Food Techno 2023

Future Foods: Innovations and Trends

EXTENDED ABSTRACTS

of Research Presentations
7th Annual Research Session

Institute of Food Science and Technology Sri Lanka (IFSTSL)

05th August 2023 | BMICH, Colombo, Sri Lanka

IFSTSL
INSTITUTE OF FOOD SCIENCE & TECHNOLOGY SRI LANKA

Extended Abstracts of the Research Presentations

FoodTechno 2023

7th Annual Research Session of IFSTSL

05th August 2023
BMICH | Colombo

Organized by the Institute of Food Science and Technology, Sri Lanka (IFSTSL)

FoodTechno 2023

7th Annual Research Session of IFSTSL

05th August 2023
BMICH | Colombo

Programme

8:30 am - 9:00 am	Registration of participants
9:00 am - 9:05 am	Lighting of the traditional oil lamp
9:05 am - 9:10 am	Welcome address by the Coordinator/FoodTechno 2023
9:10 am - 9:15 am	Address by the President of IFSTSL
9:15 am - 9:45 am	Address by the Chief Guest
9:45 am - 10:15 am	Keynote Speech
10:15 am - 10:30 am	Tea Break
10:30 am - 12:15 pm	Technical session 01
12:15 pm - 1:15 pm	Lunch
1:15 pm - 3:00 pm	Technical session 02
3:00 pm -03:30 pm	Tea Break
3:30 pm - 4:00 pm	Awarding Ceremony
4:00 pm - 4:10 pm	Vote of Thanks

FoodTechno 2023 - Technical Sessions

Technical Session I

Session Chair: Senior Professor K.K.D.S. Ranaweera

(Senior Professor / Dept. of Food Science & Technology, Faculty of Applied Science, University of Sri Jayewardenepura)

1. Functional Properties of Oleoresins and Essential Oil Composition of Leaves of Allspice [*Pimenta dioica* (L.) Merill.] for Potential New Product Development.
   D.V.S. Abeysinghe, B.E.P. Mendis, R.P.N.P. Rajapakse, T. Rengaraj

2. Investigating the Impact of Pre-Gelatinization Following Steaming on the Physico-Functional Properties of Yam Flour in Sri Lanka
   S. Umayangani, M. Silva, A. Sandaruwani

3. Formulation of a Healthy Cracker with Low Glycemic Index Ingredients
   K.M.S.A.K. Dehideniya, V.P. Bulugahapitiya, R.S. Sabaragamuwa, T.C. Kananke

4. Development of Underutilized Gahala Yam (*Colocasia esculenta*) Incoparated Pasta
   M.V.K.B. Prabodhani, C.M. Senanayake, H. Weeratunge

5. Development of Vegan Cheese Product from Skim Coconut Milk Using Lactic Acid
   D.K.J.D.K. Dodangoda, H.P.D.T. Hewa Pathirana, C. Yalegama and N.S. Weerakkody

6. Development of a Healthy Meat Analogue Using Young Jackfruits (*Artocarpus heterophyllus*) and Soya Grits
   A.M.S.K. Amarakoon, A.A.K. Lankanayaka, C.M. Senanayake, S.U. Rajapaksha

Technical Session II

Session Chair: Professor Ananda Chandrasekara

(Professor/ Department of Applied Nutrition, Faculty of Livestock, Fisheries & Nutrition, Wayamba University of Sri Lanka)

7. Antiglycation Properties of Aqueous Extracts from Selected Species of Plants: An *In Vitro* Study
   N.H.M.V.N. Senevirathne, H.K.I Perera, B.E.P. Mendis and R.P.N.P. Rajapakse

8. Evaluation of the Effect of Palm Stearin as a Stabilizer and Quality Improvement of Coconut Butter Spread
   W.M.C.P. Dissanayake, H.P.D.T. Hewa Pathirana, C. Yalegama and N.S. Weerakkody

9. Visual and Physicochemical Quality of the Mango Variety Karthakolomban at Retail Outlets in Sri Lanka
   M.A.R.M.P. Jayathilaka, J.I.S. Jayalath, W.A.H. Champa, T. Perera

10. Development of a Moringa (*Moringa oliferea*) Powder Incorporated Nutrition Bar
    W.N.M.H. Karunarathna, P.C. Bandara, U.C.A.M.S. Senarathna

11. GC-MS Study on Rice Bran Oil in Sri Lanka
    T. D. Wijayaratne, T. D. C. M. K. Wijayasiriwardena

12. *Hibiscus rosa-sinensis* Flower Powder as a Natural Nitrite Source of Chicken Sausages
    A.P.K. Thathsarani, A.U. Alahakoon, R. Liyanage

List of Reviewers

1. Emeritus Professor Upali Samarajeewa
2. Senior Professor K.K.D.S. Ranaweera
3. Prof. Niranjalie Perera
4. Prof. Anoma Chandrasekara
5. Prof. Ananda Chandrasekara
6. Prof. Ilmi Hewajulige
7. Prof. K.D. Prasanna Gunathilake
8. Dr. Harindra Champa
9. Dr. Rasangi Sabaragamuwa
10. Dr. T.C. Kananke
11. Dr. Isuru Wijesekara
12. Dr. Madhura Jayasinghe
13. Dr. Sumali Fernando
14. Dr. H.P.S. Senerath
15. Dr. Sumudu N. Warnakulasuriya

Message from the President of the IFSTSL

The Seventh Annual Research Session, FoodTechno 2023, organized by the Institute of Food Science and Technology, Sri Lanka (IFSTSL) is scheduled to be held on 05th August 2023, parallel to the Profood/Propack exhibition at BMICH. The theme of this research session is "Future Foods: Innovations and Trends" with the objective of disseminating research knowledge acquired in universities, research institutes and other line agencies to the food industry, seeking possible applications of research outcomes, in innovation and trends in the food industry.

The IFSTSL provides services to uplift the level of professionalism within the food processing sector in the country with the participation of professionals representing academia, the food industry and other line agencies.

Scientific innovations play a critical role in food sector developments. The main problem is the outcomes of research conducted by universities and other research entities in Sri Lanka are rarely shared with the food industry unless it is industry-funded research. Accomplishing this requires connecting different stakeholder groups of the Sri Lankan food sector, especially the universities, research entities and the food industry in a common platform and to make a better assembly. Sri Lanka Food Processors Association (SLFPA) pools resources with IFSTSL to hold this research session during Profood/Propack exhibition. This session provides the best opportunity for the institute to meet the industry to develop a research dialogue that would benefit the food industry, and the whole food sector in Sri Lanka.

As the president of the Institute of Food Science and Technology, I wish to extend my sincere thanks to Dr. Thilini Kananke and the entire organizing team, for their untiring efforts to make this research session a great success. I extend a special thanks to SLFPA for their generous support to IFSTSL to stage FoodTechno together with Profood/Propack exhibition with a wider audience. Further, I offer my sincere thanks to the current Executive Committee of the IFSTSL for their dedication and commitment to IFSTSL activities and especially for encouraging this very important event. I hope the participants will derive maximum benefit from this and I wish annual research session FoodTechno 2023 every success.

Prof. Niranjalie Perera
President / IFSTSL - 2023

Message from the Coordinator FoodTechno 2023

The Seventh Annual Research Session, FoodTechno 2023, hosted by the Institute of Food Science and Technology, Sri Lanka (IFSTSL), is set to be held on August 5th, 2023, parellel to the Pro Food/Pro Pack Ag-Biz Exhibition at the BMICH.

This event, organized by IFSTSL, remains a pivotal occasion on the calendar, aimed at fostering stronger connections between research entities and the food industry. FoodTechno 2023 serves as an excellent platform to highlight the numerous research endeavors undertaken by various entities, including universities.

As the field of Food Science and Technology continues to advance rapidly, and the Sri Lankan food industry shows positive growth, it becomes increasingly important to address practical challenges and expand into global food markets. It's crucial to note that a significant amount of research often goes unnoticed, failing to reach the public domain or industry platforms. Therefore, presenting key research findings to the food industry at the FoodTechno 2023 is both appropriate and timely, in bridging this gap and bringing valuable research to the forefront.

The success of such endeavours is greatly dependent on the cooperation and support of all stakeholders involved. For instance, the realization of FoodTechno 2023 would not have been possible without the collaboration and resource pooling of the Sri Lanka Food Processors Association (SLFPA) with IFSTSL.

I would like to take this opportunity to express my sincere gratitude to this year's research presenters for sharing their findings at this important forum. I extend my sincere thanks to Prof. Niranjalie Perera, the President of IFSTSL and members of the Executive Committee of IFSTSL for their unwavering support in organizing this event.

I wish FoodTechno 2023 continued success and strength in its commendable efforts in the years ahead.

Dr. Thilini Kananke
Coordinator/FoodTechno 2023

Extended Abstracts of the Research Presentations FoodTechno 2023- Seventh Annual Research Session of the IFSTSL

(05th August 2023 at Mihilaka Medura, BMICH Colombo, from 8.30 a.m. to 4.10 p.m.)

TABLE OF CONTENTS

Functional Properties of Oleoresins and Essential Oil Composition of Leaves of Allspice [*Pimenta dioica* (L.) Merill.] for Potential New Product Development

D.V.S. Abeysinghe[1], B.E.P. Mendis[1*], R.P.N.P. Rajapakse[1], T. Rengaraj[2]

[1]Department of Food Science and Technology, Faculty of Agriculture, University of Peradeniya, Sri Lanka.

[2]STAY Naturals Private Limited., No. 45, Ambangangawatte Road, Kawatayamuna, Kawdupelelle, Matale, Sri Lanka. 21072.

*Corresponding Author**: ereshamendis@agri.pdn.ac.lk

Summary

The allspice plant having the combination of flavours of four spices has not been explored in Sri Lanka for its uses. The extraction of oleoresin (Solvent extraction method) and essential oil (Hydro-distillation method) from the first 8 leaf positions of shoots of allspice was done for the process optimization. Total antioxidant capacity (TAC), total phenolic content (TPC), and total flavonoid content (TFC) in allspice oleoresin were determined using ferric reducing antioxidant power assay, modified Folin-Ciocalteu method and a calorimetric method, respectively. Characterization of essential oil was done using gas chromatography. The highest oleoresin yield (8.92±0.03%) and the highest yield (4.45±0.10%) of leaf essential oil were observed in 7th and 3rd leaf respectively. Both the highest TAC (1,555.69±7.04 mg TE/g) and TPC (143.19±2.24 mg GAE/g) were observed in oleoresin extracted from 2nd leaf. Eugenol was the most abundant (89.43±0.03% in 7th leaf) chemical of the leaf essential oil. Three beverage products from allspice leaves were developed. The findings of this study encourage the commercial-scale cultivation of allspice in Sri Lanka.

Keywords: Antioxidant capacity, Essential oil, Oleoresins, Phenolics, *Pimenta dioica*

Introduction

Pimenta dioica (L.) Merill is also known as Jamaican pepper, English spice, and '*Sarakku*' plant in Sinhala. This allspice plant has a combination of both flavours and aromas of clove, cinnamon, cardamom, and nutmeg. There are a lot of therapeutic values of this plant such as, reducing high blood pressure, reducing depression, good androgen receptors for prostate cancers of males, mind relaxing ability during the menstrual period of women, etc. Oleoresins and essential oils from Allspice can be widely used in the culinary sector, fragrance, and cosmetics. Even though there is a huge potential, the extraction of oleoresins from the leaves of allspice has not been done yet (Mérida-Reyes *et al.*, 2020). Quantification

of the extracted oil content and the TAC, TFC, and TPC of the oleoresins obtained from the leaves have not been done up to the 8th leaf level (Panawala, Abeysinghe, and Dharmadasa, 2016). The overall objective is to extract, identify, and quantify essential oil and oleoresins from allspice leaves to explore the commercial feasibility of product development. Also, to identify the correct harvesting position for commercialization. Process optimization is important to get the benefits of allspice for a healthy life.

Methodology

Leaf samples were collected from Privet allspice grower in Gomagoda, Sri Lanka. The sample size was 72 plants of 3.5 years of age. Plant authentication was done through the National Herbarium, Sri Lanka. Shoots containing leaves up to 8th leaf level were collected separately and allowed for shade drying for 7 days at room temperature (30 °C). Dried leaves were flaked and sieved with 2 mm sieve. Samples were packed in an airtight bag until further use.

The moisture content and bulk densities of the dried leaf samples were determined using the toluene method and measuring cylinder method respectively. Essential oil content of different leaf levels were determined according to the hydro-distillation method using Clevenger arm apparatus unit (Wesołowska, Grzeszczuk and Jadczak, 2014). The chemical composition of the extracted oils was analyzed using a chromatograph Shimadzu 2014 system. Oleoresins were extracted from the solvent extraction method using Soxhlet apparatus. TAC was determined using ferric ion reducing antioxidant power (FRAP) assay described by Benzie and Szeto, (1999). TPC was determined using a modified Folin-Ciocalteu method (Cai *et al.*, 2004). TFC was determined by a colorimetric method as described by Liu *et al.* (2003) with slight modifications.

The residual values were analyzed using a chromatograph Shimadsu GC-HS 2030 instrument. Three novel products were developed using leaves. A consumer preference test was done for the sensory evaluation. Statistical comparison of mean values was performed by general linear model of ANOVA followed by Turkey multiple range test of the SAS software.

Results and Discussion

According to the toluene method, the average final moisture level was identified as 9.45 %. The moisture level prior to the extraction should be in between 5 % -10 % to obtain a high-quality oleoresin. The highest average moisture content of the fresh leaves was observed in the second leaf (70.32±0.62% WB) and the moisture content has a reducing trend from 2nd leaf to 8th leaf. When leaves are in the immature stage it contains more moisture inside the vacuole and a higher number of mesophyll cells inside the leaves.

Table 1. – Variation of Moisture content of fresh leaves, Bulk density of flacked leaves, Average Oleoresin yield, Oil yield, TAC, TPC, TFC, Eugenol%, β-caryophyllene% and myrcene% with different leaf positions

Leaf Position	P1	P2	P3	P4	P5	P6	P7	P8
Average Moisture content%(WB)	69.54±0.04^{b}	70.32±0.04^{a}	67.13±0.10^{c}	60.42±0.05^{d}	54.59±0.05^{f}	52.71±0.35^{g}	55.35±0.24^{e}	48.17±0.15^{h}
Bulk density kg/m3	557.79±5.76^{a}	477.07±0.49^{b}	405.54±1.59^{c}	391.93±0.31^{d}	376.20±0.39^{gf}	379.76±0.19^{ef}	371.47±0.39^{g}	382.71±0.18^{e}
Average Oleoresin yield%	3.68±0.04^{f}	4.18±0.18^{e}	7.59±0.01^{d}	7.90±0.08^{c}	8.05±0.05^{c}	8.54±0.10^{b}	8.92±0.03^{a}	8.84±0.02^{a}
Average Oil yield%	3.86±0.22^{b}	4.10±0.10^{ab}	4.45±0.10^{a}	3.58±0.36^{cb}	2.95±0.17^{d}	3.06±0.10^{cd}	2.83±0.10^{d}	2.95±0.17^{d}
Total Antioxidant Capacity (TAC) (mg TE /g of oleoresin)	1421.54±18.63^{b}	1555.69±7.04^{a}	1399.86±72.76^{b}	1123.44±10.23^{d}	1291.46±21.51^{c}	1026.91±18.63^{e}	875.69±15.68^{f}	866.75±16.24^{f}
Total Phenolic Capacity (TPC) (mg GAE /g of oleoresin)	142.27±0.21^{ab}	143.19±2.24^{a}	138.87±2.59^{ab}	139.49±1.05^{ab}	134.24±0.37^{c}	139.49±1.12^{ab}	140.41±1.20^{ab}	139.92±1.19^{ab}
Total Flavonoid Capacity (TFC) (mg RE /g of oleoresin)	469.33±39.19^{e}	539.33±32.45^{ed}	544.33±1.67^{ed}	678.78±42.83^{ba}	718.78±25.24^{a}	641.56±22.63^{bac}	602.11±9.18^{bdc}	585.44±27.50^{dc}
Average Eugenol%	81.54±0.05^{h}	81.72±0.02^{g}	86.81±0.01^{f}	88.55±0.10^{d}	87.92±0.06^{e}	88.95±0.06^{c}	89.43±0.03^{a}	89.13±0.10^{b}
Average β-caryophyllene%	10.92±0.07^{a}	10.78±0.03^{b}	8.05±0.05^{c}	6.84±0.06^{d}	6.45±0.01^{e}	6.25±0.01^{f}	6.14±0.01^{f}	6.23±0.03^{f}
Average Myrcene%	2.21±0.02^{a}	2.17±0.01^{b}	1.61±0.01^{c}	1.38±0.01^{d}	1.32±0.02^{e}	1.29±0.01^{fg}	1.26±0.01^{hg}	1.31±0.01^{fe}

All data are mean ±SD (n=3)
P1=1st Leaf Position
WB= wet basis
TE= Trolox equivalent
GAE= Gallic Acid equivalent
RE= Rutin equivalent
Values in each column having the same superscript letter are not significantly (P>0.05) different.

A reducing trend was observed in bulk density with the maturity of the leaves. Strong negative relationship was identified between the particle size and the oleoresin yield which having a R^2 value of 0.9431. When the particle size of the sample is smaller the extraction efficiency would be higher. However, due to the higher volatile oil loss, the optimum particles size (2.00 mm) was used for the extractions.

Acetone and Hexane were mixed to identify the best solvent for the extraction. When two solvents are mixed with each other the boiling points of the mixture can be reduced (Randová *et al*., 2016). When the boiling point of a solvent is low the energy that needs to remove the solvents from the extraction solvents is also low. Therefore, a mixed solvent is more important than a one single solvent.

The polar components can be extracted by acetone whereas, non-polar particles can be extracted by hexane. Presence of both polar and non-polar extraction solvents may increase the yield. Hexane is cheaper than acetone and the incorporation of hexane will reduce the overall cost for the solvents. Acetone: Hexane = 90:10 solvent mixture was selected as the optimum solvent mixture for the oleoresin extractions.

The highest essential oil yield (4.45 %) was observed in the 3rd leaf position. There was no significant difference between the leaf oil contents from leaf positions 4 to 8. Therefore, up to fourth leaf positions can be recommended as the sustainable and optimum point of harvesting. According to the Gas chromatography results, 3 main chemical components (eugenol, β-caryophyllene and myrcene) were identified. Significantly ($p<0.05$) higher eugenol yield was observed in upper leaf positions. The highest β-caryophyllene (10.92±0.07 %) and myrcene (2.21±0.02 %) contents were recorded in the 1st leaf position. The highest oleoresin content was observed from the 7th leaf position (8.92±0.03 %). There was no significant ($P>0.05$) difference between the oleoresin yield of 6th to 8th leaf positions. However, considering sustainable extraction first 4 leaves can be recommended. The highest amount of TAC (1,555.69±7.04 mg TE/g of oleoresin) and TPC (143.19±2.24 mg GAE/g of oleoresin) were observed in oleoresin extracted from 2nd leaf position whereas the highest TFC (718.78±25.24 mg RE/g of oleoresin) was recorded in the 5th leaf position (Table 1).

The residual solvent level was maintained below 25 mg/kg levels (acetone= 17.70 mg/kg, hexane=0.25 mg/kg) in the final allspice oleoresin product. Two products, allspice herbal drink (Black) and (Green), from allspice leaves, were developed. The black one recorded 7.5/9 value of overall acceptability whereas, green one obtained 6.7/9 value from the sensory evaluation (Figure 1). The findings of this study encourage the commercial-scale cultivation of allspice in Sri Lanka.

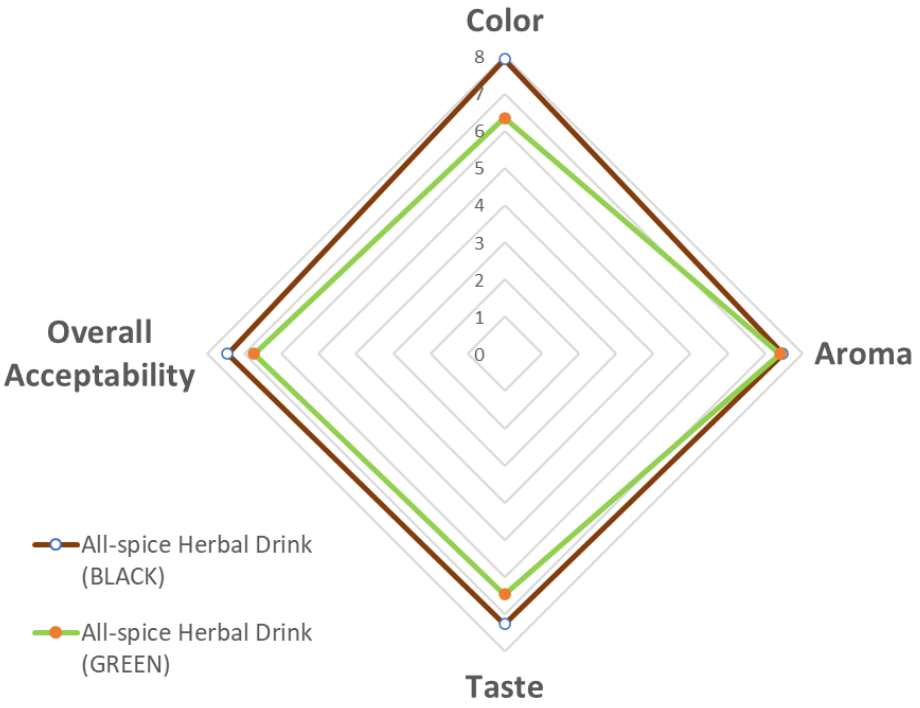

Figure 1: Results of the Sensory Evaluation

Conclusion

The commercial potential of the leaves of allspice is significant. Upper leaves (Up to 4th level) can be recommended for both commercial level essential oil and oleoresin extractions from the allspice leaves. Allspice herbal beverage can be recommended as a good refreshment beverage for Sri Lankan consumers.

