka,S.C. and Das ,A,B.(2017). Presented oral presentation on topic "Effect of passion fruit powder on rheological properties of gluten free dough" Trends and Innovation in Food Processing Technology: Prospects and Challenges. (TIFPT-2017). Date: 9th and 10th February, *2017,* Dept. of Food Engineering & Technology, Tezpur University, Assam

10. Samyor,D.,Deka, S,C. and Das,A,B.(2017). Presented oral presentation on topic "Quality evaluation of extrudate products by using Fuzzy logic tool" One Day UGC-SAP Seminar on Research Trends in Food Processing: Value Addition & Enterprise Development (RTiFP-2017), 27th March, 2017, Dept. of Food Engineering & Technology, Tezpur University, Assam

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December 2016

CERTIFICATE FROM THE HOST SUPERVISOR

Newton-Bhabha PhD Placement Undertaken in United Kingdom (2016)

This is to certify that Miss Duyi Samyor, pursuing a PhD within the Department of Food Engineering and Technology, Tezpur University, India has successfully completed 6 months (2nd June to 2nd December 2016) of research work within our laboratories at the Institute for Global Food Security, Queen's University, Belfast, United Kingdom under the supervision of Dr Brian Green. This work primarily involved the assessment of the anti-diabetic potential of red rice (*Oryza sativa*), and rice-based food products.

Dr Brian Green
Senior Lecturer in Molecular Nutrition

About the Author

Ms. Duyi Samyor, daughter of Shri Lingdung Samyor and Smt. Yape Samyor, was born in Aalo, West Siang District, Arunachal Pradesh. She completed her graduation in B.Sc. Home Science (Food Science & Nutrition) from Central Agriculture University, Imphal in 2011. She completed her M.Sc. in Food Science and Technology from Pondicherry University in 2013. She qualified her University Grant Commission –NET (LS) exam in the year 2013. She also pursued Ph.D. (2013-2017) in Food Engineering & Technology from Tezpur University, Assam and was funded by Rajiv Gandhi National Fellowship (UGC-RGNF). During her Ph.D. tenure, she got selected as visiting research associate in the Newton-Bhabha PhD Placement Programme (2015-16) for a period of 6 months in collaboration with Department of Biotechnology, New Delhi and British council. She also worked as a Junior Research Fellow (JRF) in the project "Studies on development of cereal based functional breakfast food from the underutilized crops of North-East India 2013-2015 funded by Ministry of Food Processing Industries (MoFPI). She has published 6 scientific research papers and attended various national/international conference in India and United Kingdom. She is an active member of Association of Food Scientists and Technologies [AFSTI]. India. Her research interest includes in depth study of underutilized crops, extrusion technology processing and its assessment of antidiabetic properties.