References

Benzie, I.F.F. and Szeto, Y.T. (1999). 'Total antioxidant capacity of teas by the ferric reducing/antioxidant power assay', *Journal of Agricultural and Food Chemistry*, 47(2), pp. 633–636. doi: 10.1021/jf9807768.

Cai, Y., Luo, Q., Sun, M., and Corke, H. (2004). 'Antioxidant activity and phenolic compounds of 112 traditional Chinese medicinal plants associated with anticancer', *Life Sciences*, 74(17), pp. 2157–2184. doi: 10.1016/j.lfs.2003.09.047.

Liu, M., Qi, L.X., Weber, C., Yong Lee, C., Brown, J., and Liu, R.H. (2003). 'Antioxidant and Antiproliferative Activities of Raspberries', *Journal of Agricultural and Food Chemistry*, 51(23), pp. 6887–6892. doi: 10.1021/jf034506n.

Mérida-Reyes, M.X., Muñoz-Wug M.A., Oliva-Hernández B.E., Gaitán-Fernández I.C., Simas D.L.R., da Silva A.J.R., and Pérez-Sabino J.F. (2020). 'Composition and Antibacterial Activity of the Essential Oil from Pimenta dioica (L.) Merr. from Guatemala', *Medicines*, 7(10), p. 59. doi: 10.3390/medicines7100059.

Panawala, P. B. C., Abeysinghe, D. C. and Dharmadasa, R. M. (2016). 'Phytochemical Distribution and Bioactivity of Different Parts and Leaf Positions of Pimenta Dioica (L.) Merr (Myrtaceae)', *World Journal of Agricultural Research*, 4(5), pp. 143–146. doi: 10.12691/wjar-4-5-3.

Randová, A., Bartovská, L., Kačírková, M., Ledesma, O. I. H., Červenková-Šťastná, L., Izák, P., Žitková, A., & Friess, K. (2016). 'Separation of azeotropic mixture acetone + hexane by using polydimethylsiloxane membrane'. *Separation and Purification Technology*, *170*, 256–263. https://doi.org/10.1016/j.seppur.2016.06.061

Wesołowska, A., Grzeszczuk, M. and Jadczak, D. (2014). 'Comparison of chemical compositions of essential oils isolated by hydrodistillation from wild thyme (Thymus serpyllum L.) with use of Deryng and Clevenger apparatus ', *Herba Polonica*, 60(2), pp. 7–17. doi: 10.2478/hepo-2014-0006.

Investigating the Impact of Pre-Gelatinization Following Steaming on the Physico-Functional Properties of Yam Flour in Sri Lanka

S. Umayangani[1], M. Silva[1], A. Sandaruwani[2*]

[1]Department of Biosystems Technology, Faculty of Technology, University of Sri Jayewardenepura, Pitipana, Homagama, Sri Lanka.
[2]School of Science, STEM College, RMIT University, Bundoora VIC 3083, Australia.

Corresponding Author: sandaruwani@sjp.ac.lk*

Summary

This study employs the effect of pre-gelatinization on the physico-functional properties of lesser yam (*Dioscorea esculanta*) flour. Cleaned and sliced lesser yam tubers were divided into three portions. Two portions were steamed at 100 °C for gelatinization, one portion for 5 minutes and the other for 10 minutes. Steamed samples were drained and cooled down to room temperature and cooled at 4 °C for 24 hours in a refrigerator. The remaining portion was prepared as the non-gelatinized sample by only oven-drying the sliced raw yam tubers. After being dried in hot air oven until its crispy level, samples were ground and sifted (100 mesh). Yield, swelling power, solubility, and water holding capacity were investigated. The swelling power and water holding capacity (WHC) of the samples significantly increased ($p>0.05$) with the application of steaming while solubility has significantly decreased ($p>0.05$). The sample which was steamed only for 5 minutes showed a higher yield. It was concluded that not only the gelatinization process but also the increase in steaming time can be affected to the physico-functional properties of the lesser yam flour.

Keywords: Lesser yam flour, Physico-functional properties, Pre-gelatinization

Introduction

Lesser yams, *Dioscorea esculenta* (variety: Kukulala, java-ala, and nattala) is a widely grown yam species in Sri Lanka. These tubers are primarily composed of starch, which accounts for 60–85 % of their dry weight (Jayakody *et al.*, 2009). Lesser yams have a great production potential and a crop that ensures food security while they are adaptable to areas with few resources. Lesser yams include a number of beneficial substances, including dioscorin and diosgenin, that can enhance the immune system (immunomodulator), and prevent metabolic disorders (hypercholesterolemia, dyslipidemia, diabetes, and obesity), inflammation, and cancer (Nokami, 2019). Although the inulin found in yam tuber is one of

the promising sources of prebiotics and it can sustain probiotic bacteria development (Lestari and Nissa, 2016).

Currently yam flour is used for bakery products, weaning food and plant based beverages (Kulasinghe and Ranaweera, 2019). The properties of flour can be altered based on the method of processing employed and they can affect the quality of the food product and its processing conditions. Hence, the objective of this research is to examine the impact of pre-gelatinization on the physico-functional characteristics of lesser yam flour, as well as the effect of different steam durations of pre-gelatinization on same properties.

Methodology

Three samples of yam tubers were weighed and washed thoroughly. The stem end was sliced off to avoid the bitter taste. Peeled tubers were put into 6% NaCl solution to prevent browning reactions. Peeled tubers were thinly sliced and soaked in NaCl solution immediately. Then it was washed and strained to remove the water. Thin slices of lesser yam tubers were divided into three portions. Two portions were spread out inside the steamer and steamed at 100 °C for gelatinization, one portion for 5 minutes and the other for 10 minutes. The remaining portion was prepared without any steaming and cooling treatments as the non-gelatinized samples. Steamed samples were drained and cooled down to room temperature and cooled at 4 °C for 24 hours in a refrigerator. After thawing, samples were cut into thin strips and spread out in 3 labeled trays. After being dried in hot air oven at temperature of 50 °C for 60 minutes and then at 60 °C for 90 minutes until its crispy level, samples were ground using a domestic blender and sifted (100 mesh). The flour obtained was packed inside polythene bags and vacuum sealed. Then Sealed flour bags were stored at 4 ˚C for further use.

The flour yields of lesser yam tubers were measured by the ratio of the weight of flour to the weight of the whole yam tubers. Swelling power was determined by using Leach method (Leach, Mc Cowen, and Schoch, 1959). Here 0.1 g of each sample was heated in 10 ml of deionized water in a water bath at 60 °C with continual stirring for 30 minutes. The samples were centrifuged for 15 minutes at 1600 rpm at 25 °C. Supernatant was removed to measure the weight of sediment paste. Water solubility was determined using Kainuma method (Kainuma, Odat, and Cuzuki, 1967). The 0.5 g of each sample was heated at 60 °C for 30 minutes in a 10 ml water bath without mixing. Then the samples were centrifuged at 1600 rpm at 25 °C for 10 minutes. The watch plates with the supernatant were dried inside a hot air oven for 15 hours. Then the starch was scraped out and weighed using an analytical balancer. WHC was measured as follows. Mixture of 5 g of flour and 30 ml of distilled water was centrifuged for 30 seconds, followed by a 10-minute rest period. Then, 10 ml of distilled water was used to rinse flour clinging to the stirring rod, followed by 25 minutes of centrifugation at 2300 rpm at 25 °C (Sousulski, 1962). All the tests were done as triplicate except for the yield. Finally, the collected data were analyzed by One-way ANOVA to test the significance of variables (α=0.05).

Results & Discussion

The swelling power of the samples significantly increased ($p>0.05$) with the application of steaming as Figure 1. Swelling power of samples steamed for 5 minutes is significantly ($p>0.05$) lower than sample which is steamed for 10 minutes. This occurs because heat treatment causes the starch in the flour to gelatinize, causing the flour to expand with more force. As starch is heated with an excessive amount of water, granules increasingly hydrate, hydrogen bonds are broken, causing crystalline parts to transform into amorphous regions, and granules continue to absorb water and swell (Ratnayake, 2002).

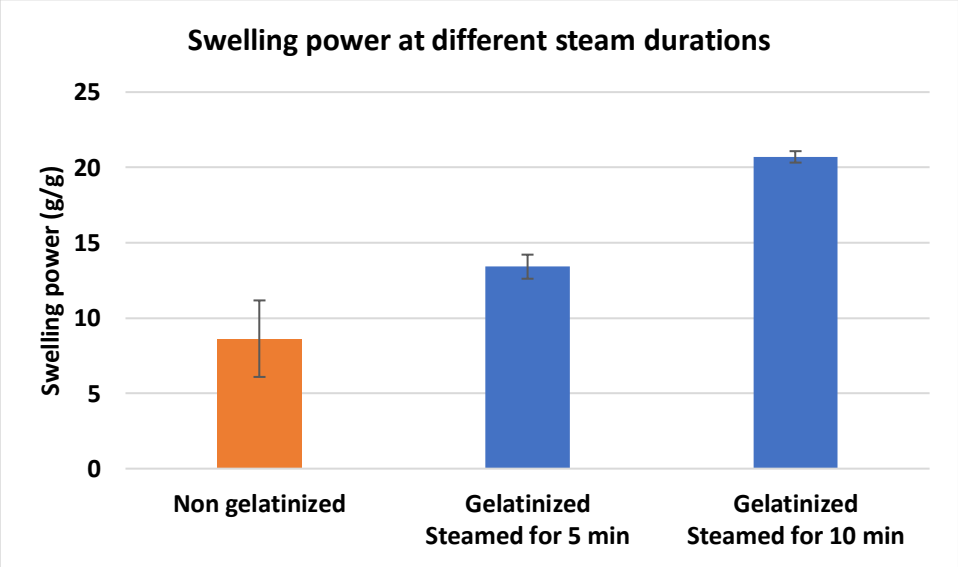

Figure 1: Effect of the gelatinization and steaming on the swelling power

According to Figure 2, non-gelatinized sample has the highest solubility ($p>0.05$). This could be the result of a decrease in the granules' stability under non-gelatinized conditions, which led to the unraveling of double helices that were possibly present on a crystalline array in the original granules (Yadav, Guleria and Yadav, 2013). Moreover, solubility of samples steamed for 5 minutes is significantly lower than sample which is steamed for 10 minutes ($p>0.05$). The results revealed that steaming time had a substantial impact on the water solubility, which improved as steaming time increased. This was likely the result of the starch granules weathering during the gelatinization process, which led to an increase in solubility (Yadav, Guleria and Yadav, 2013).

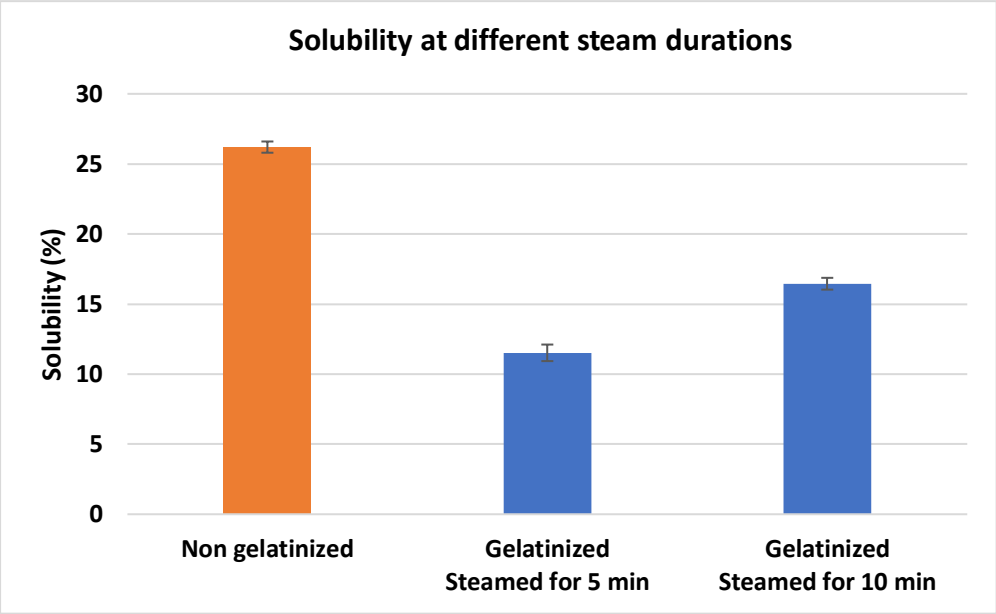

Figure 2: Effect of the gelatinization and steaming on the solubility

The purpose of determining the WHC was to establish the capacity of flour to take up water. Significantly higher ($p>0.05$) values for WHC were obtained in pre-gelatinized flour samples compared to non-gelatinized sample as Figure 3. There is no significant difference between WHC of samples which are steamed for 5 minutes and sample which is steamed for 10 minutes. The steaming treatment is a part of the process of creating physical alterations to flour that can have an effect on these higher values. There is a possibility that the severity or intensity of the steaming promotes bio-physical readjustments in the structural matrix of the tubers, which results in an increase in the tubers' innate capacity to hold more water (Iwuoha, 2004). Because the yam starch in the flour has been gelatinized, it is no longer contained in amylose starch granules; rather, it is distributed throughout the flour together with amylopectin. Since amylose is no longer found in granule form, it will be simpler to form hydrogen bonds and will be able to take in water more readily.

Gelatinized flour samples show significantly ($p>0.05$) higher yield than the non-gelatinized samples as Figure 4. Reports indicated that blanching improved yield by making the food's texture more amenable to grinding (Kluza and Wolak, 2003). However, the sample which was steamed only for 5 minutes shows a higher yield than the sample which was steamed for 10 minutes. This can be due to the absorption of excessive moisture during the 10-minute time period. It was reported that absorbing excessive moisture leads to reducing the milling yield (Aghinezhad *et al.*, 2016). As a result, longer steaming times for the pre-gelatinization are not advised.

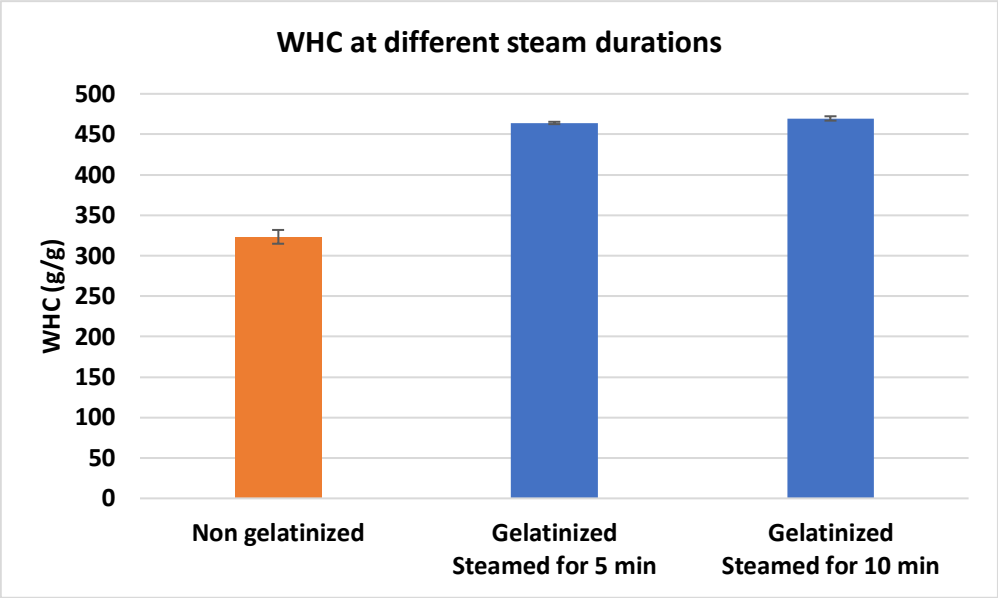

Figure 3: Effect of the gelatinization and steaming on the WHC

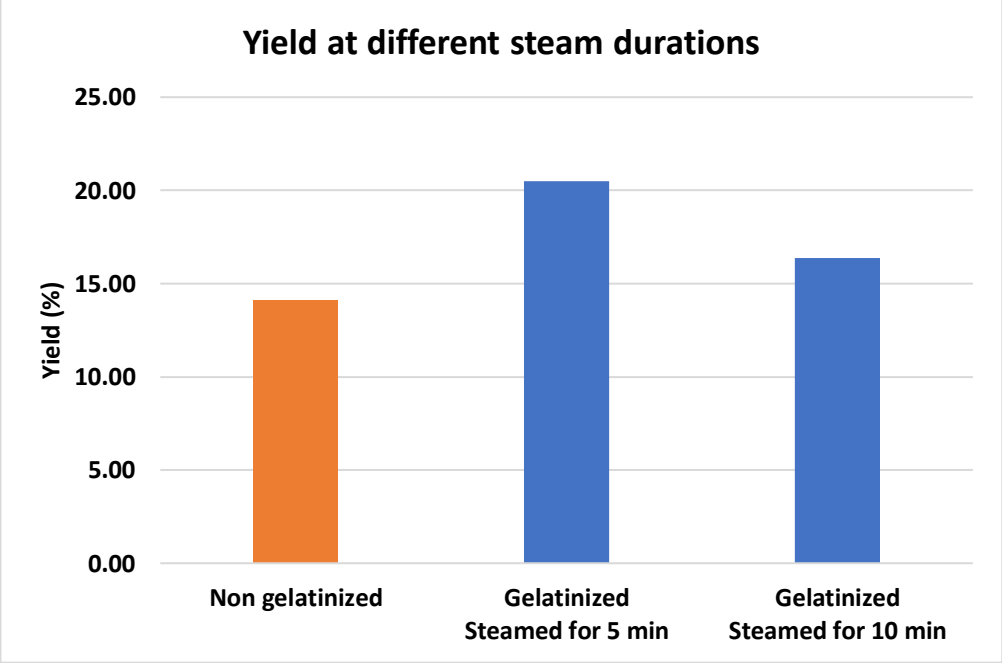

Figure 4: Effect of the gelatinization and steaming on the yield

Indicating swelling power and solubility as 3.90±0.01 g/g and 11.07±0.05 as observed by Retnowati *et al* (2018), even for non-gelatinized samples, the method used in this analysis yields higher solubility values. However, it has decreased as a result of pre-gelatinization, whereas WHC has increased. Similar observation; increase of WHC with pre-gelatinization phase, has resulted in additional research (Estiasih, Saputri and Kusnadi, 2013: Iwuoha,

2004). Altering the physico-functional properties of lesser yam flour through pre-gelatinization with varying steam durations can be a promising technique, as different food processing requires different flour properties. So that it will add value to the lesser yam which is an underutilized crop in Sri Lanka.

Conclusion

The lesser yam is a crop that is not fully utilized despite its desirable properties, including high yield, culinary attributes, and elevated nutritional value. The obtained data pertaining to yield, swelling power, water solubility, and water holding capacity values indicates that a steaming duration of 10 minutes results in greater water holding capacity and swelling power. The solubility value is highest in lesser yam flour that has not been gelatinized. The gelatinization process increased yield, WHC and swelling power and with the steaming time, swelling power and solubility have been increased. Therefore, not only the gelatinization process but also the increase in steaming time affect to the physico-functional properties of the yam flour.

References

Aghinezhad, E., Khoshtaghaza, M.H., Minaei, S., Suzuki, T., Brenner T. (2016). 'Relationship Between Degree of Starch Gelatinization and Quality Attributes of Parboiled Rice During Steaming', *Rice Science*, 23(6), pp. 339-344. doi:10.1016/j.rsci.2016.06.007.

Estiasih, T., Saputri, D.S. and Kusnadi, J. (2013). 'Effect of Blanching on Properties of Water Yam (*Dioscorea alata*) Flour', *Advance Journal of Food Science and Technolog*y, 5. pp.1342-1350. doi:10.19026/ajfst.5.3108.

Iwuoha, C.I. (2004). 'Comparative evaluation of physicochemical qualities of flours from steam-processed yam tubers', *Food Chemistry*, 85, pp. 541–551. doi: 10.1016/j.foodchem.

Jayakody, L., Hoover, R., Liu, Q., Donner, E. (2009). 'Studies on tuber starches III. Impact of annealing on the molecular structure, composition and physicochemical properties of yam (Dioscorea sp.) starches grown in Sri Lanka', *Carbohydrate Polymers*, 76(1), pp. 145–153. doi:10.1016/j.carbpol.2008.10.003.

Kluza, F. and Wolak, S. (2003). 'Effect of blanching, freezing and thawing on some quality factors of Sweet Pepper (*Capsicum annuum*)'. *Acta Horticulture*. 628, 797-797 DOI:10.17660/ActaHortic.2003.628.101,https://doi.org/10.17660/ActaHortic.2003.628.101

Kulasinghe, W.M.A.A. and Ranaweera, K.K.T.N. (2019). 'Physical, chemical and biological aspects of Dioscorea yams and potential value additions', *Journal of Agriculture and Value Addition*, 2(1), pp. 43–59.

Lestari, R.P. and Nissa, C. (2016) 'Effect of modified yam (Dioscorea esculenta) flour on some physicochemical and sensory properties of synbiotic yoghurt', *IOP Conference Series:*

Materials Science and Engineering, 128. doi:10.1088/1757-899X/128/1/012035.

Nokami, T. (2019). 'Isolation oligosaccharides from gembili (Dioscorea esculenta Lour . Burkill) as prebiotics', *IOP Conf. Series: Materials Science and Engineering*, 633 doi:10.1088/1757-899X/633/1/012006.

Ratnayake, W., Hoover, R. and Warkentin, T. (2002). 'Pea Starch : Composition , Structure and Properties', *Starch/Stärke*, 54, pp. 217–234.

Retnowati, D.S., Kumoro, A.C. and Ratnawati, R. (2018). 'Physical , thermal and functional properties of flour derived from Ubi Gembili (*Dioscorea esculenta* l). Tubers grown in indonesia', *Potravinarstvo*, 12(1), pp. 539–545.

Yadav, B.S., Guleria, P. and Yadav, R.B. (2013). 'Hydrothermal modification of Indian water chestnut starch : Influence of heat-moisture treatment and annealing on the physicochemical , gelatinization and pasting characteristics', *LWT - Food Science and Technology*, 53(1), pp. 211–217. doi:10.1016/j.lwt.2013.02.007.

Formulation of a Healthy Cracker with Low Glycemic Index Ingredients

K.M.S.A.K. Dehideniya[1], V.P. Bulugahapitiya[1*], R.S. Sabaragamuwa[2], T.C. Kananke[3]

[1]Department of Chemistry, University of Ruhuna, Matara, Sri Lanka.
[2]Auckland University of Technology, Auckland, New Zealand.
[3]Department of Food Science and Technology, Faculty of Applied Sciences, Sabaragamuwa University, Belihuloya, Sri Lanka.

Corresponding Author:vajira@chem.ruh.ac.lk*

Summary

Beyond fundamental nutritional requirements, functional foods give a positive influence on human health and/or help to reduce the risk of Non-Communical Diseases. Therefore, it is required to develop innovative functional foods at low cost to support the community to promote their health. This research aims to develop a healthy cracker that is compatible with diabetics, using low glycemic, nutritious ingredients including flattened rice (rice Flakes/ Habala pethi), oats, whole grain wheat flour, and gram flour. The moisture, crude protein, total fat, crude fiber, ash, and carbohydrate contents of the healthy cracker product were 1.08±0.19%, 2.08±0.09%, 6.07±0.80%, 2.18±0.51%,3.58±0.46%, and 85.01±0.01% respectively. In the microbial analysis, total plate count and yeast and mold counts were not detected for four months. Furthermore, water activity, pH value, calory value, total sugar, mineral content, antioxidant activity, total phenolic content, predicted Glycemic index and hardness of the product were carried out. No preservatives or artificial flavours were added to the product and different types of packaging materials were used to extend the shelf life.

Keywords: Cracker, Functional food, Flatted rice, Healthy, Low glycemic index

Introduction

The concept of the development of functional food products does not only include the incorporation of certain functional compounds/ingredients which affect the established health benefits but also the product must be balancing with sensory attributes such as taste, flavor, and texture. These attributes mostly affect consumer's buying choices (Hernández *et al.*, 2018). This study aimed to develop a healthy cracker product with accepted textural and sensory properties.

In general, all snacks contain wheat flour as the key ingredient. In addition, a number of snacks/cracker products contain high amounts of fat, oil, salt, or sugar, which can lead to negative health consequences including, dental caries, obesity, and diabetes.

Additionally, consumers frequently eat snacks as major dishes, which may result in obesity or malnutrition (Chittapalo and Songsanandr, 2014). Wangcharoen *et al.* (2005) found that most consumers purchased snacks because of their taste and factors influenced by advertising, than the nutrient factors. Considering this situation, the study was focused on developing a nutritious, healthy, and novel cracker product with low glycemic index and good sensory appeal. The main ingredient used for the cracker formulation was flattened rice (rice flackes/ *Habala pethi*), while the other ingredients include oats, whole grain wheat flour, and gram flour. The developed cracker is a feasible formulation for vegetarians with potential as a healthy and nutrient-rich product with satisfactory texture properties. This formulation has demonstrated potential application in the bakery industry as a value-added functional product.

Methodology

Raw materials

Habala pethi, whole grain flour, gram flour, oats, wheat pieces, fat spread, salt, sodium bicarbonate and yeast were obtained from local supermarkets in Sri Lanka.

Experimental design

Ingredients selection was done after a comprehensive literature review. Low glycemic, highly nutritious, and low-cost ingredients were selected for product formulation.

A completely randomized design was used to find the optimum particle size and the main ingredient for the final product formulation. A factorial design was used with two levels. Fine powder, and large-size particles of wheat flour and *Habala pethi*. The particle size was determined from the mesh size of the sieve (large particles- 2 mm mesh size, small particles- 0.5 mm mesh size). The process of preparing crackers was the same as the standard cracker preparation method (Figure 1).

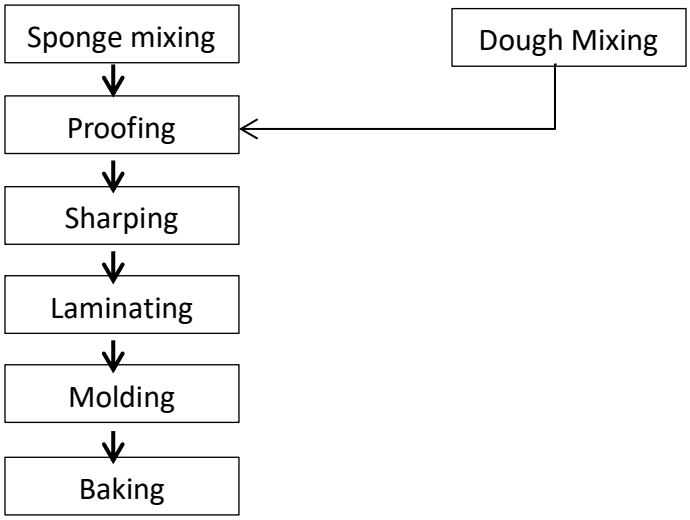

Figure 1: Cracker preparation procedure

Sensory evaluation

The prototype product's sensory evaluation was conducted using a 5-point hedonic scale and 30 untrained panelists.

Proximate analysis

Proximate analysis was carried out for the selected cracker formulation from the sensory evaluation. The moisture (oven drying method, AOAC 990.19), ash (dry ashing, AOAC, 900.02), crude protein (Kjeldhal method, AOAC 955.04), crude fat (Soxhlet method AOAC 920.39), and crude fiber (AOAC 978.10) contents were determined.

Analysis of other physicochemical and techno-functional properties

The water activity and pH were analyzed based on previous methods with some modifications. The calorific value of the final product was determined using a bomb caloric meter (Model C 200 S000). Hydrolysis Index (HI), Predicted Glycemic Index (PGI), Ferric reducing antioxidant potential, DPPH free radical scavenging ability, total phenolic content (TPC), and total sugar content were determined as described previously with few modifications (Monro and Shaw, 2008; Dudonné *et al*., 2009; Nielsen, 2017).

Texture analysis was carried out by Texture Analyzer (Brookfield, CT3, USA) according to the method of Nurhanan *et al*., (2021) with some modifications. Texture profile analysis was conducted with a 50 g trigger load, 3 mm/s test speed, and using TA 7 probe. The mineral content of the digested cracker sample was analyzed by Fast Sequential Atomic Absorption Spectrophotometer.

Analysis of shelf-life

The shelf-life of the formulated cracker was determined for two types of packaging materials (laminated package and polythene packages) at ambient temperature. The total plate count and yeast and mold count (Betts and Blackburn, 2009), moisture content, and pH value were evaluated at two weeks time intervals for four months.

Statistical analysis

The mean and standard deviation values for each parameter were calculated. All data are expressed as mean ± SD by measuring three independent replicates. Analysis of variance using one-way ANOVA and the significance of differences between means obtained among the treatments at the 5% level of significance using the Minitab software (Version 18).

Results & Discussion

Sensory evaluation for formulation selection

Table 1. Different formulations for sensory analysis

Sample code / Ingredients	S1	S 2	S 3	S 4
Whole grain flour	46 % (small particle)	36 % (small particle)	20 % (large particle)	20 % (small particle)
Habala pethi	0	10 % (small particle)	19 % (large particle)	19 % (small particle)
Gram flour	8 %	8 %	15 %	15 %
Oats	16 %	16 %	16 %	16 %
Broken wheat	8 %	8 %	8 %	8 %
Fat spread	16 %	16 %	16 %	16 %
Salt	1.2 %	1.2 %	1.2 %	1.2 %
Sodium bicarbonate	0.2 %	0.2 %	0.2 %	0.2 %
Yeast	0.3 %	0.3 %	0.3 %	0.3 %
Water	4.3 %	4.3 %	4.3 %	4.3 %

The prepared ingredients were combined at different proportion (Table 1) and a pilot-scale sensory evaluation was conducted to obtain a basic idea about the formulation.

For each formulation, 30 untrained panelists completed a ballot form assessing different sensory attributes (taste, appearance, aroma, aftertaste, crispiness, and overall acceptability), on a 5-point hedonic scale. The results were shown in Table 2.

Table 2. Sensory properties of different formulations

Attribute	S1	S2	S3	S4	P value
Color	4.00	3.12	2.88	4.00	0.081
Taste	3.75	3.62	3.25	3.38	0.646
Appearance	4.00	4.00	3.00	4.00	0.044
Aroma	3.50	3.50	3.50	3.50	0.595
After taste	3.50	3.62	3.50	3.38	0.678
Crispiness	4.06	3.94	3.18	3.94	0.435
Overall acceptability	3.81	3.69	3.19	3.56	0.483

There was no significant difference between treatments for color, taste, aroma, aftertaste, crispiness, and overall acceptability. However, in appearance, there was a significant difference between treatments, as *habala pethi* gives a darker color and rough appearance to the product, compared with the control.

From the organoleptic evaluation, it was found that *habala pethi* can be replaced with wheat flour effectively and according to the results, fine particles were more acceptable than large particles in cracker products. The best-formulated cracker (S4) includes *Habala pethi* with fine particle size.

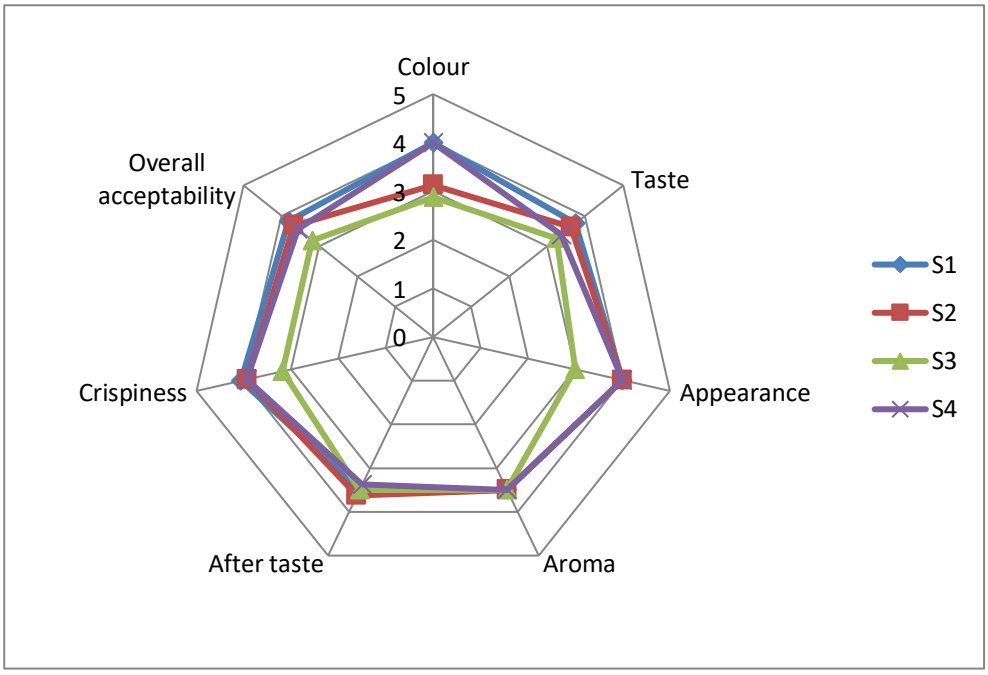

Figure 2: Spider web chart of the sensory analysis

Physicochemical and techno-functional properties

Table 3. Chemical composition of prepared formulation

Parameter	Amount
Moisture content	1.08± 0.19 %
Crude protein	2.08±0.09 %
Total fat	6.07±0.80 %
Crude fibre	2.18±0.51 %
Ash	3.58±0.46 %
Total carbohydrate	85.01±0.01 %
Water activity	0.32±0.05
pH value	6.47±0.42
Calorie	4.86 kcal/g

Table 4. Mineral content in the final formulation

Mineral type	Amount (mg/100g)
Na	73.60±0.81
Mg	11.99±0.56
Ca	10.12±0.37
K	46.34±1.94

Table 5. Functional properties of the final cracker formulation

Functional property	Amount
Antioxidant- FRAP assay	33.07±0.89 Trolox mg/100g dry basis
Antioxidant- DPPH	IC50 5.67±0.32 (31.59±2.92 mg/ml-Ascobic acid) dry basis
Total sugar	68.78±0.54 glucose mg/100g dry basis
Total Phenolic Content	1.29±0.19 GAE mg/100g dry basis

The major component of the Healthy Cracker was carbohydrates since the main ingredients were rice flakes and oats. Rice flakes are locally known as *Habala pethi*, which are prepared from paddy and have been claimed as a good source of protein, fat, and carbohydrates. It is rice that flattened into flat, light, dry flakes. They are lactose-free, heart-healthy, and fat-free, rich in carbohydrates, B vitamins and are supposed to be great for diabetics. It is with low glycemic index and promotes the slow release of sugar into the bloodstream and keeps the satiety feel for a longer time, while easily digestible. Further, it helps to keep the heart healthy, reduces Iron deficiency, and is good for bone health (Šťastná *et al.*, 2019).

Table 6. Comparison of the Hydrolysis Index (HI) and Predicted Glycemic index (PGI)

Sample	HI (Hydrolysis Index)	Predicted Glycemic index(PGI)
Commercial bread	0.87 ± 0.05^{b}	71.08 ± 0.01^{b}
Whole wheat flour	1.00 ± 0.06^{a}	75.47 ± 0.05^{a}
Commercial cracker	0.75 ± 0.03^{c}	66.77 ± 0.01^{c}
*Healthy cracker	0.56 ± 0.01^{d}	59.84 ± 0.02^{d}

*Mean values in the same column with different superscript letters are significantly different at $p<0.05$

There was a significant difference in Hydrolysis Index and Predicted Glycemic index in tested samples ($p<0.05$), and the Healthy cracker showed the least HI and PGI.

Table 7. Hardness values for commercial cracker sample and healthy cracker sample

Sample	Hardness/g
Developed Formulation	133.33±4.69
Commercially available cracker sample	93.66±11.29

The hardness value of the healthy cracker was higher than the commercial cracker. A comparatively high percentage of *habala pethi* may increase the hardness of the product than wheat flour. It gives more favorable crispiness to the final product.

Microbial analysis

The total plate count and yeast and mold count of the cracker were less than 10 CFU/g. Thus, it could be implied that the product was safe to consume for more than 4 months. pH and moisture content was not changed in aluminum foil packaged samples for more than four months.

Conclusion

According to the evaluation of sensory, physicochemical, and other techno-functional properties, newly prepared healthy cracker can be introduced as an alternative product for crackers prepared from wheat flour. Considering the low moisture content, type of packaging material, and analyzed microbial counts, there is a possibility of extending the shelf life beyond four months while retaining the product quality and safety. This is an appropriate product choice to fulfill the nutritional demand while having the potential to introduce as a functional food for the prevention of diabetes.

Acknowledgment: authors wish to thank the AHEAD/RA3/DOR-05/RUH/SCI/CHE project for financial support

References

Betts, R. and Blackburn, C. W. (2009). 'Detecting pathogens in food, Foodborne Pathogens: Hazards, Risk Analysis and Control: Second Edition. Woodhead Publishing Limited. doi: 10.1533/9781845696337.1.17.

Chittapalo, T. and Songsanandr, P. (2014). 'Product development of black glutinous rice cracker with Panang flavor and its quality changes', *International Food Research Journal*, 21(5), pp. 2025–2029.

Dudonné, S. , Vitrac, X., Coutière, P., Woillez, M., and Mérillon, J. (2009). 'Comparative Study of Antioxidant Properties and Total Phenolic Content of 30 Plant Extracts of Industrial Interest Using DPPH, ABTS, FRAP, SOD, and ORAC Assays', *Journal of Agricultural and Food Chemistry*, 57 (5), pp. 1768–1774, https://doi.org/10.1021/jf803011r.

Hernández, G., León, R., and Urtubia, A. (2018). 'Application of computational intelligence techniques for forecasting problematic wine fermentations using data from classical chemical measurements', *Innovations in Technologies for Fermented Food and Beverage*

Industries. doi: 10.1007/978-3-319-74820-7_16.

Monro, J. A., and Shaw, M. (2008). "Glycemic impact, glycemic glucose equivalents, glycemic index, and glycemic load: Definitions, distinctions, and implications." *The American Journal of Clinical Nutrition*, 87(1), pp. 237S-243S, https: //doi.org/10.1093/ajcn/87.1.237s.

Nielsen, S. (2017). 'Food Analysis Laboratory Manual'. 3rd Edition, *Food Science Text Series*, https://doi.org/10.1007/978-3-319-44127-6_14. Accessed 8 Feb. 2023

Nurhanan, A. R., Xin, D. T. W, and Tham, L. (2021). 'Physicochemical properties and sensory evaluation of green and red spinach crackers', IOP Conference Series: *Earth and Environmental Science*, 756(1). doi: 10.1088/1755-1315/756/1/012079.

Šťastná, K., Mrázková, M., Sumczynski, D., Cındık, B., and Yalçın, E. (2019). 'The nutritional value of non-traditional gluten-free flakes and their antioxidant activity', *Antioxidants*, 8(11), pp. 1–18. doi: 10.3390/antiox8110565.

Development of Underutilized Gahala Yam (*Colocasia esculenta*) Incorporated Pasta

M.V.K.B. Prabodhani[1], C.M. Senanayake[1*], H. Weeratunge[2]

[1] Department of Biosystems Technology, Faculty of Technology, University of Sri Jayewardenepura, Gangodawila, Nugegoda.

[2] Department of Quality Assurance, Freelan Enterprises Pvt. (Ltd.), Udukawa, Waligama.

[*]Corresponding author: chathurisnnk@sjp.ac.lk

Summary

This study aimed to incorporate gahala yam (*Colocasia esculenta*) tubers into wheat pasta to improve their nutritional value. The gahala yam flour sample treated with 0.1% SMS solution exhibited the best properties, including color with L*a*b* values (68.07±2.20, 0.53±0.21, and 8.90±0.10 respectively), water activity (0.49±0.23), and water solubility (7.72±1.47%). The pasta sample prepared with 10 % gahala yam flour blended with wheat flour and rice flour into 9:1 ratio was acceptable in terms of sensory attributes. This formulation showed improved cooking yield (196.00±18.3%), reduced cooking loss (3.00±1.0%), and shorter cooking time (6.43±0.04 min). It enhanced the content of carbohydrates, fiber, and ash of the pasta while reducing protein, fat, and moisture compared to 100 % wheat pasta. After two months, it contained less than 700 CFU/g and can safely store for up to two months. Hence, gahala yam flour can be an effective ingredient to improve pasta quality.

Keywords**:** Physicochemical properties**,** Pre-treatments, Sensory evaluation, Steam blanching

Introduction

Tubers are commonly known as a staple food in the human diet due to their high starch content (Kaushal, Kumar, and Sharma, 2015). However, some tuber crops, such as gahala yam (*Colocasia esculenta*), remain underutilized despite their potential to contribute to food security and offer various health benefits. Gahala tubers are rich in carbohydrates, fiber, and micronutrients, making them nutritious food (Sonia, Julianti, and Ridwansyah, 2020). It also possesses functional properties that can influence textural and structural qualities of the food products. Gahala yam has limited use in Sri Lanka. This study aims to develop value-added pasta using gahala yam flour, which offers nutritional advantages over wheat flour pasta. However, commercially available gahala yam-based products are limited. Therefore, it is important to enhance the utilization of gahala yam-based products. The objective is to enhance the nutritional content, acceptability, and cooking quality of gahala yam incorporated pasta. Overall, this research aims to promote the use of

underutilized gahala yam, improve its nutritional value, and create marketable pasta. Exploring its potential as a food ingredient contributes to sustainable tuber crop utilization, food security, and post-harvest losses.

Methodology

Pretreatments for gahala yam flour

Flour preparation was carried out using three pretreatments as mention in Table 1.

Table 1. Pretreatment for gahala yam flour

Treatment group	Pre-treatment method
Control	Gahala yam slices were dried at 65 °C for 14 hrs.
T1	Gahala yam slices were dried under sun radiation without blanching treatments for 4 days
T2	Gahala yam slices were steam blanched for 5 min and oven dried at 65 °C for 14 hrs.
T3	Gahala yam slices were placed in 0.1 % SMS ($Na_2S_2O_5$) solution for 5 min, steam blanched for 5 min, and then oven dried at 65 °C for 14 hrs.

Then dried slices were ground into flour, packed using low-density polyethylene (LDPE), and kept at 4 °C. Then the color, water activity, and water solubility of the different flour samples were evaluated, and the best flour sample was selected.

Formulation of gahala yam incorporated pasta

To formulate gahala yam-incorporated pasta, a partial substitution of the blend of gahala yam flour, wheat flour, and rice flour was used in this study. Other ingredients were carboxyl methyl cellulose (CMC), water, and salt. A mix factorial design (3×2 factorial design) was used, consisting of three levels of gahala yam flour substitution (10 %, 20 %, and 30 %) and two levels of wheat flour/rice flour composition (a ratio of 9:1 and 8:2). The laboratory pasta machine was used to form pasta, subjected to steam, and dried.

Analysis of gahala yam incorporated pasta

Cooking quality analysis

Optimum cooking time, cooking loss, and cooking yield were analyzed (Falade and Badanga, 2021).

Sensory evaluation

Sensory evaluation was done by 30 semi-trained panelists. The cooked pasta samples were evaluated with a 9-point hedonic scale. The evaluation attributes included color, aroma, taste, texture, stickiness, and overall acceptability.

Proximate analysis

Proximate analysis (moisture, protein, crude fat, ash, crude fiber, carbohydrates) was done only for best pasta sample and the 100% wheat pasta sample (control) using AOAC methods.

Microbial analysis

Total plate count and yeast and mold count of the gahala yam incorporated pasta was determined according to the procedure mentioned in MicroChem's Experiments, (2022).

Statistical analysis

The collected data were analyzed using the one-way analysis of variance (ANOVA) and the Tukey pairwise comparisons test. These tests were employed to detect any differences in mean values of the data with a significance level of $p< 0.05$.

Results and discussion

Analysis of gahala yam flour

Determination of color of flour samples

Table 2. L^*, a^*, and b^* value of flour with different treatments

Sample	L^*	a^*	b^*
Control	66.17 ± 0.84^c	2.67 ± 0.23^a	10.30 ± 0.10^a
T1	78.03 ± 1.31^a	2.50 ± 0.35^a	06.17 ± 0.21^c
T2	68.07 ± 2.20^c	0.53 ± 0.21^b	08.90 ± 0.10^b
T3	72.93 ± 1.05^b	2.73 ± 0.32^a	06.50 ± 0.17^c

*Mean values in the same column with different letters are significantly different at $p<0.05$

A B C D

Figure 1: Color variation of flour sample after the pre-treatment condition (A- control, B- dried under sun radiation without blanching, C- steam blanched for 5 min and oven dried, D- placed in 0.1 % SMS for 5 min, steam blanched for 5 min and then oven dried)

Determination of Water activity and water solubility of flour samples

Table 3. Water activity & water solubility of gahala yam flour samples

Sample	Water activity	Water solubility (%)
1. Control	0.578±0.010[a]	9.99±0.63[a]
2. T1	0.713±0.003[a]	10.08±0.14[a]
3. T2	0.576±0.004[a]	9.95±1.86[a]
4. T3	0.493±0.228[a]	7.72±1.47[b]

*Mean values in the same column with different letters are significantly different at $p<0.05$

Analysis of gahala yam flour incorporated pasta

The following formulation groups were used for cooking quality determination and sensory evaluation. According to their results, the best pasta formulation was selected and other analysis was done only for it and the control sample.

Control sample = 100 % wheat flour pasta
F1= 10 % of gahala yam flour and 9:1 ratio of wheat and rice flour
F2= 20 % of gahala yam flour and 9:1 ratio of wheat and rice flour
F3= 30 % of gahala yam flour and 9:1 ratio of wheat and rice flour
F4= 10 % of gahala yam flour and 8:2 ratios of wheat and rice flour
F5= 20 % of gahala yam flour and 8:2 ratios of wheat and rice flour
F6= 30 % of gahala yam flour and 8:2 ratios of wheat and rice flour

Determination of cooking qualities of pasta

Table 4. Cooking quality analysis of pasta

Pasta Sample	Optimum Cooking Time (min)	Cooking Loss (%)	Cooking Yield (%)
Control	5.50±0.07[c]	4.00±0.00[a]	183.33±05.77[d]
F1	6.43±0.04[b]	3.00±1.00[a]	196.00±18.30[c]
F2	6.44±0.16[b]	3.67±0.58[a]	169.33±07.02[f]
F3	7.32±0.23[a]	1.00±1.00[b]	233.33±06.11[b]
F4	6.29±0.15[b]	3.33±1.16[a]	220.00±06.00[b]
F5	5.87±0.46[c]	3.67±0.58[a]	174.67±08.33[e]
F6	7.24±0.20[a]	3.67±0.58[a]	253.33±06.11[a]

*Mean values in the same column with different letters are significantly different at $p<0.05$

The six variants of pasta took significantly less time to cook compared to the control sample. This was due to the variation in ingredient composition, processing methods such as drying and extrusion, and precooking treatments such as steaming. According to the results, the inclusion of gahala yam flour can impact the cooking yield of pasta.

Determination of sensory properties of pasta

This diagram (Figure 2) shows the variation of mean values of each sensory attribute of the six gahala yam pasta samples. The F1 sample showed the highest preference for every attribute, making it the statistically best sample. Additional analyses, such as proximity and microbial analysis, were conducted for this sample to further evaluate its quality.

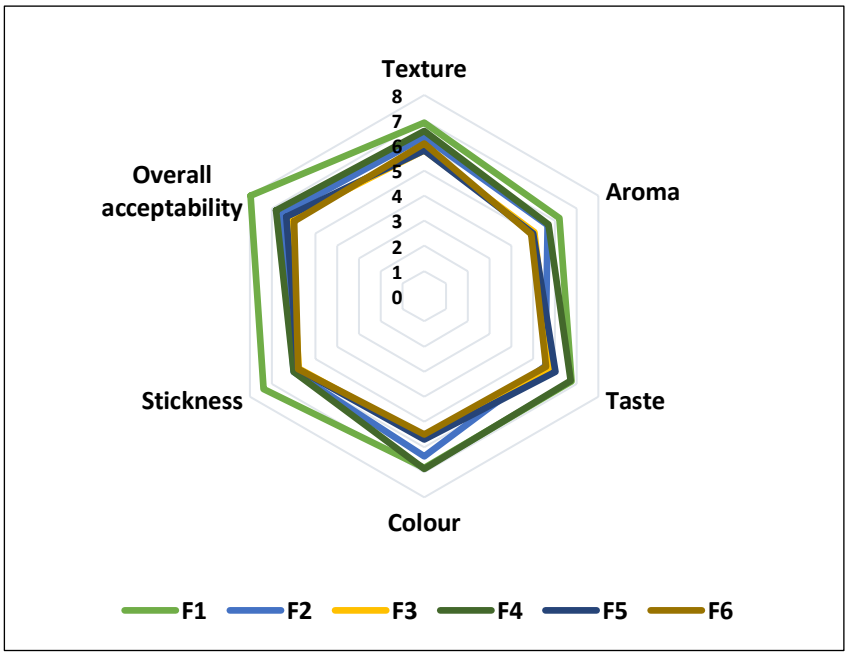

Figure 2: Sensory evaluation results for prepared gahala yam pasta

Determination of proximate composition of pasta

Table 5. Analysis of proximate composition of the control and F1 pasta sample

Pasta Sample	Moisture %	Crude Protein %	Ash %	Fat %	Crude Fibre %	Carbohydrates %
Control	6.95±0.47^{a}	13.10±0.1^{a}	0.54±0.05^{b}	1.67±0.16^{a}	1.00±0.1^{b}	76.73±0.39^{a}
F1	4.96±0.21^{b}	8.50±0.1^{b}	2.26±0.13^{a}	1.50±0.04^{a}	6.86±0.8^{a}	75.92±0.91^{a}

*Mean values in the same column with different letters are significantly different at $p<0.05$

A comparison was made between the F1 sample and commercially available 100 % wheat pasta. The results suggest that the incorporation of gahala yam flour in pasta decreases protein and increases fiber content.

Determination of microbial quality of pasta

Table 6. Total plate count and Yeast and Mold count of pasta samples

	Total plate count of at $\times 10^{-2}$ CFU/g		Yeast and Mold at $\times 10^{-2}$ CFU/g	
Time	Control (CFU/g)	F1 (CFU/g)	Control (CFU/g)	F1 (CFU/g)
Initial	ND	ND	Less than 400	Less than 500
After one month	ND	Less than 400	Less than 400	Less than 400
After two months	Less than 400	Less than 700	Less than 400	Less than 700

(ND – not detected)

The allowable level for the total plate count of pasta is less than 1,000 CFU/g (Pongpichaiudom and Songsermpong, 2017). Pasta can be safely stored for up to two months from a microbiological perspective.

Conclusion

In conclusion, soaking gahala yam in 0.1 % SMS solution, steam blanching, and oven drying treatment group improved the physical characteristics of the flour, making it suitable for pasta production. Final product enhanced cooking characteristics, and nutrient content. However, sensory attributes like color and taste were negatively affected with higher amounts of gahala yam flour.

References

Chandrasekara, A. and Kumar, T.J. (2016). 'Roots and Tuber Crops as Functional Foods: A Review on Phytochemical Constituents and Their Potential Health Benefits', *International Journal of Food Science*, pp. 1–15. Available at: https://doi.org/10.1155/2016/3631647.

Falade, K.O. and Badanga, S.E. (2021). 'Optimization of instant fried noodles from wheat (*Triticum aestivum*) substituted with cocoyam (*Colocasia esculenta*) and defatted soya bean flours', *Journal of Food Processing and Preservation*, 45(1). Available at: https://doi.org/10.1111/jfpp.15048.

Kaushal, P., Kumar, V. and Hl, S. (2015). 'Utilization of taro (Colocasia esculenta): a review', *Journal of Food Science and Technology*, 52(1), pp. 27–40. Available at: https://doi.org/10.1007/s13197-013-0933.

MicroChem's Experiments (2022). 'Total Plate Count (Total Aerobic Bacterial Count). A Complete Procedure (BAM, Ch-3)', Available at: https://www.youtube.com/watch?v=IlTnLEgivts.

Pongpichaiudom, A. and Songsermpong, S. (2017). 'Characterization of frying, microwave drying, infrared-drying, and hot-air drying on protein-enriched, instant noodle microstructure, and qualities', *Journal of Food Processing and Preservation*, 42(3), pp e13560. Available at: https://doi.org/10.1111/jfpp.13560.

Sonia, S., Julianti, E. and Ridwansyah, R. (2020). 'The Characteristic of Taro Flour Based Pasta with Addition of Modified Starch and Hydrocolloids', *Indonesian Food and Nutrition Progress*, 16(1), p. 27. Available at: https://doi.org/10.22146/ifnp.45681.

Development of Vegan Cheese Product from Skim Coconut Milk Using Lactic Acid

D.K.J.D.K. Dodangoda[1*], H.P.D.T. Hewa Pathirana[2], C. Yalegama[2] and N.S. Weerakkody[1]

[1]Department of Agriculture, Faculty of Engineering Technology, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka.

[2]Coconut Processing Research Division, Coconut Research Institute, Bandirippuwa Estate, Lunuwila, Sri Lanka.

Corresponding Author: dk.damithdodangoda@gmail.com*

Summary

This study aimed to produce cheese from skim coconut milk which can fulfil the cheese requirement of vegans and those with lactose intolerance. Protein concentration was prepared by using acid-heat coagulation of milk and four cheese combinations were prepared by changing Nutritional yeast (3%, 5%) and sodium chloride (3%, 4%) proportions. Sensory evaluation was performed with 30 semi-trained panelists to select the final product formulation and the results revealed there were significant differences ($p<0.05$) in the odour and appearance of samples. Considering that the sample with 3% salt, and 3% Nutritional yeast which scored significantly higher scores selected as the final product and tested for nutrition composition. The final product contained 61.20±0.25% moisture and 05.83±0.31% fat in it. The findings indicated the possibility of developing a cheese analogue with further development to reduce moisture content.

Keywords: Cheese analogue, Lactose intolerance, Nutritional yeast, Skim coconut milk, Vegan cheese

Introduction

The by-product of virgin coconut production is called defatted coconut kernel, and it is an edible solid by-product containing a considerable amount of nutrients. Virgin oil cake has nutrient content as, fat 9.2%, protein 12.6%, carbohydrates 39.1% (Yalegama *et al*., 2013). Therefore, it would be beneficial if those nutrients could be extracted and converted into value-added products for consumption, especially by lactose intolerant individuals. Lactose intolerance is one of the reasons for increased interest in researching on non-dairy products. Cheese analogues are referred to as products made by blending constituents such as non-dairy fats or proteins, to produce cheese-like products to meet specific requirements. Cheese analogues are popular because of their cost-effectiveness, the simplicity of their manufacture and the replacement of selected milk ingredients by vegetable products (Bachmann, 2001). By considering all these factors it was decided to develop coconut skimmed milk incorporated cheese product.

Methodology

Four cheese combinations and three replicates of them were prepared by using different formulas in CRD method.

Table 1. Different types of combinations

Treatment	Corn starch	Salt	Nutritional yeast
T1	3 %	4 %	5 %
T2	3 %	3 %	3 %
T3	3 %	3 %	5 %
T4	3 %	4 %	3 %

Virgin coconut oil cake was soaked for 1 hour in water with a 1:2 ratio and skim milk was extracted using a hydraulic press machine (Sakaya-12, Taiwan). Protein concentrate (curd) was prepared by heating skim milk at 90 ^{o}C for 20 min. and adding 0.4% lactic acid until pH is 4.0. The content was allowed to stand for one hour at room temperature. Cheesecloth was used for draining the whey till the curd was firm. Pre-determined percentages of curd, corn starch, and nutritional yeast were mixed well and heat treated by keeping them in a hot water bath at 80 ^{o}C for 15 min. Then the mixture was pressed into a mould (with holes made at the bottom and sides) and placed in a cold room (4 ^{o}C) for 24 h. The final product was selected by sensory evaluation using a 30-member semi-trained panel. The panelists were instructed to evaluate the coded samples for appearance, texture, odour, taste, sourness, mouthfeel and overall acceptability. The preferred treatment of coconut skim milk cheese was identified by Freidman statistical test using Minitab 17 software.

The Proximate analysis of the selected product was done for moisture and ash (AOAC international 18th edition, 2005), crude fibre (Weenden method), fat (Randall hot extraction method), protein (Kjedhal method) and carbohydrate content. The final product was tested for Total Plate Count (TPC) and Total Yeast and Mold Count (TYMC) according to SLS 516, Part 1, within one month.

Results and Discussion

Sensory data revealed significant differences ($P<0.05$) in the responses of the sensory panelists to the odour and appearance of samples. T2 showed a significantly higher sum of rank for odour and appearance compared to T1, T3 and T4. No significant difference was observed in sourness, texture, taste, mouth feel and overall acceptability among treatments. The overall result showed that T2 scored significantly higher scores compared with other treatments. The sensory evaluation results are presented in Table 02.

Table 2. Freidman test mean values for the sensory evaluation of coconut cheese

Treatment	Taste	Odour	Sourness	Appearance	Texture	Mouth feel	Overall acceptability
T1	69.5	76.5 [b]	74.5	69.5 [c]	71	71.5	74.5
T2	81.5	88 [a]	75.5	84.5 [a]	85.5	85.5	80.5
T3	76	62 [c]	74.5	66.5 [c]	65.5	72.5	66.5
T4	73	73.5 [b]	75.5	79.5 [b]	78	70.5	78.5
P value	0.604	0.012	0.999	0.036	0.065	0.27	0.443

*Rank score in the same column with different superscript are significantly different at P<0.05

The panelists were able to detect a cheese aroma in the samples arising from the nutritional yeast used as cheese flavour. Significantly different odor and appearance were observed between T2 and other samples perhaps due to the low availability of salt and nutritional yeast compared to the other samples. The taste of all samples was accepted and a similar light-yellow colour is observed in all samples. This may be due to the light-yellow colour of nutritional yeast influencing the development of the same level of yellowish colour in all samples.

Table 3. Proximate analysis of the final product

Component	Test value (%)
Protein	13.10±0.25
Moisture	61.20±0.06
Ash	03.87±0.19
Fat	05.83±0.31
Fiber	00.90±0.02
Carbohydrate	15.10±0.06

*The values are means of three replicates ± standard error

The proximate analysis reveals that the protein 13.10% and carbohydrate 15.10% values of the sample are considerably low. The final product contains the highest moisture content of 61.20% and the lowest amount of fiber 0.90%. The moisture content of the developed product is an important parameter because it influences the cheese's texture, including softness, elasticity, and low susceptibility to compression fractures.

Shelf-life changes can be categorized as physical changes, chemical changes, and microbiological changes. The values of total plate count and yeast mold count increased

with time significantly during refrigerated storage (4 ^{0}C). That can be occurred due to the high moisture content and the high carbohydrate content.

Table 4. Microbial count of coconut cheese

Test	Time duration		
	Initial	After 10 days	After one month
Total Plate Count (log cfu/g)	4.5302	5.6274	6.7931
Yeast and Mold Test (log cfu/g)	4.5647	5.6675	6.7566

Express the counts as log values x 10^5

Conclusion

This study confirms that skim coconut milk can be used to produce a lactose-free vegan cheese for consumption as a low-fat diet, especially for lactose intolerant persons. The results obtained from the proximate analysis showed that the product was rich in coconut protein and carbohydrates but high in moisture. It is safe to assign a low shelf-life for the product because of the high moisture content and the higher microbial activities.

References

Yalegama, L. L. W. C., Karunaratne, D. N., Sivakanesan, R., and Jayasekara, C. (2013). 'Chemical and functional properties of fibre concentrates obtained from by-products of Coconut Kernel', *Food Chemistry*, 141(1), pp. 124–130. doi: 10.1016/j.foodchem.2013.02.118.

Suri, S., Kumar, V., Prasad, R., Tanwar, B., Goyal, A., Kaur, S., Gat, Y., Kumar, A., Kaur, J. and Singh, D. (2019). 'Considerations for development of lactose-free food', *Journal of Nutrition & Intermediary Metabolism*, 15, pp.27-34.

Bachmann, H. (2001). 'Cheese Analogues: a review', *International Dairy Journal*, 11(4-7), pp. 505-515.

Implementation of revised Sri Lanka standards for food and water. Available at: https://www.researchgate.net/publication/299513519_Implementation_of_Revised_Sri_Lanka_Standards_for_Food_and_Water_Microbiology_at_the_MJF_Holdings_Microbiology_Laboratory (Accessed: 14 June 2022).[Better to refer to original SLSI or ISO standard]

Development of a Healthy Meat Analogue Using Young Jackfruits (*Artocarpus heterophyllus*) and Soya Grits

A.M.S.K. Amarakoon[1], A.A.K. Lankanayaka[1], C.M. Senanayake[1*], S.U. Rajapaksha [2]

[1]Department of Biosystems Technology, Faculty of Technology, University of Sri Jayewardenepura, Pitipana, Homagama, Sri Lanka.
[2]JanRich Food Limited, Wathupitiwala, Nittambuwa, Sri Lanka.

Corresponding author[*]: chathurisnnk@sjp.ac.lk

Summary

The main objective of this study was to develop a protein-enriched meat analogue and analyze the quality of the final product with similar sensory characteristics as that of animal meat. Jackfruits and soy grits were the major elements in this study's attempt to create a meat analogue. The process of two factors optimized each selected ingredient of the meat analogue using the Taguchi experimental design. A nine-point hedonic sensory evaluation scale was used to assess the generated product after choosing the final basis ingredients for the meat analogue. According to the nine-point hedonic scale, young jackfruit (64%) and soy grits (27%), which obtained maximum sensory attributes, were selected for further analysis. The moisture content, fat, protein, ash, carbohydrate and pH were 57.3±2.4%, 1.5±0.3%, 15.1±0.1%, 2.8±0.2%, 22.0±2.7%, 5.6±0.0% respectively. The cooking yield and cooking loss were 91.3±1.0% and 9.0±0.8% respectively.

Keywords: Plant-based meat analogue, Sensory evaluation, Soya grits, Young jackfruit

Introduction

Overeating meat, particularly meat high in saturated fat, has been associated with a number of health issues (Yadav *et al.,* 2015). As a result, there has been an increase in interest in plant-based meat alternatives brought on by worries about one's morality, the environment, and one's health. The demand for meat substitutes has also been influenced by vegetarianism, religious beliefs, and the difficulty in obtaining meat in some places, such as Sri Lanka (Department of Census and Statistics, 2013). Proteins from jackfruit and soy have been recognized as viable components for making meat substitutes because they provide sustainable and affordable options with desirable qualities. In order to promote healthier and more environmentally friendly options, research is being done to develop the best plant-based protein compositions and assess their physicochemical, microbial, and sensory properties (*Yadav et al.,* 2015; Department of Census and Statistics, 2013).

Methodology

Pre-treatment

Young jackfruit pieces were cleaned to eliminate residues, sliced into little pieces, the latex was removed, and the pieces were separated from the core. To stop the pieces from browning, they were rinsed once more and immersed in a citric acid solution. Then steamed for 20 minutes before being crushed into a creamy consistency and frozen.

Experimental design

A Taguchi L9 experimental design was used to create a high-quality product by taking interactions between various aspects into account. Young jackfruit (25 g, 40 g, and 55 g) and soy grits (15 g, 30 g, and 45 g) were added in different amounts to nine samples while maintaining the same amounts of the other ingredients.

Table 1. Levels of the Ingredients used in Statistical Product Designing

Notation	Factors	Low level (g)	Medium level (g)	High level (g)
A	Jackfruit (Young)	25	40	55
B	Soy Grits	15	30	45

Preparation of meat analogue

Steamed young jackfruit at varied levels (49.50%, 57.13%, and 64.70%) and texturized soy grits at different concentrations (27.27%, 35.29%, and 37.50%) were combined to develop formulations that resemble young jackfruit meat. Hydrated soy grits were added, along with tapioca starch to change the texture and stabilize the emulsion. The source of fat was vegetable oil, and the source of protein was defatted soy flour. Also, seasonings and spices were used. After being shaped into patties, the mixed material was steamed, cooled, and packed before being frozen for storage.

Sensory evaluation (Sensory analysis 01 & 02)

Nine samples were evaluated by 30 untrained panelists using a 9-point hedonic scale for overall acceptability, appearance, texture, flavor, and mouthfeel. The formulation with the highest ratings for development was chosen in sensory-02 after the best-performing samples from sensory-01 and a market control sample were further assessed.

The developed product was subjected to analysis of physical properties (pH, cooking yield and cooking loss), proximate composition and shelf-life study (on 0, 15, 30, 45, 60, 75, and 90 day intervals at 30 ℃).

Results and Discussion

Sensory evaluation of jackfruits and soy grits on the sensory attributes of meat analogue

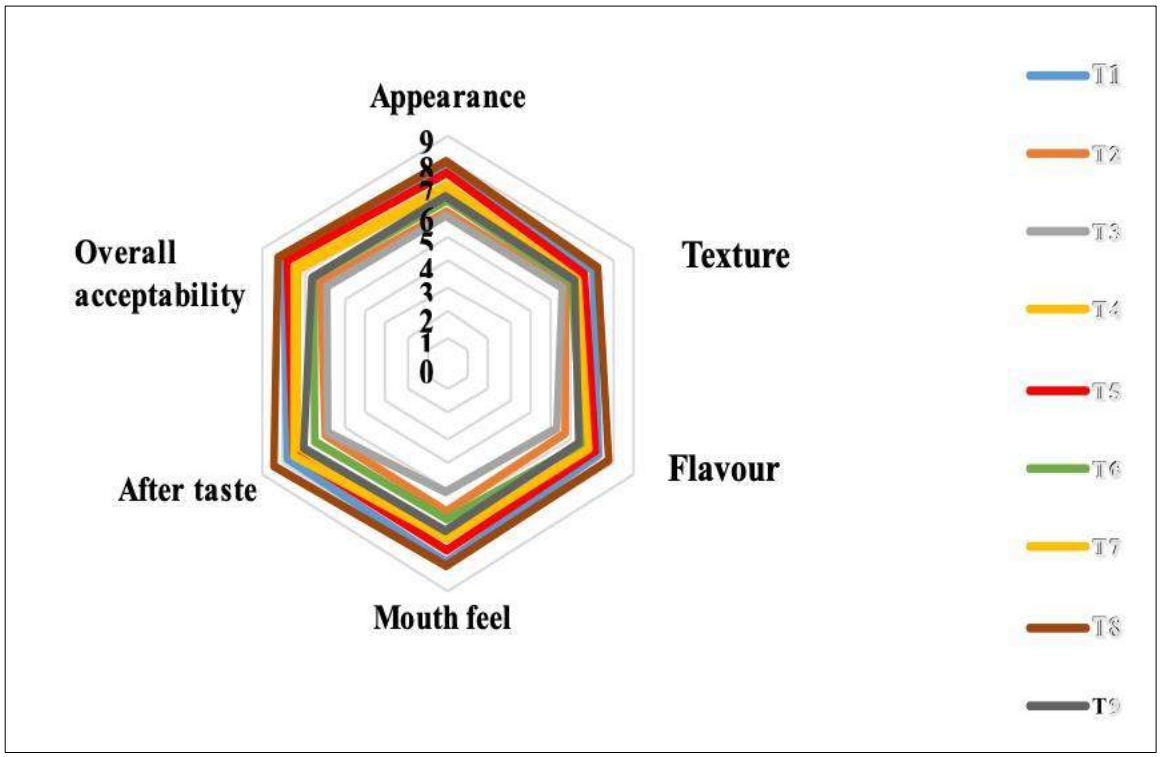

Figure 1: Radar chart of sensory characteristics of meat analogue

Based on the radar chart (Figure 1), sample T3 (jackfruits 35.71% and soy grits 64.28%) had the lowest preference for sensory properties. Most mean values for T2 (jackfruits 45.45% and soy grits 54.54%) and T3 (jackfruits 35.71% and soy grits 64.28%) were below 6.0. Conversely, T8 (jackfruits 64.70% and soy grits 35.29%) and T1 (jackfruits 62.5% and soy grits 37.5%) exhibited higher mean values for sensory properties.

Effect of best samples on the sensory attributes of meat analogue

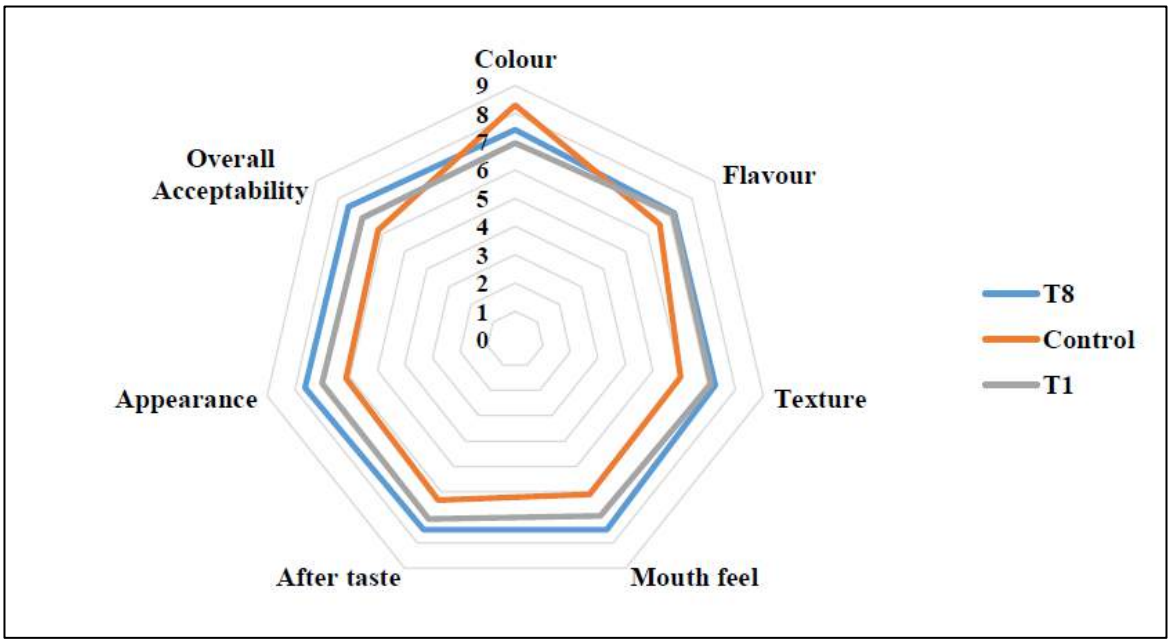

Figure 2: Radar chart of sensory characteristics of meat analogue

The control sample (commercial meat analogue), T8 (jackfruits 64.70% and soy grits 35.29%), and T1 (jackfruits 62.5% and soy grits 35.29%) had the greatest mean values for color. T8 had the highest mean value for flavor which was followed by T1 and the control sample. The control sample received the lowest rating for texture, followed by T1 and T8. While the control group had the least preference for six of the seven sensory qualities assessed, T8 obtained the highest preference for appearance and overall acceptability.

Proximate composition of meat analogue

The meat analogue had a lower pH value, cooking yield, and cooking loss compared to meatballs. This is likely due to the use of plant proteins in the analogue, which have lower pH values and higher moisture content. The lower fat content in the analogue also contributed to lower cooking loss. In comparison to meatballs, the meat equivalent included less moisture, ash, protein, fiber, and fat, but more carbohydrates.

These variations can be attributable to the addition of various types of flour to the meat imitation, as well as the use of plant-based protein sources with lower protein and fat contents. Due to naturally present minerals, meatballs produced from actual meat have a higher moisture content and ash value. There was no discernible change in the sensory preferences of the chosen samples over time (90 days of storage at 30℃ packaged with LDPE).

Table 2. Physical and proximate composition of the developed meat analogue vs. meatball available in the market

Parameter	Food item	
	Meat analogue	Meatball
pH	5.6±0.0[b]	6.2±0.0[a]
Cooking yield	91.3±1.0[b]	95.2±0.3[a]
Cooking loss	9.0±0.8[b]	11.5±0.8[a]
Moisture content (%)	57.3±2.4[a]	64.4±0.5[a]
Ash content (%)	2.8±0.2[b]	4.1±0.0[a]
Protein content (%)	15.1±0.1[b]	19.8±0.3[a]
Fiber content (%)	4.1±0.3[b]	5.5±0.3[a]
Fat content (%)	1.5±0.3[b]	10.9±0.1[a]
Carbohydrate content (%)	22.0±2.7[a]	8.8±0.8[b]

*Mean values in the same row with different letters are significantly different at $p<0.05$

Conclusion

The best ingredient ratio for meat mimic was found to be 64% jackfruit and 27% textured soy grits. The meat analog could be used as a meat substitute with high protein, according to the nutritional analysis. The recommendation is to conduct more research on microbiological shelf-life study.

References

Association of Official Analytical Chemists (2005). AOAC Official Method 981.12: pH of Acidified Foods. *Official Methods of Analysis of AOAC International*, AOAC International.

Yadav, P., Ahlawat, S. S., Jairath, G., Rani M., and Bishnoi, S. (2015). 'Studies on physico-chemical properties and shelf life of developed chicken meat analogue rolls', *Haryana Vet*, 54(1), pp. 25–28.
Available at: https://www.luvas.edu.in/haryana-veterinarian/download/harvet2015/7.pdf.

Egbert, R., and Borders, C. (2006). 'Achieving success with meat analogs', *Food Technology*, 60(1), pp. 28–34.

Kyriakopoulou, K., Dekkers, B. and van der Goot, A.J. (2019). 'Plant-Based Meat Analogues, Sustainable Meat Production and Processing'. *Elsevier Inc*. Available at: https://doi.org/10.1016/B978-0-12-814874-7.00006-7.

Bakhsh, A., Lee, S. J., Lee, e. Y., Hwang, Y. H., and Joo, S. T. (2021). 'Traditional Plant-based Meat Alternatives, Current, and Future Perspective: A Review', *Journal of Agriculture & Life Science*, 55(1), pp. 1–11. Available at: https://doi.org/10.14397/jals.2021.55.1.1.

Antiglycation Properties of Aqueous Extracts from Selected Species of Plants: An *In Vitro* Study

N.H.M.V.N. Senevirathne[1*], H.K.I Perera[2], B.E.P. Mendis[1] and R.P.N.P. Rajapakse[1]

[1]Department of Food Science and Technology, Faculty of Agriculture, University of Peradeniya, Peradeniya, 20400, Sri Lanka.
[2] Department of Biochemistry, Faculty of Medicine, University of Peradeniya, Peradeniya, 20400, Sri Lanka.

*Corresponding Author**: snvashikee@gmail.com

Summary

Non-enzymatic glycation generates advanced glycation end-products leading to structural and functional changes in biomolecules. Speed of glycation is accelerated in chronic hyperglycemia as seen in diabetes mellitus. Glycation is implicated in the pathogenesis of numerous diseases including chronic diabetic complications. The objective was to assess the antiglycation effects of aqueous extracts from five species of spices. Aqueous extracts of lemongrass (*Cymbopogon citratus*), turmeric (*Curcuma longa)*, Ceylon cinnamon (*Cinnamomum zeylanicum*) and ginger (*Zingiber officinale*), and Piperine 95, a pure compound extracted from *Piper nigrum* were assessed. Extracts were subjected to previously developed and validated antiglycation assay to determine the inhibition ability of plant extracts against glycation mediates cross-link formation in proteins. Except for Piperine 95, all the plant extracts inhibited glycation-induced cross-linking in proteins but *C. zeylanicum and C. citratus* aqueous extracts demonstrated the highest *in vitro* antiglycation activity. Further development of the study can identify the cross-linking inhibition potential of these plant extracts on food systems, as well as the potential to be used as therapeutics.

Keywords: Antiglycation, Aqueous extracts of plants, Cross-linking in proteins, *In vitro*

Introduction

Non-enzymatic glycation is a complex and spontaneous reaction occurring between reducing sugars and free amine groups of proteins, DNA or lipids. This reaction forms a heterogeneous group of compounds known as advanced glycation end-products (AGEs). AGEs are irreversibly formed compounds that induce cross-linking among proteins, leading to structural and functional alterations of proteins in living organisms. They also mediate the activation of inflammatory cell signaling pathways and increase oxidative stress in the body (Yan *et al*., 2008).

AGEs are produced at a lower rate under normal metabolic conditions; but they are

subjected to change based on the bodily concentration of glucose and proteins (Lima and Baynes, 2013). Thus, the rate of glycation is accelerated in chronic hyperglycemia as seen in diabetes mellitus due to higher glucose concentration in blood, leading to the formation and accumulation of excess AGEs. It has been scientifically proven that these AGEs lead to the occurrence of chronic diabetic complications such as cataract, retinopathy, nephropathy, neuropathy and cardiomyopathy in diabetic patients (Kim *et al*., 2017).

Studies have shown that pharmacological interventions capable of interfering with the production or function of AGEs are effective in alleviating chronic diabetic complications and other non-communicable diseases. Such compounds are known as 'antiglycation' agents (Peyroux and Sternberg, 2006). Although some synthetic antiglycation agents have been discovered, they have failed in clinical trials to be used by humans. With the increasing prevalence of diabetes, the focus is on identifying novel antiglycation agents which are safe for humans. Currently, plant-based antiglycation agents have gained popularity due to their absence of toxicity and higher availability (Lima and Baynes, 2013).

Plants have been used to treat diabetes and chronic diabetic complications under indigenous and ayurvedic medicine in Sri Lanka even though they have not been scientifically studied for their antiglycation potential. Researches have shown that some plants possess hypoglycemic and antioxidant properties which complement the antiglycation effect. Scientific studying of the antiglycation potential of plants can lead to the successful development of therapeutics and functional foods in future (Perera and Handuwalage, 2015).

Methodology

Cymbopogon citratus (Lemongrass) whole plant*, Curcuma longa (Turmeric)* rhizome*, Cinnamon zeylanicum (Ceylon cinnamon)* bark and *Zingiber officinale (Ginger)* rhizome and piperine 95, a pure compound extracted from *Piper nigrum,* were used in this study. All the plant materials were purchased in their dried and powdered form through spice exporters and processors within the Central province of Sri Lanka under the recommendations of the Department of Export Agriculture.

Except for piperine 95, other dried and powdered plant materials were extracted using distilled water based on a previously published method (Annegowda *et al.*, 2012). Known weights of powdered samples were extracted using distilled water and were concentrated with a rotary evaporator under 50 ^{o}C and freeze-dried.

Extracts along with piperine 95 were re-dissolved in distilled water to obtain the test samples in a concentration series of 0.0125 mg/mL to 4 mg/mL in incubation mixtures. To determine the antiglycation potential of plant extracts, a previously developed and validated method by Perera and Ranasinghe (2014) was used. The antiglycation potential of plant extracts was determined using inhibition of glycation-mediated cross-link formation of proteins. Chicken egg lysozyme was incubated with D-fructose in phosphate

buffer (pH 7.4) at 37 ^{o}C for 30 days in the presence and absence (negative control) of plant extracts. Aminoguanidine was used as a standard glycation inhibitor in the positive control.

Aliquots of samples were collected on days 7 and 21 of incubation and analyzed using sodium dodecyl-sulfate polyacrylamide gel electrophoresis (SDS-PAGE) to identify the inhibitory effect of plant extracts against glycation-induced cross-linking of proteins.

Results and Discussion

The resulting gels after SDS-PAGE were observed under the naked eye to determine the potential of each plant extract to inhibit glycation-mediated cross-linking of proteins. The principle of the assay is based on the extent to which high molecular weight products produced in the incubated samples are proportionate to the degree of glycation-induced cross-link formation within the samples (Perera and Ranasinghe, 2014).

The inhibition of incubated samples was determined by comparing their band patterns in the gel against the negative control (-P) and positive control (AG). As in Figure 1, all three concentrations of *C. zeylanicum* and 1 mg/mL and 0.5 mg/mL concentrations of *C. citratus* indicated complete inhibition against cross-linking of proteins, similar to aminoguanidine (AG). *C. longa and Z. officinale* only indicated a partial inhibition at 1 mg/mL concentration.

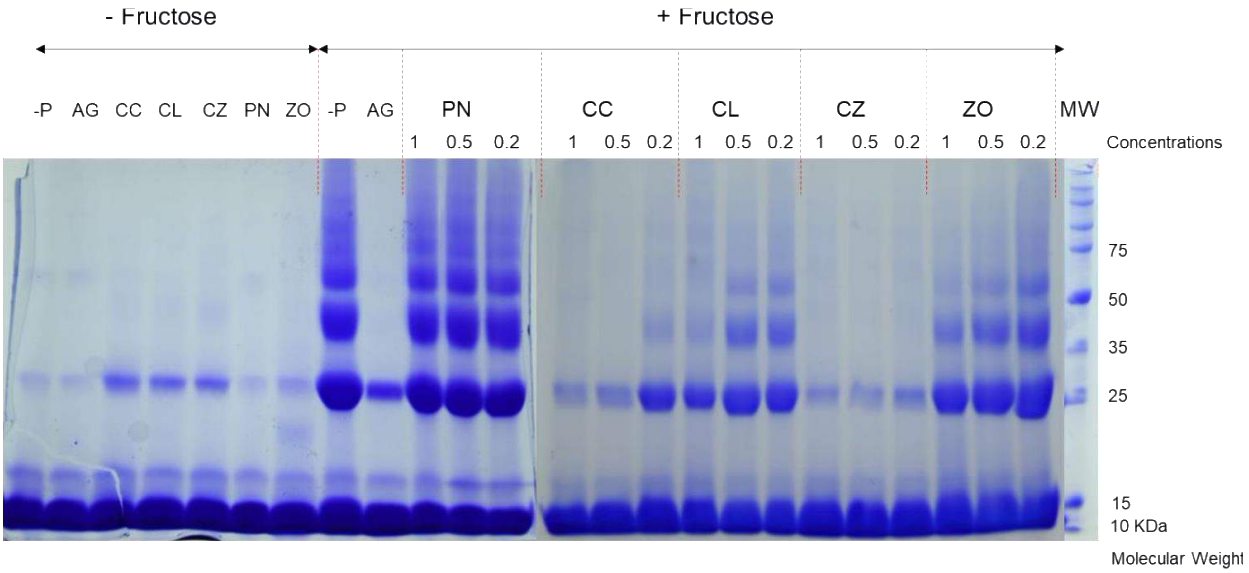

Figure 1: Gel image results of SDS-PAGE conducted for aliquots obtained on incubation day 7 from samples incubated with and without fructose.

Lysozyme was incubated in the presence and absence of fructose at 37 °C for seven days. The samples without Fructose were blank samples that included lysozyme and, -P: No plant extract or Aminoguanidine, AG: With Aminoguanidin, CC: *C. citratus*, CL: *C. longa*, CZ: *C. zeylanicum*, PN: Piperine 95, ZO: *Z. officinale,* in 1 mg/mL, 0.5 mg/mL and 0.2 mg/mL concentrations.

A second concentration series was incubated to identify the minimum concentrations that give complete inhibition for all four samples. Based on the results of the second series obtained on day 7, *C. citratus* indicated a complete inhibition of cross-link formation at a minimum of 0.5 mg/mL concentration and *C. zeylanicum* at 0.1 mg/mL. On contrary, *C. longa* and *Z. officinale* exerted complete inhibition on glycation at a concentration of 4 mg/mL.

To identify the persistence of the glycation inhibition ability of the plant extracts, the same test was carried out for aliquots obtained on day 21. The results obtained on both day 7 and 21 are compiled on the Table 1. As of Table 1, both *C. citratus* and *C. zeylanicum* indicated a complete inhibition of glycation-induced cross-linking up to 0.5 mg/mL concentration. Both *C. longa* and *Z. officinale* also indicated complete inhibition of cross-linking at a minimum of 4 mg/mL concentration. These results indicate that the glycation inhibition activity of all four plants is consistent over three weeks.

Table 1. Compilation of inhibition exhibited by 5 plant extracts on day 7 and 21 of incubation

Concentrations (mg/mL) **Plant Extract**	**Days**	**4**	**2**	**1**	**0.5**	**0.2**	**0.1**	**0.05**	**0.025**	**0.0125**
C. citratus	7			Complete	Complete	Partial	No			
	21			Complete	Complete	No	No			
C. longa	7	Complete	Partial	Partial	No	No				
	21	Complete	No	No	No	No				
C. zeylanicum	7			Complete	Complete	Complete	Complete	Partial	No	No
	21			Complete	Complete	Partial	No	No	No	No
Piperine95	7			Complete	Complete	Complete				
	21			Complete	Complete	Complete				
Z. officinale	7	Complete	Partial	Partial	No	No				
	21	Complete	No	No	No	No				

Complete Inhibition Partial Inhibition No Inhibition

However as of Figure 1 and Table 1, on neither days piperine 95 indicated any anti-glycation properties. It may be because piperine was insoluble in both distilled water and DMSO which were the two solvents used in the assay. Non-uniform concentration distribution due to insolubility may have resulted from the absence of anti-glycation ability because in previous studies it has been concluded that piperine exerts antiglycation properties (Tupe *et al.*, 2021). Hence it was highly unlikely to make an inference based on the results obtained regarding piperine as optimum solubility nor homogeneity of the incubated sample could be achieved during the study.

Nevertheless, the results for the other four aqueous extracts did conform with the research

done in other countries for the above plants as individual studies. Using the same method, research conducted on methanolic extracts of *C. zeylanicum* indicated a complete inhibition of glycation at the minimum concentration of 1 mg/mL on day 7 after incubation (Perera and Handuwalage, 2015). The change in effective concentration can bedue to the differences in solvents used for extractions. In previous studies, similar differences have been observed due to differences in solvent polarities.

Conclusion

Except for piperine 95, all the other plant aqueous extracts; *C. citratus, C. longa, C. zeylanicum and Z. officinale* exhibited inhibition of glycation modulated protein cross-linking mechanism in lysozyme/D-fructose model. Out of the aqueous extracts studied *C. citratus* and *C. zeylanicum* have the highest anti-glycation potential under *in vitro* conditions and their antiglycation ability is consistent over time.

References

Annegowda, H. V., Bhat, R., Min-Tze, L., Karim, A. A., and Mansor, S. M. (2012). 'Influence of sonication treatments and extraction solvents on the phenolics and antioxidants in star fruits', *Journal of Food Science and Technology*, 49(4), pp. 510–514.

Kim, C.-S., Park, S., and Kim, J. (2017). 'The role of glycation in the pathogenesis of aging and its prevention through herbal products and physical exercise', *Journal of Exercise Nutrition & Biochemistry*, 21(3), pp. 55–61.

Lima, M., and Baynes, J. W. (2013). 'Glycation', *Encyclopedia of Biological Chemistry: SecondEdition*, 2, pp. 405–411.

Perera, H., and Ranasinghe, H. (2014). 'A simple method to detect plant-based inhibitors of glycation induced protein cross-linking', *Asian Journal of Medical Sciences*, 6(1), pp. 28– 33.

Perera, H. K. I., and Handuwalage, C. S. (2015). 'Analysis of glycation induced protein cross-linking inhibitory effects of some antidiabetic plants and spices', *BMC Complementary and Alternative Medicine*, 15(1), pp. 1–9.

Peyroux, J., and Sternberg, M. (2006). 'Advanced glycation endproducts (AGEs): pharmacological inhibition in diabetes', *Pathologie Biologie*, 54(7), pp. 405–419.

Tupe, R. S., Bangar, N., Nisar, A., Kulkarni, A., Sankhe, N., Chauhan, R., Mistry, N. and Shaikh, S. (2021). 'Piperine exhibits preventive and curative effect on erythrocytes membrane modifications and oxidative stress against in vitro albumin glycation', *Journal of Food Biochemistry*, 45(8), pp. 1–15.

Yan, S. F., Ramasamy, R., and Schmidt, A. M. (2008). 'Mechanisms of Disease: Advanced glycation end-products and their receptor in inflammation and diabetes complications' *Nature Clinical Practice Endocrinology and Metabolism*, 4(5), pp. 285–293.

Evaluation of the Effect of Palm Stearin as a Stabilizer and Quality Improvement of Coconut Butter Spread

Dissanayake W.M.C.P.[1*], Hewa Pathirana H.P.D.T.[2], Yalegama C.[2] and Weerakkody N.S.[1]

[1]Department of Agriculture, Faculty of Engineering Technology, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka.

[2]Coconut Processing Research Division, Coconut Research Institute, Bandirippuwa Estate, Lunuwila, Sri Lanka.

Corresponding Author: chandimaprd@gmail.com*

Summary

The purpose of this study was to evaluate the effect of palm stearin as a stabilizer and quality improvement of coconut butter spread. For this purpose, butter combinations were prepared with desiccated coconut, sugar, salt, defatted coconut flour, corn flour and palm stearin as a stabilizer using a grinding method. The oil layer separation was less in the treatments that added corn flour or defatted coconut flour with palm stearin compared to the treatments that only used palm stearin. But in treatments in which defatted coconut flour was applied with palm stearin, the oil layer separation increased relatively to the palm stearin percentage. It was concluded that the addition of palm stearin reduced the oil layer separation to some extent, but palm stearin did not bring about a significant effect when used with corn flour or defatted coconut flour.

Keywords: Coconut butter spread, Defatted coconut flour, Oil layer separation, Palm Stearin

Introduction

Major problems in the production of high-quality plant-based butter-like spreads are textural and spreadability features and oil separation which affect the shelf life of the product and the product's stability. In making plant-based-butter-like spreads, the amount of oil present in its composition affects the stability of the product. Therefore, when making plant-based butter spreads, adding stabilizers and emulsifiers to improve the quality of the product is done (Ningtyas, 2022). Coconut butter is plant-based butter and the main problem of coconut butter spread is an oil layer separation at the top of the product when increasing temperature. So, there is a requirement to control layer separation of coconut butter to enhance consumer acceptability. The layer separation can be minimized by adding suitable stabilizers and also storing coconut butter in a refrigerator. To minimize oil layer separation Palm stearin was used as a stabilizer to minimize oil separation in coconut butter. The hard fraction of palm oil is made of palm stearin, which increases the stability of foods requiring solid fat functionality (Pande *et al*. 2012). The purpose of this study was to evaluate the effect of palm stearin in quality improvement of coconut butter spread.

Methodology

Butter combinations were prepared by changing the amount of desiccated coconut (75%, 65%), defatted coconut flour (0%, 10%), corn Flour (0%, 10%) and stabilizer (0%, 0.5% and 1.5%) and were evaluated as a factorial design with three replicates.

Table 1. Different types of combination

Treatment	Desiccated coconut (g)	Sugar (g)	Salt (g)	Defatted Coconut Flour (g)	Corn Flour (g)	Stabilizer % (Palm Stearin)
01	75	25	0.5	-	-	1.5
02	75	25	0.5	-	-	0.5
03	75	25	0.5	-	-	-
04	65	25	0.5	10	-	1.5
05	65	25	0.5	10	-	0.5
06	65	25	0.5	10	-	-
07	65	25	0.5	-	10	1.5
08	65	25	0.5	-	10	0.5
09	65	25	0.5	-	10	-

Butter combinations were prepared by the grinding method. The oil layer separation of prepared butter sample was observed after 10 days and the data were analyzed with one-way ANOVA at a significant level of 0.05 and their mean comparison was done by using Tukey's multiple comparison test at a significant level of 0.05 using Minitab 17 software package. The best five butter combinations were selected according to the oil layer separation intensity. Out of five combinations the best final product formula was selected through sensory evaluation. The preferable recipe for coconut butter spread was identified by using the sensory evaluation results and statistical data were analyzed by (Freidman statistical test) using Minitab 17 software.

Results and Discussion

According to the oil layer separation results, T1, T2 and T3 showed high oil layer separation and T7, T8 and T9 showed slightly low oil layer separation. T4 showed a slightly high oil layer separation and T5 showed a slightly low oil layer separation. T6 showed the lowest oil layer separation.

Table 2. Oil layer separation intensity of coconut butter spread (cm) after 10 days

Treatment	Oil layer separation (cm) after 10 days
T1	0.65^{c}
T2	0.73^{b}
T3	0.81^{a}
T4	0.61^{c}
T5	0.51^{d}
T6	0.44^{d}
T7	0.51^{d}
T8	0.54^{d}
T9	0.54^{d}

*Means with column that do not share same superscript letter are significantly different at significant level l 0.05.

The oil layer separation was less in the treatments that added corn flour or defatted coconut four with palm stearin compared to the treatments that only used palm stearin. When palm stearin was used with corn flour, the oil layer separation could be slightly reduced. But in treatments in which defatted coconut flour was added with palm stearin, the oil layer separation was increased relatively to the palm stearin percentage. It was concluded that the addition of palm stearin reduced the oil layer separation to some extent and palm stearin did not have a significant effect when used with corn flour or defatted coconut flour.

Sensory data revealed that there were significant differences ($P<0.05$) in the responses of the sensory panelists to the spreadability, texture, appearance and melting behaviour of samples. T7 showed a significantly highest texture ($p<0.05$) value (104) due to the combined effect of the corn flour and the highest percentage (1.5%) of stabilizer compared to other treatments. T8 showed significantly the highest ($p<0.05$) value for appearance compared to other treatments. However, there was no significant difference between T7 and T8 for the tested attributes except for appearance and texture. The T7 was selected as the final product through sensory evaluation.

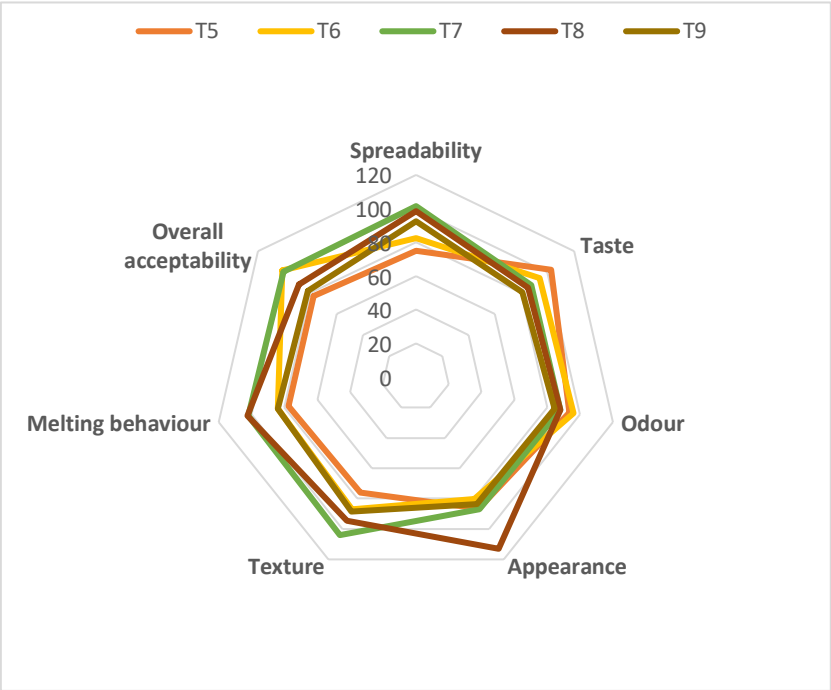

Figure 1: Web diagram from sum of ranks value of sensory evaluation

Panellists remarked that the taste of the product should be improved by reducing the taste of flour, improving the saltiness, reducing the sweetness and reducing the oil. The appearance of the product should also be improved.

Conclusion

The addition of palm stearin reduced the oil layer separation to some extent and palm stearin did not have a significant effect when used with corn flour or defatted coconut flour.

References

Ningtyas, D. (2022). 'Engineering Plant Based Food Systems', [Online], Elsevier. Available at: https://www.sciencedirect.com/book/9780323898423/engineering-plant-based-food-systems. (Accessed: 5 June 2022)

Pande, G., Akoh, C.C., and Lai, O. (2012). 'Palm 0il: Production, Processing, Characterization, and Uses', [Online]. Elsevier. Available at: https://www.sciencedirect.com /topics/agricultural-and-biological-sciences/stearin (Accessed: 5 June 2022)

Visual and Physicochemical Quality of the Mango Variety 'Karthakolomban' at Retail Outlets in Sri Lanka

M.A.R.M.P Jayathilaka[1], J.I.S. Jayalath[2], W.A.H Champa[3], T. Perera[1]

[1]Department of Applied Nutrition, Faculty of Livestock, Fisheries & Nutrition, Wayamba University of Sri Lanka, Makandura, Gonawila, 60170, Sri Lanka.
[2]Department of Aquaculture & Fisheries, Faculty of Livestock, Fisheries & Nutrition, Wayamba University of Sri Lanka, Makandura, Gonawila, 60170, Sri Lanka.
[3]Biostatistics Unit, Faculty of Livestock, Fisheries & Nutrition, Wayamba University of Sri Lanka, Makandura, Gonawila, 60170, Sri Lanka.

Corresponding Author:madhushikapj96@gmail.com*

Summary

A study was conducted to evaluate the quality of mangoes available at retail outlets in Sri Lanka. The mango variety 'Karthakolomban' was purchased from the supermarkets and roadside fruit shops. The mangoes were evaluated for visual and physicochemical quality attributes on the day they were purchased and until they become inedible. The measured parameters were fruit weight (g), size (length/breadth), peel and pulp color (CIE lab values), firmness (N), total soluble solids (%), titratable acidity (%), and physiological weight loss (%). No significant differences were observed with reference to physicochemical parameters. However, the visual quality and shelf life of mangoes sold at supermarkets were higher compared to the mangoes sold at traditional roadside fruit shops. The research findings highlight the importance of implementing standard quality control procedures along the mango supply chain to ensure the supply of quality mangoes to consumers.

Keywords: Color, Firmness, Shelf Life, TA, TSS

Introduction

Mango (*Mangifera indica*) is a popular and widely consumed fruit in Sri Lanka. The cultivation extent of mango is 27,460 ha with an average annual production of 155,448 t (Agstat, 2020). Mango is a rich source of folate, vitamins C, D, B6 and minerals magnesium, calcium, iron and dietary fiber. Demand for mangoes continues to increase with increased awareness among the consumers on health benefits. In Sri Lanka, the most common consumer access points for purchasing mangoes are the fruit vendors by the roadsides and supermarkets. Though there are complaints about the poor eating quality of mangoes sold in the country, no systematic study has been conducted to assess its quality at retail points. Postharvest quality evaluation of mangoes is crucial to recognize markets maintaining quality requirements of consumers .

Methodology

The study was conducted during the peak mango season (May – June) of 2023. Mango variety 'Karthakolomban' was purchased from reputable supermarkets and permanent fruit shops around Pannala. Fruits were selected randomly. A total of 24 mangoes representing supermarkets and fruit shops were purchased, packed in a corrugated fiberboard boxes and transferred to the laboratory for testing .

External quality attributes namely peel color (1-mature green, 2- 10% yellow & 90% green, 3-30% yellow & 70% green, 4-50% yellow and 50% green, 5-90% yellow and 10% light green, 6-100% reddish yellow), finger feel firmness (1- extremely soft, 2, soft, 3-moderate, 4-hard, 5- extremely hard), defects (1-none, 2-minor, 3-moderate, 4-severe, 5-extremely severe), and latex burning of the peel (1-Yes, 2-No) were observed soon after purchasing and until they become inedible.

Peel and pulp color were measured objectively using the Hunter lab color difference meter (CR 400, Konica Minolta) and the values of CIE L*, a*, b* were recorded. Three representative mangoes from respective retail outlets were taken and peel colour measured around the shoulder area while the pulp color was measured near the stone area of the center of the fruit after halving . Firmness was measured by a texture analyzer (Schimadzu EZ Test, EZ-SX) fixed to a flat-tipped cylindrical plunger (8 mm diameter). The depth of penetration was set to 5 mm at a constant traveling speed of 2 mm/s. The readings were taken around the shoulder area of both sides of the fruit after peeling off and the average was recorded as Newton (N).

Juice was extracted by squeezing through a muslin cloth of representative pulps of mangoes. The total soluble solids (TSS) content in juice was measured using a temperature-compensated digital pocket refractometer (ATAGO-PAL, Japan). Titratable acidity (TA) was measured as per AOAC, (2005) and the results were expressed as grams of citric acid equivalents per 100 mL of juice. The ripening index (RI) was calculated as a ratio between TSS/TA. Physiological loss in weight (PWL) was recorded by subtracting final weights from the initial weights of mangoes and was expressed as percent PWL with reference to the initial weight.

Experimental design and data analysis

The experiment was laid out as Complete Randomized Design with three replicates (n=12). The independent sample T-test was performed to determine if there is any significant difference between the means of two retail outlets at the probability level of 5% ($p<0.05$) using SPSS software.

Results and Discussion

The external appearance of mango var. Karthakolomban at the time of purchasing acquired an "Excellent" rank while the fruit purchased from vendors was ranked "Good" (data not shown). The overall external appearance of the fruit purchased from traditional fruit shops was degraded at a higher rate compared to the fruit purchased from the supermarket (Figure 1) of which the former had a shelf life of 3 days after purchase while the latter stayed fresh until 5 days after purchasing.

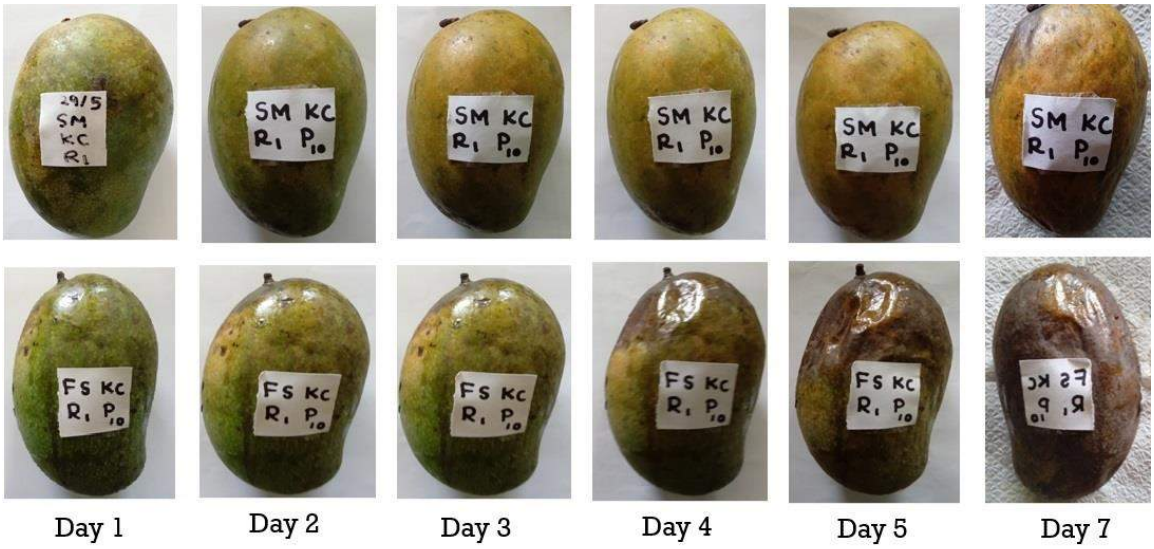

Figure 1: Variation in visual quality of mango var. Karthakolomban after purchasing from two different retail outlets in Sri Lanka. SM: Supermarket, FS: fruit shop (vendors).

The physicochemical properties of mango var. Karthakolomban at the time of purchasing is shown in Table 1. The average fruit weight, size, peel & pulp color, texture and internal fruit quality attributes (TSS, TA and TSS/TA ratio) were not significantly different between two different retail outlets studied ($P>0.05$).

According to a reference color chart published by the Industrial Technology Institute and as per Amarakoon *et al.*, (1999), the TSS and TA values of mangoes displayed at the retail outlets should be around 15.0 - 15.5% and 0.24 - 0.29% respectively. The TSS values observed in two retail outlets subjected to this study were on par with those reports (Table 1). However, it was noted that the TA values are higher than the values mentioned in the aforesaid reports indicating mangoes sold in both places were poor in flavor quality reported by Amarakoon *et al*. (1999) high sugar: acid ratio reflects the good flavor.

Table 1. Physicochemical properties of mango var. Karthakolomban at the time of purchasing.

Quality attribute		Supermarket	Traditional fruit shop	Probability (α = 0.05)
Fruit weight (g)		255.40±29.90	268.30±56.40	0.80
Fruit size (length/breadth)		1.60±0.50	1.61±0.10	0.84
Peel colour	L*	40.18±3.92	40.39±4.89	0.71
	a*	-7.70±6.10	-10.86±4.42	0.42
	b*	25.28±2.27	25.82±6.95	0.22
Pulp colour	L*	44.75±10.96	46.66±4.81	0.23
	a*	-3.05±7.63	-3.86±6.74	0.74
	b*	34.25±15.22	33.40±10.94	0.68
Firmness (N)		1.00±0.35	0.83±0.08	0.05
Total soluble solids (%)		17.53±3.10	15.63±1.60	0.12
Titratable acidity (% citric acid)		0.53±0.15	0.35±0.15	1.00

Values represent the mean ± standard deviation (n = 12 for the physical parameters and n = 3 for the chemical parameters).

Fruit firmness and physiological loss in weight of mango var. Karthakolomban purchased from two different retail outlets are shown in Figure 2. Fruit firmness was higher in the mangoes purchased from supermarket whereas it is low in fruit purchased from vendors. However, firmness was not significantly different (P>0.05) between fruits from the two sources. According to Dang Le *et al.*, (2022), the firmness of ripe mangoes varies between 1.18 to 1.92 N. At the time of purchasing the firmness of mangoes in both markets was ≤ 1.0 N (Table 1) and declined rapidly (Figure 2a) indicating poor texture properties of mangoes sold in the local markets despite whether it is supermarket or fruit shop.

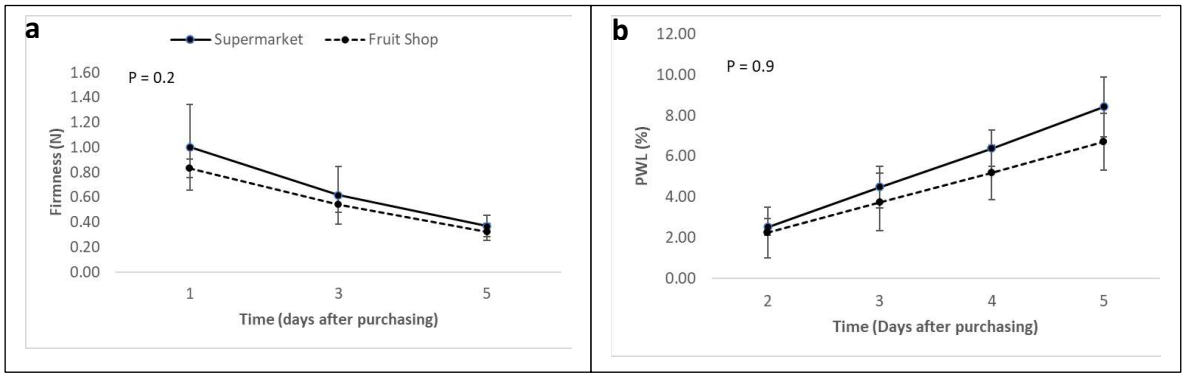

Figure 2. Variation in fruit firmness and physiological loss in weight (PWL) of mango var. Karthakolomban purchased from two different retail markets in Sri Lanka.

Values represent the mean ± standard deviation (n = 6).

Figure 2b illustrates the physiological weight loss (PWL) of mangoes during 5 days of storage under ambient conditions (31±1 °C, 70% RH). The percent PWL increased at an accelerated rate indicating rapid deterioration in both internal and external fruit quality parameters.

Conclusion

There is no significant difference in the physicochemical parameters of mangoes purchased from supermarkets or roadside vendors . However, the visual quality and shelf life of mangoes sold at supermarkets were higher compared to the mangoes sold at vendors It is imperative to implement standardized quality control procedures for ensuring consistency in the supply of mangoes to the consumer.

Acknowledgment: Financial assistance provided by the Australian Centre for International Agricultural Research (ACIAR), Grant No.CS/2020/193 is gratefully acknowledged.

References

AgStat (2020). Socioeconomic and Planning Center, Department of Agriculture, Peradeniya, Sri Lanka.

Amarakoon, R., Sarananda, K. H., Illeperuma, D.C.K. (1999). 'Quality of mangoes as affected by stage of maturity', *Tropical Agriculture Research*.11, 74-85.

Dang Le, T., Nguyen, T. V., Muoi, N. V., Toan, H. T., Lan, N. M., and Pham, T. N. (2022). 'Supply chain management of mango (*Mangifera indica* L.) fruit: a review with a focus on product quality during postharvest', *Frontiers in Sustainable Food Systems*, doi: 10.3389/fsufs.2021.799431.

Industrial Technology Institute. Maturity indices of Mango Var. Karthakolomban, A reference colour chart. 363, Bauddaloka Mawatha, Colombo, Sri Lanka.

www 1, United State Department of Agriculture, Agriculture Research Service, Nutritional fact sheets available at (https://fdc.nal.usda.gov/fdc-app.html#/food-details/169910/nutrients) date cited: 05 July 2023.

Development of a Moringa (*Moringa oleifera*) Powder-Incorporated Nutrition Bar

W.N.M.H. Karunarathna[1], P.C. Bandara[1], U.C.A.M.S Senarathna[2,*]

[1]*Department of Biosystems Technology, Faculty of Technology, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka,*
[2] *Food Research Unit, Department of Agriculture, Gannoruwa, Sri Lanka*

Corresponding author: upulasena@gmail.com*

Summary

The aim of this research was to develop a nutrition bar incorporating moringa (*Moringa olifera*) powder as a functional ingredient. Moringa powder is known for its nutrient density and medicinal properties. The study involved formulating nutrition bars with different ratios of Moringa powder, pumpkin seeds, dates, popcorn, peanuts, plums, and sweet potatoes. The bars were evaluated for physical, chemical, and microbiological characteristics, and a sensory analysis. The results showed that Moringa powder could be successfully incorporated into the nutrition bars without adversely affecting sensory properties. The nutrition bars formulated with moringa powder had higher nutritional content and improved shelf stability compared to the control bars. Sensory analysis indicated that the sample containing 2% moringa powder had the highest acceptability in sensory attributes. Then for the selected formula chocolate coating was applied. According to the proximate analysis, the sample which contained 2% moringa powder with the chocolate coating had moisture content (8.80±0.01%), fat content (9.2±0.03%), protein content (19.00±0.02%), ash content (5.00±0.02%), and carbohydrates (47.1±0.2%).

Keywords**:** Food product, Healthy snack, Moringa powder, Nutrition bar, Sensory evaluation

Introduction

Nutrition bars are a convenient food carrying healthy criteria due to their compositions. Basically, nutritional bars contain cereals and other high-energy-rich ingredients (Shahangir, 2015). They are used as meal replacements, nutritional meals, or snacks that can supply essential nutrients to consumers (Orrego *et al*., 2014). According to the World Bank data collection of development indicators, malnutrition is identified as a major problem in Sri Lanka. Also obesity, diabetes, and heart diseases are considered major health problems in Sri Lanka. Incorporation of healthy food options in daily diets and exercise seems to be a need. The study, examined the replacing unhealthy snack foods with a nutrition bar aiming a change in dietary habits.

The majority of the nutritional bars in the local and world market are overloaded with high glycemic ingredients. Some products even exceed the acceptable glucose and unhealthy fat concentrations. The bars supply energy but do not contribute to sustain an active and healthy routine life. Most of the bars are made out of cereals, and dairy-based proteins such as casein and whey proteins. People suffering from lactose intolerance cannot use the bars rich with dairy ingredients. Moreover, most of the nutritional bars contain wheat flour containing gluten protein. Gluten rich bars are not healthy for people suffering from celiac (gluten intolerance) disease. The specialty of the proposed nutrition bar is the use of gluten and lactose free ingredients.

Methodology

Moringa powder was supplied by the Food Research Unit, Gannoruwa. Sweet potatoes were washed, peeled, and cut into uniform sizes using a grater. The two raw materials were dried at 55-65 °C for 3 h in a commercial dehydrator. Followed by a laboratory scale grinder (model - OBP-K300G). The powder was sieved through a 50 µm mesh sieve. Pumpkin seeds were washed well and the outer shells of the dried pumpkin seeds were removed using a cutter. The seeds were roasted for 5 min at 120 °C using an oven (Model: Mammbert GmbH). Peanuts were roasted at the same temperature for 15 min until they were golden brown. The bars were prepared in 4 formulas. Dry ingredients like sweet potato powder, popcorn dried plums, were added to a bow in calculated quantities. Date seeds were removed and made into a paste using a laboratory scale grinder. After that glucose syrup and date paste were added and homogenized. The mixture was spread to a 1.3 cm thickness on a flat molding board by tipping and leveling with a rolling pin. The spread mixture was cut into rectangular shaped pieces (2.5 cm×7.5 cm, approximately 50 g per piece). The pieces were transferred onto a tray with parchment paper and baked at 170 ºC for 20 min and allowed to cool at room temperature.

A preliminary sensory experiment was conducted to select the best formulation of moringa powder (2%, 3%, and 4%). The sensory properties of three samples were evaluated by semi trained panel of Food Research Unit, Gannoruwa based on a nine-point hedonic scale. The sample containing 2% moringa powder was selected as the best after analyzing the data gathered from the sensory trial with respect to appearance, color, taste, mouth feel, texture, and overall acceptability. Chocolate coating was done for the selected bars containing 2% moringa powder. The variation in product pH, moisture, proximate composition, water activity, and yeast and mold count, total plate count, and antioxidant activity were examined to evaluate the shelf-life of the product. The data were analyzed statistically using one – way ANOVA by mini tab.

Table 1. Formulations for nutrition bar

Ingredients	Samples				
	A	B	C	D	Control
Moringa powder (g)	0.5	1.0	1.5	2.0	0
Pumpkin seeds (g)	3.0	2.5	2.0	1.5	3.5
Popcorn (g)	5.0	5.0	5.0	5.0	5.0
Dates (g)	11.0	11.0	11.0	11.0	11.0
Peanuts (g)	8.0	8.0	8.0	8.0	8.0
Sweet potatoes (g)	15.0	15.0	15.0	15.0	15.0
Glucose syrup (g)	2.5	2.5	2.5	2.5	2.5
Dried plums (g)	5.0	5.0	5.0	5.0	5.0
Total mass (g)	50	50	50	50	50

Results and Discussion

Sensory analysis

Table 2. Sensory characteristic of different samples

Treatments	Appearance	Taste	Texture	Mouth-feel	Color	Overall acceptability
Control	7.9 ± 0.5^{a}	7.80 ± 0.6^{a}	7.60 ± 0.6^{a}	7.8 ± 0.7^{a}	7.1 ± 0.8^{a}	7.5 ± 0.6^{a}
2% moringa powder	7.60 ± 1.0^{a}	7.00 ± 1.7^{ab}	$7.\pm1.4^{a}$	6.7 ± 1.5^{bc}	8.1 ± 0.6^{b}	7.9 ± 1.1^{b}
3% moringa powder	7.60 ± 1^{a}	6.3 ± 1.1^{ab}	6.8 ± 0.7^{a}	6.2 ± 1.2^{bc}	7.0 ± 0.7^{b}	6.60 ± 0.6^{a}
4% moringa powder	$6.3\pm1.^{b}$	5.3 ± 0.9^{c}	5.6 ± 1.3^{b}	5.6 ± 1.2^{c}	6.6 ± 0.9^{b}	5.8 ± 1.3^{c}

Different letters in the same column indicate the values are significantly different ($p<0.05$)

According to the data collected from the sensory evaluation 2% moringa powder incorporated sample selected as the best and subjected to product development and further analysis (Table 2).

Physical parameters

Table 3. Determination physical properties of developed nutritional bars

Sample	Length (cm)	Thickness (cm)	Width (cm)	Weight (g)	Volume (cm^3)
Control	6.0±0.1[a]	1.1±0.0[a]	3.1±0.1[a]	50.1±0.0[a]	20.4±0.4[a]
Without coating	6.1±0.2[a]	1.2±0.1[a]	3.0±0.1[a]	50.1±0.0[a]	21.5±1.3[a]
With coating	6.2±0.1[a]	1.8±0.1[b]	3.0±0.1[b]	50.6±0.0[b]	36.5±0.6[b]

Different letters in the same column indicate the values are significantly different (p<0.05)

According to the table 3, when changing in the ratio of moringa powder and also the chocolate coating, the resulting content of protein and fibers are slightly influenced and lead to slight changes in the volume and weight of the prepared nutritional bars. The volume of nutritional bars ranged from 20.4 to 36.5 cm^3, and the weight differ from 50.1 g and 50.6 g with the highest value of coated sample and the lowest was found in control sample.

Determination pH value

Table 4. pH value of different samples with time

Sample	0 day	14^{th} day	28^{th} day
Control	5.6±0.0[a]	5.3±0.0[a]	5.1±0.0[a]
Without coating	5.1±0.0[b]	4.6±0.0[b]	4.4±0.0[b]
With coating	5.4±0.0[b]	5.1±0.0[c]	4.9±0.0[c]

Different letters in the same row indicate the values are significantly different (p<0.05)

Chocolate coated sample showed the lowest pH fluctuation while the highest fluctuation in pH was found with the control sample.

Water activity

Chocolate coated has the lowest water activity. Also, the water activity of each sample significantly increased over 28 days. It suggests the limitations that may arise during storage.

Table 5. Water activity of different samples with time

Sample	0 day	14th day	28th day
Control	0.5±0.005[a]	0.5±0.005[a]	0.6±0.000[a]
Without coating	0.6±0.005[b]	0.6±0.005[b]	0.6±0.005[b]
With coating	0.5±0.005[c]	0.5±0.005[a]	0.5±0.005[c]

Different letters in the same row indicate the values are significantly different (p<0.05)

Proximate analysis

Table 6. Determination of proximate composition

Parameter	Control	Without coating	With coating
Moisture %	8.8±0.05[a]	9.7±0.05[b]	8.8±0.05[c]
Protein %	16.2±0.02[a]	17.9±0.02[b]	19.0±0.02[c]
Fat %	8.5±0.04[a]	8.7±0.02[b]	9.2±0.03[c]
Ash %	4.2±0.01[a]	4.9±0.04[b]	5.0±0.02[b]
Carbohydrate %	46.1±0.14[a]	46.2±0.28[a]	47.1±0.15[b]
Fiber %	12.6±0.02[a]	13.0±0.00[b]	14.0±0.01[c]

Different letters in the same row indicate the values are significantly different (p<0.05)

Moisture content (8.8%), fat content (9.2%), protein content (19%), ash content (5%) and carbohydrates (47%) were recorded in the chocolate coated sample.

Determination DDPH inhibition

Table 7. Total antioxidant content of different samples

Sample	Inhibition (%)
Control	14.0±0.00[a]
Without coating	20.1±0.01[b]
With coating	20.4±0.02[c]

Different letters in the same column indicate the values are significantly different (p<0.05)

The current study exhibited the highest % DPPH inhibition value, at 20.44±0.02%. Studies have indicated that moringa powder supplement promote antioxidant activity and increase the production of antibodies.

Microbiology analysis

Table 8. Total plate count and yeast and mold count in different samples

	Total plate count CFU g^{-1}			Yeast and mold CFU g^{-1}		
Standards [Regulation (EC) No 2073/2005]	Less than 10^5 CFU/g			Less than 10^2 CFU/g		
	Initial	14^{th} day	28^{th} day	Initial	14^{th} day	28^{th} day
Control	$1.5x10^3$	$1.8x10^3$	$2.3x10^3$	<10	$0.5x10^2$	$0.8x10^2$
Without coating	$1.4x10^3$	$1.6x10^3$	$1.9x10^3$	<10	$0.4x10^2$	$0.7x10^2$
With coating	$1.4x10^3$	$1.6x10^3$	$1.9x10^3$	<10	$0.4x10^2$	$0.5x10^2$

Different letters in the same row indicate the values are significantly different (p<0.05)

Table 8 gives the microbial results of chocolate coating, without chocolate coating and control nutrition bar samples. The counts are within the tolerance limits stipulated in the European Union (EU) regulations for microbial analysis in nutrition bars, suggesting the safety of the prepared nutrition bar.

Conclusion

The 2% moringa powder incorporated sample had the highest acceptance in sensory attributes than the control sample with no significant difference (p>0.05). The proximate composition values of the 2% moringa powder incorporated sample revealed moisture content (8.76%), fat content (9.23%), protein content (19.02%), ash content (4.95%) and carbohydrates (47.10%).

References

AOAC (1995). 'ANNEX G AOAC Official Method 991.43 Total, Soluble, and Insoluble Dietary Fibre in Foods', *Cereal Foods*, pp. 7–9. Available at: https://acnfp.food.gov.uk/sites/default/files/mnt/drupal_data/sources/files/multimedia/ pdfs/annexg.pdf.

Benjamin, B. (2018). 'Prospective studies', Social and economic factors affecting mortality, pp. 64–66. doi:10.1515/9783111416878-028.

Berue, S. (2012). 'Vegan Protein Powder Supplements of High Biological Value', *Journal of Renal Nutrition*, 22(4), pp. e39–e41. doi:10.1053/j.jrn.2012.03.005.

Ciuris C., Lynch H. M., Wharton C., Johnston C. S. (2019). 'A Comparison of Dietary Protein Digestibility based on DIAAS Scoring, in Vegetarian and Non-Vegetarian Athletes', *Nutrients*, 11(3016), pp. 1–10.
Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6950041/.

Codex Alimentarius (2013). 'Guidelines on Nutrition Labelling', CAC/GL 2-1985, 53(9), pp. 1689–1699.

Cox S., Sandall A., Smith L., Rossi M., and Whelan K. (2021). 'Food additive emulsifiers: A review of their role in foods, legislation and classifications, presence in food supply, dietary exposure, and safety assessment', *Nutrition Reviews*, 79(6), pp. 726–741. doi:10.1093/nutrit/nuaa038.

Srigley, C. T. and Mossoba, M. M. (2017). 'Current Analytical Techniques for Food Lipids', *Food Safety: Innovative Analytical Tools for Safety Assessment*, pp. 33–64. Available at: http://digitalcommons.unl.edu/usfda/7.

Day, L., Cakebread, J. A. and Loveday, S.M. (2022). 'Food proteins from animals and plants: Differences in the nutritional and functional properties', *Trends in Food Science and Technology,* 119, pp. 428–442. doi:10.1016/j.tifs.2021.12.020.

GC-MS Study on Rice Bran Oil in Sri Lanka

T. D. Wijayaratne[1], T. D. C. M. K. Wijayasiriwardena[2]*

[1]Department of Botany, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka.
[2]Industrial Technology Institute, 503 A, Halbarawa Gardens, Thalahena, Malabe, Sri Lanka.

*Corresponding Author**: drchandima@iti.lk

Summary

Rice bran oil stands out as a remarkable value-added product of rice bran, a by-product of rice milling. The aim of this study was to analyze the fatty acid profile of a composite crude rice bran oil samples prepared from parboiled, red and mixed rice brans. Rice bran oil was extracted using hexane by reflux condensation and the fatty acid composition of the composited crude oil sample was analyzed by gas chromatography. The total saturated fatty acid and unsaturated fatty acid content in the composited oil sample was shown to be 24.27% and 75.65% respectively. Oleic (18:1), palmitic (16:0), and linoleic (18:2) acids present in proportions of 55.80%, 20.39%, and 18.38% in the composite oil, were the main fatty acids. The fatty acid content of rice bran oil is affected by rice variety, agroclimatic conditions, extraction conditions and storage duration. The crude form of rice bran oil should be further purified and refined to produce food grade form of rice bran oil although the crude oil can be utilized for certain cosmetic purposes.

Keywords: Fatty acids, Rice bran oil, Value addition

Introduction

The primary food crop cultivated in Sri Lanka is rice. Paddy is milled to remove the husk before marketing as rice. Rice bran is a by-product of rice milling. Rice bran is used mainly as a livestock feed in Sri Lanka. The bran contains 12-18% of oil which can be extracted prior to feeding livestock to produce crude rice bran oil (Wang, 2019). The extraction of rice bran oil (RBO) would increase the value of the basic by-product rice bran rather than allowing it to be wasted or used for lower-value purposes. Consequent to this value addition, use of rice bran for oil production would promote sustainability across product development and waste optimization resulting in increased profitability of both rice production and processing.

RBO is a functional oil with health benefits due to its balanced fatty acid profile, closest to meeting requirements stipulated by American Heart Association and World Health Organization for edible oils and bioactive compounds (Usha and Premi, 2011).

The objectives of this study were to extract oil from parboiled, red and mixed rice bran types in Sri Lanka, prepare a composite crude RBO sample and analyze the fatty acid profile of the composited crude oil sample.

Methodology

Sample collection and oil extraction

Samples of about 3 Kg of bran from parboiled rice, red rice and mixed (red and white) rice were collected from rice mills at Polonnaruwa, Rathnapura, and Gampaha respectively.

Rice bran samples (200 g) were refluxed at 65 °C for 3 hours with 400 mL hexane. Cooled oil was filtered with a Whatman filter paper and hexane was recovered by rotary evaporation. Extractions were carried out six times from each rice bran sample. Each extracted crude RBO sample was collected in an air-tight glass reagent bottle to produce the composite crude RBO.

Determination of fatty acid profile

Fatty acid composition was determined using GC/MS analysis. Fatty acids were derivatized to methyl esters following the procedure ISO 5509: 2000 (E). Composited crude RBO sample (60 mg) was taken into a stoppered test tube. To the test portion 4 mL of isooctane was added and dissolved. Then, 200 µL of 2 M methanolic KOH was added. Test tube was stoppered and shaken vigorously for 30 s until a clear solution was formed. About 1 g of sodium hydrogen sulfate monohydrate was added and shaken. Upper layer was decanted and injected to GC/MS as methyl esters. The methylated sample (0.2 µL) was injected into the gas chromatograph (Agilent 6890 series) equipped with a splitless injector and a mass selective detector/ MSD (Agilent 5973 N series). A capillary column 30 m x 0.25 mm internal diameter, coated with 0.25 µm of 5% phenyl methyl siloxane phase (HP – 5 MS) was used with He as the carrier gas at the flow rate of 1.0 mL/ min. Oven temperature program was set as 40 ^{o}C to 240 ^{o}C at the rate of 15 ^{o}C/min then raised to 280 ^{o}C at the rate of 10 ^{o}C/min. At each stage of programming, the temperature was held for 5.0, 40.0 and 2.0 min, respectively. The injector and detector were held at 250 ^{o}C. Identification and quantification of the methyl esters were made by comparison of retention time with NIST14 library. The analysis was carried out in triplicates for the composited crude oil sample.

Results and Discussion

Rice bran is considered a low oil source (<25%) therefore oil recovery was carried out by solvent extraction using hexane as it is the most common and conventional solvent for

commercial RBO extraction owning to its low price and high extractability (Garba *et al.*, 2017; Peanparkdee and Iwamoto, 2019).

RBO is one of the most popular value-added ingredients used in food, pharmaceutical and cosmetic products for its notable fatty acid composition (Wijayaratne *et al.*, 2023). Results for the fatty acid composition of the composited crude RBO is shown in Table 1. The total saturated fatty acid (SFA) and unsaturated fatty acid content in composite crude RBO were found to be 24.27% and 75.65% respectively. Similarly, monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) composition were shown to be 57.28% and 18.38% respectively. The total fatty acid content in composite crude RBO was revealed to be 99.92%.

Table 1. Fatty acid composition of crude composite RBO sample

Fatty Acid	Percentage Composition ± SD (%)
Lauric acid (C12:0)	0.14 ± 0.00
Myristic acid (C14:0)	0.26 ± 0.00
Pentadecanoic acid (C15:0)	0.48 ± 0.00
Palmitic acid (C16:0)	20.39 ± 0.06
Palmitoleic acid (C16:1)	0.14 ± 0.00
Stearic acid (C18:0)	1.81 ± 0.08
Oleic acid (C18:1)	55.80 ± 0.11
Linoleic acid (C18:2)	18.38 ± 0.06
Arachidic acid (C20:0)	0.74 ± 0.18
Gondoic acid (C20:1)	1.33 ± 0.07
Behenic acid (C22:0)	0.21 ± 0.00
Lignoceric acid (C24:0)	0.23 ± 0.02

The major saturated fatty acid in composite crude RBO sample was palmitic acid (20.39 ± 0.06 %) while lauric, myristic, pentadecanoic, stearic, arachidic, behenic and lignoceric acids were present in trace amounts. The palmitic acid content in the composite oil sample in the present study is higher compared to those reported for traditional rice varieties 'Suwandal' (19.67 ± 0.21%) and 'Nilkanda' (19.56 ± 0.34%) (Samaranayake *et al.*, 2017). Consumption of fat rich in SFA are reported to increase the low-density lipoprotein (LDL) cholesterol whose high level is associated with coronary heart disease (CHD) (World Health Organization, 2008). SFAs such as lauric and myristic acids are correlated with CHD and they were present in trace amounts in this study. RBO is a rich PUFA oil and responsible for reducing LDL by 6-7% when compared to other oils such as sunflower, corn and safflower oils (Ahmad Nayik *et al.*, 2015; Bopitiya and Madhujith, 2015). The predominant unsaturated fatty acid in crude composite RBO was oleic acid (55.80 ± 0.11%). A study conducted on the fatty acid profiling of RBO extracted from raw bran showed oleic acid content in the range of 41.41-44.18% which is lower compared to the present study (Akhter

et al., 2016). Linoleic acid (C18:2), an essential fatty acid that cannot be synthesized in the human body was present in 18.38 ± 0.06% in the crude RBO sample. Variations in the fatty acid composition of rice bran oil could be due to varietal differences in the rice, external environment factors, and the extraction process utilized (Blanche *et al*., 2009; Gopala Krishna *et al*., 2006). Lignoceric acid (C24:0) is a predominant long chain fatty acid present in the soft wax fraction of the crude RBO and present in the crude sample in trace amounts.

Conclusion

GC/MS results for the composite oil sample revealed palmitic, oleic and linoleic acids as major fatty acids. The unsaturated fatty acid (75.65%) content was higher than for saturated fatty acids (24.27%) and monounsaturated fatty acid and polyunsaturated fatty acid contents were shown to be 57.28% and 18.38% respectively. The presence of linoleic acid in 18.38% on the composited crude rice bran oil sample may also lead to the conclusion that it is a good source of an essential fatty acid.

References

Ahmad Nayik, G., Majid, I., Gull, A., and Muzaffar, K. (2015). 'Rice bran oil, the future edible oil of India: A Mini Review', *Journal of Rice Research*. 03, 151-153.

Akhter, M., Mahmood, A., Raza, M.A., Zulqarnain, H., Bibi, T., and Naseem, I. (2016). 'Free fatty acid profiling of rice bran oils for improving shelf life through parboiling and different treatments', *Journal of Nutrition and Food Sciences.* 06, 449-455.

Blanche, S.B., Utomo, H.S., Wenefrida, I., and Myers, G.O. (2009). 'Genotype × Environment interactions of hybrid and varietal rice cultivars for grain yield and milling quality', *Journal of Crop Science*. 49, 2011–2018.

Bopitiya, D., and Madhujith, T. (2015). 'Antioxidant potential of rice bran oil prepared from red and white rice', *Tropical Agricultural Research*. 26, 1-11.

Garba, U., Singanusong, R., Jiamyangyuen, S., and Thongsook, T. (2017). 'Extraction and utilization of rice bran oil: A review', in: The 4th International Conference on Rice Bran Oil 2017. Rice Bran Oil Application: Pharma-Cosmetics, Nutraceuticals and Foods. pp. 24–25.

Gopala Krishna, A. G., Hemakumar, K. H., Khatoon, S. (2006). 'Study on the composition of rice bran oil and its higher free fatty acids value', *Journal of American Oil Chemists' Society*. 83, 117–120.

Peanparkdee, M., and Iwamoto, S. (2019). 'Bioactive compounds from by-products of rice cultivation and rice processing: Extraction and application in the food and pharmaceutical industries', *Journal of Trends Food Science and Technology.* 86, 109–117.

Samaranayake, M. D. W., Yathursan, S., Abeysekera, W. K. S. M., Herath, H. M. T. (2017). 'Nutritional and antioxidant properties of selected traditional rice (Oryza sativa L.) varieties of Sri Lanka', *Sri Lankan Journal of Biology.* 2, 25-35.

Usha, P. T., and Premi, B. R. (2011). 'Rice bran oil - natures gift tomankind [WWW Document]. URL https://www.scribd.com/document/122297199/Rice-bran-oil-natures-gift-to-mankind (accessed 12.13.22).

Wang, Y, (2019). 'Applications of rice bran oil. *In*: Rice bran and rice bran oil, (Eds Ling-Zhi, C. and Xuebing, X.) pp 159–168, Elsevier publisher, New York.

World Health Organization, 2008. Interim summary of conclusions and dietary recommendations on total fat & fatty acids. From the joint FAO/WHO expert consultation on fats and fatty acids in human nutrition 10–14.

Hibiscus rosa-sinensis Flower Powder as a Natural Nitrite Source of Chicken Sausages

A.P.K. Thathsarani[1], A.U. Alahakoon[1]*, R. Liyanage[1]

[1]*Department of Biosystems Technology, Faculty of Technology, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka*

Corresponding author: amalialahakoon@sjp.ac.lk*

Summary

The meat industry acknowledges the health concerns associated with nitrite and is proactively searching for natural alternatives to lower residual nitrite levels and replace synthetic nitrite in processed meat products. This pursuit aims to address health implications and maintain the desirable qualities traditionally provided by nitrite in meats.Natural solutions are being actively explored to achieve reduced nitrite levels or eliminatethe need for nitrite entirely in cured meat products. This study investigated the potential for using *Hibiscus rosa-sinensis* (HS) flowers for the reduction of residual nitrite content ofchicken sausages. The oven-dried *Hibiscus rosa-sinensis* flower powder (HSP) was utilized in the development of chicken sausages following standard procedures. The experimental groups were analyzed for residual nitrite after freezer storage at -18±5 °C for 28 days. Six treatments were included: Positive control- C1 (125 ppm sodium nitrite and 0% HSP), Negative control- C2 (0 ppm sodium nitrite and 0% HSP), treatment 1- T1 (125 ppm sodium nitrite and 8% HSP), treatment 2- T2 (125 ppm sodium nitrite and 10% HSP), treatment 3- T3 (125 ppm sodium nitrite and 8% HSP), treatment 4- T4 (125 ppm sodium nitrite and 10% HSP). The highest concentrations of residual nitrite (19.27 mg/ kg) were observed inthe C1 group. The results revealed a significant decrease ($p<0.05$) in the residual nitrite content with an increase in the percentage of HSP. Moreover, the residual nitrite level declined both during the storage of sausage and after the addition of HSP. The results indicate potential of HSP to replace synthetic nitrite in naturally cured meat products, appealing to consumers.

Keywords: Chicken sausages, *Hibiscus rosa-sinensis*, Residual Nitrite, Sodium nitrite

Introduction

Modern day consumers are more concerned on the negative impacts of synthetic additives in their meals due to the risk of toxicity and carcinogenicity. Owing to that, thereis a growing trend towards using natural additives such as plant materials to substitute synthetic additives from the recipes in the meat industry (Alahakoon *et al.,* 2015). The reduction of residual nitrite levels could be an acceptable alternative in reducing the intake of nitrite in processed meat and meat products. According to

the literature, many Hibiscus species including *Hibiscus rosa-sinensis* (HS) have been investigated and found to contain many classes of secondary metabolites, including flavonoids, anthocyanins, terpenoids, steroids, polysaccharides, amino acids, lipids, quinones, and naphthalene groups (Tyagi andTyagi, 2017). More specifically, HS flowers contain flavonoids, vitamins, thiamine, riboflavin, niacin, and ascorbic acid (Tyagi and Tyagi, 2017). Some of these compounds havebeen shown to have antibacterial, anti-inflammatory, antihypertensive, antifertility, hypoglycemic, antifungal, and antioxidative activities. Therefore, HS may possess the potential to reduce the residual nitrite content in meat products and also antimicrobial and antioxidant properties of HS would provide an opportunity for use as a nitrite alternative. This study investigated the potential for using HS flowers and their effects on reducing the use of nitrite in chicken sausages.

Methodology

Preparation of HS powder and cured chicken sausages

Fresh flowers of HS with no apparent physical, insect, or microbial damage were selected. HS double flower (red) powder was prepared (Mak *et al.,* 2013) with some modifications. Dried flower petals were crushed into small particles using a mortar and pestle. After that, the oven-dried flower petal particles were ground into a fine powder (mesh size 30) by using the mixer grinder covered with aluminum foil to avoid exposure to light. The powder was stored in air-tight bottles at -22 °C in the freezer pending analysis. The standardized formulation for the chicken emulsion for chicken sausages was prepared using a preheated hot air oven according to the methoddescribed by Munsu *et al*. (2021) with some modifications. 125 ppm Sodium Nitrite was selected according to the regulations of the Sri Lanka Standards Institute.

Experimental plan

A multilevel factorial design was used in this study. The first factor (HSP) was the source ofHSP extracts consisting of 3 levels i.e., 0% HSP, 8% HSP, and 10% HSP. The second factor was the level of Sodium Nitrite consisted of 2 levels i.e., 0 ppm and 125 ppm. Each treatment consisted of 5 replications. The percentages of HSP were selected after conducting a series of preliminary trials.

Six experimental groups were included:

1. Positive control - C1 (125 ppm sodium nitrite and 0% HSP)
2. Negative control - C2 (0 ppm sodium nitrite and 0% HSP)
3. Treatment 1 - T1 (125 ppm sodium nitrite and 8% HSP)
4. Treatment 2 - T2 (125 ppm sodium nitrite and 10% HSP)
5. Treatment 3 - T3 (0 ppm sodium nitrite and 8% HSP)
6. Treatment 4 - T4 (0 ppm sodium nitrite and 10% HSP)

Determination of residual nitrite content in chicken sausages

The samples in all groups were analyzed for residual nitrite content after frozen storage at -18±5 °C for 28 days. All analysis were done by Griess colorimetric method modified by Norwitz and Keliher (1987).

Statistical analysis

The effects of HS on the residual nitrite of chicken sausages were analyzed via a one-way ANOVA. The data analysis was done using Excel datasheets, SPSS, and Origin Pro 9 software. The differences between the control and the treatments in these experiments were tested for statistical significance by Tukey comparison. A significance level of $p<0.05$ was used for all evaluations. Values are expressed as mean±standard deviation. Data interpretations of the samples during the shelf- life study was done by the Origin software.

Results & Discussion

The residual nitrite content of HS flower-incorporated chicken sausages is shown in Figure 1. The C1 group exhibited significantly higher concentrations of residual nitrite (19.27 mg/kg) compared to the other groups. The results revealed a significantdecrease ($p<0.05$) in the residual nitrite content with an increase in the percentage of HS powder. The conversion of nitrite into nitric oxide is a predominant process in cured meat and meat products. Upon conversion, nitric oxide binds to different components within the product, such as myoglobin (5-15%), sulfhydryl groups (5-15%), lipids (1-5%), and proteins(20-30%) (Alahakoon *et al.,* 2015). Moreover, certain polyphenolic compounds have demonstrated potent protective properties against nitrite ions, effectively inhibiting the formation of nitrosamines (Hirota and Takahama, 2015; Xie *et al.,* 2019). Hibiscus calyx is rich in bioactive compounds, particularly with polyphenols, known for their potent antioxidant properties (Fernández-López *et al*., 2008; Villasante *et al*., 2020). As a consequence, residual nitrite might react with these active compounds, such as phenolic compounds, leading to the production of nitrite acid or nitric oxide. The antioxidants can scavenge free radicals and potentially decrease the formation of harmful nitrosamines, during processing. Addition of HS powder to chicken sausages resulted in a decrease in the residual nitrite content.

In samples without added nitrite, residual nitrite levels below 11 mg/kg were observed. Specifically, T3 (8% HS and 0 ppm Nitrite) and T4 (10% HS and 0 ppm Nitrite) contained 8-11 mg/kg of residual nitrite. This residual nitrite presence can be attributed to the naturally occurring nitrate content found in HS. The petals of open flowers in HS were reported to contain high nitrate concentration, reaching 2.6 µg per organ (Trivellini *et al.,* 2011).

The study found that the residual nitrite concentration decreased over time during sausage storage and after the addition of HSP. A study conducted by Shen *et al.* (2023) demonstrated that the storage period has a significant impact on the residual nitrite content in meat products. Further, it was discovered that substances such as Ascorbic acid can play a role in reducing the levels of nitrite in meat during storage (Ahn *et al.,* 2004). During storage, the residual nitrite content in meat gradually decreases due to the action of reducing agents like Ascorbic acid, which facilitates the conversion of nitrite into nitric oxide.

The results of this study indicate potential of HSP to replace synthetic nitrite in naturally cured meat products, appealing to consumers.

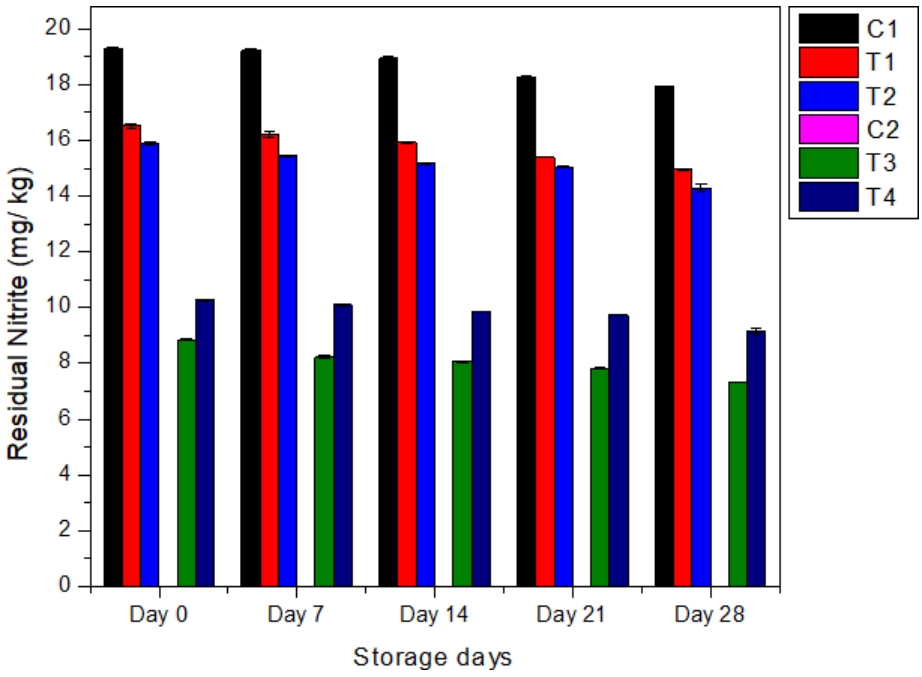

Figure 1: Residual nitrite content of *Hibiscus rosa-sinensis* flower incorporated chicken sausages

Conclusion

Hibiscus rosa-sinensis flower powder was able to reduce the residual nitrite in chicken sausages. *Hibiscus rosa-sinensis* flowers were investigated as a natural alternative to nitrite in meat products, with the objective of evaluating their applicability in reducing the residual nitrite content. Further research and development are needed to optimize the application of *Hibiscus rosa-sinensis* flowers as nitrite alternatives in the meat industry, considering factors such as formulation, processing parameters, and storage conditions.

References

Ahn, H. J., Kim, J. H., Jo, C., Lee, J. W., Yook, H. S., and Byun, M. W. (2004). 'Effects of gamma irradiation on residual nitrite, residual ascorbate, color, and N-nitrosamines of cooked sausage during storage', *Food Control*, 15(3), pp. 197–203. https://doi.org/10.1016/S0956-7135(03)00047-1

Alahakoon, A. U., Jayasena D. D., Ramachandra S., and Jo, C. (2015). 'Alternatives to nitrite in processed meat: Up to date', *Trends in Food Science & Technology*, 45, pp. 37–49. doi:10.1016/j.tifs.2015.05.008.

Fernández-López, J., Sendra, E., Sayas-Barberá, E., Navarro, C., & Pérez-Alvarez, J. A. (2008). 'Physico-chemical and microbiological profiles of "salchichón"(Spanish dry-fermented sausage) enriched with orange fiber', *Meat science*, 80(2), 410-417.

Hirota, S. and Takahama, U. (2015). 'Reactions of polyphenols in masticated apple fruit with nitrite under stomach simulating conditions: Formation of nitroso compounds and thiocyanate conjugates', *Food Research International*, 75, pp. 20–26. doi:10.1016/j.foodres.2015.05.018.

Mak, Y.W., Chuah, L.O., Ahmad, R., and Bhat R. (2013). 'Antioxidant and antibacterial activities of hibiscus (*Hibiscus rosa- sinensis L.*) and Cassia (*Senna bicapsularis L.*) flower extracts', *Journal of King Saud University - Science*, 25(4), pp. 275–282. doi:10.1016/j.jksus.2012.12.003.

Munsu, E., Mohd Zaini, H., Matanjun, P., Ab Wahab, N., Sulaiman, N.S., and Pindi, W. (2021). 'Physicochemical, sensory properties and lipid oxidation of chickensausages supplemented with three types of seaweed', *Applied Sciences (Switzerland)*, 11(23). doi:10.3390/app112311347.

Norwitz, G., and Keliher, P.N. (1987). 'Interference of ascorbic and isoascorbic acids in the spectrophotometric determination of nitrite by the diazotisation - coupling technique', *The Analyst*, 112(6), pp. 903–907. doi:10.1039/an9871200903.

Shen, Q., Zeng, X., Kong, L., Sun, X., Shi, J., Wu, Z., Guo, Y., and Pan D. (2023). 'Research Progress of Nitrite Metabolism in Fermented Meat Products', *Foods*, 12(7). doi:10.3390/foods12071485.

Trivellini, A., Ferrante, A., Vernieri, P., and Serra, G. (2011). 'Effects of abscisic acid on ethylene biosynthesis and perception in Hibiscus rosa-sinensis L. flower development', *Journal of Experimental Botany*, 62(15), pp. 5437–5452. doi:10.1093/jxb/err218.

Tyagi, S., Kumar, A., and Tyagi, P. K. (2017). 'Comparative analysis of metal nanoparticles synthesized from Hibiscus rosa-sinesis and their antibacterial activity estimation against nine pathogenic bacteria', *Asian Journal of Pharmaceutical and Clinical Research*, 10(5), pp. 323–329. doi:10.22159/ajpcr.2017.v10i5.17458.

Villasante, J., Ouerfelli, M., Bobet, A., Metón, I., & Almajano, M. P. (2020). 'The Effects of pecan shell, roselle flower and red pepper on the quality of beef patties during chilled storage', *Foods*, 9(11), 1692.

Xie Z., Li X., Tang R., Wang G., Lu Y., Li X., Cheng K., Li L., and He Q. (2019). 'Reactions of polyphenols in pomegranate peel with nitrite under simulated stomach conditions', *Food Science and Nutrition*, 7(9), pp. 3103–3109. doi:10.1002/fsn3.1173.