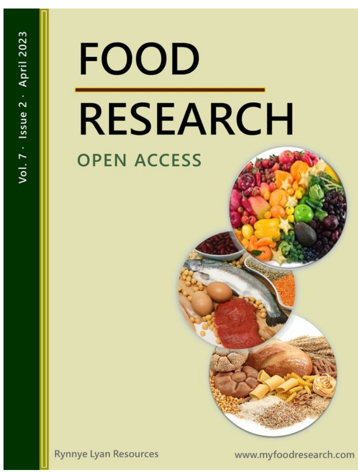
F|R

VIEW ARTICLES ISSUES ABOUT FOR AUTHORS FOR REFEREES

FOOD
RESEARCH



View Editorial Board

eISSN: 2550-2166

SUBMIT YOUR MANUSCRIPT

PEER REVIEW PROCESS

Food Research

OPEN ACCESS

Aim and Scope

Food Research is an **Open Access journal** that publishes reviews, original research articles and short communications focusing on **food science and technology, food service management, nutrition, nutraceuticals, food innovation, and agriculture food science.**

The Journal welcomes papers within the intended scope as follows:

- Food science and food chemistry
- Food technology, food processing, and food engineering
- Food safety and quality - microbiological and chemical
- Sensory, habits, consumer behaviour/practice and preference
- Nutrition and Dietetics
- Nutraceuticals and functional food
- Food service management
- Food trends, innovation and business
- Post-harvest and agribusiness
- Food security
- Food packaging

Studies should be of general interest to the international community of food researchers.

Journal Indexing

- Scopus

- EuroPub
- *i*-journals
- *i*-focus
- Index Copernicus International **(ICV Value = 89.65)**
- Directory of Open Access Journal (DOAJ)
- Directory of Open Access Scholarly Resources (ROAD)
- Scholarsteer
- Malaysian Citation Index (MYCITE)
- Directory of Research Journal Indexing (DRJI)
- J-Gate
- Bielefeld Academic Search Engine (BASE)
- Google
- Asean Citation Index
- Jouroscope

Food Research
Q3 Food Science best quartile
SJR 2021 0.23
powered by scimagojr.com

1.2 2021 CiteScore
30th percentile
Powered by Scopus

We are Crossref Member

Latest Issues

April 2023 ***(In progress)***
Volume 7, Issue 2

February 2023
Volume 7, Issue 1

Special Issue: National Food Technology Seminar 2020
(In progress)
Volume 6, Supplementary 2

Special Issue: International Halal Conference Research & Technical 2021
(In progress)
Volume 6, Supplementary 3

Special Issue: AFOB-MC International Symposium 2021
(In progress)
Volume 6, Supplementary 4

View Issues

December 2022
Volume 6, Issue 6

October 2022
Volume 6, Issue 5

June 2022
Volume 6, Issue 3

August 2022
Volume 6, Issue 4

Article In Press

VIEW MORE

…ed with a potent …n *Escherichia coli*

…, Dewanti, T., Rahayu, …k, I.

Effect of rosemary (*Rosmarinus officinalis*) extract on the protection of the fish balls from knife fish (*Chitala chitala*) and striped catfish by-product (*Pangasianodon hypophthalmus*) against spoilage during frozen storage

Nguyen, L.A.D., Huynh, T.K.D., Nguyen, T.N.H., Nguyen, Q.T. and Tran, M.P.

Probiotic potential of Indonesian local variety of fermented parboiled rice (tape) improved the metabolic syndrome of diabetic rats

Wulandari, W., Yulianto, W.A., and Pujimulyani, D.

Immobilized therm… the interesterificat…

Najm, T.A. and Walsh, …

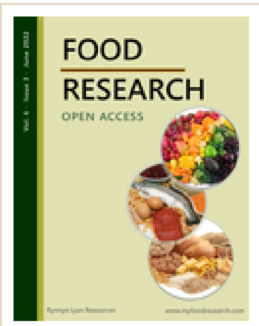
F|R

VIEW ARTICLES ISSUES ABOUT FOR AUTHORS FOR REFEREES

EDITORIAL BOARD

F R

VIEW ARTICLES ISSUES ABOUT FOR AUTHORS FOR REFEREES



Search

FOOD RESEARCH

Volume 6, Issue 3

June 2022

Mini Review

Full Papers

Osiriphun *et al*. developed a protein drink from fish protein hydrolysate obtained from tilapia skin waste.

The addition of lactic acid bacteria in the soybean soaking process of tempeh

Magdalena, S., Hogaputri, J.E, Yulandi, A. and Yogiara, Y.

Available Online: 5 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).304

The addition of lactic acid bacteria in the soybean soaking process of tempeh was studied by Magdalena *et al*.

Breadfruit (*Artocarpus altilis*) starch-based nanoparticle formation through dropwise mixing nanoprecipitation

Harsanto, B.W., Pranoto, Y., Supriyanto and Kartini, I.

Available Online: 8 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).308

Harsanto *et al*. formed breadfruit (*Artocarpus altilis*) starch-based nanoparticle through dropwise mixing nanoprecipitation.

Physical properties and sensory acceptability of gum arabic-coated cherry tomato fruit during storage

Sumonsiri, N., Charoensantisuk, K., Paonoi, N. and Kittayangkul, P.

Available Online: 8 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).395

The physical properties and sensory acceptability of gum arabic-coated cherry tomato fruit during storage was evaluated by Sumonsiri *et al*.

Physicochemical properties of yam starches from fifty-five lines of Dioscorea species

Olayide, S.L., Kehinde, O.S., Adeolu, A.A., Olushola, S.A., Nishinari, K. and Simphiwe, M.N.

Available Online: 8 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).224

Olayide *et al*. evaluated the physicochemical properties of yam starches from fifty-five lines of Dioscorea species

Whey protein concentrate mixed beverages and plasma amino acid response in young males

Klaewkla, J., Hudthagosol, C., Chaijenkij, K., Panya, A., Sang-ngoen, D., Phonsatta, N. and Kaewkul K.

Available Online: 8 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).630

Klaewkla *et al*. evaluated the plasma amino acid response in young males consuming whey protein concentrate mixed beverages.

Antioxidant activities and polyphenol compounds of kenaf leaf tea infusion after in-vitro gastrointestinal digestion and consumer perception survey

Goh, K.M., Lee, S.W. and Nyam, K.L.

Available Online: 11 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).590

The antioxidant activities and polyphenol compounds of kenaf leaf tea infusion after in-vitro gastrointestinal digestion and consumer perception survey was conducted by Goh *et al.*

Assessment of *Pseudomonas aeruginosa* biofilm-forming capacities from drinking water in water vending machine

Elexson, N., Sabrina, H., Dalene, L., Eddy, B., Nurul, F.R., Nasra, P., Grace, B., Nick, L., Amirah, Z.J., Nur, D.Z., Dayang, N.A.B., Manju, S. and Tunung, R.

Available Online: 11 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).324

Elexson *et al.* assessed the biofilm-forming capacities of Pseudomonas aeruginosa from drinking water in water vending machine.

Isolation of active compound from *Nephelium lappaceum* L. rind as an antioxidant

Nurani, L.H., Edityaningrum, C.A., Suhaera, Windarsih, A., Riyanto, S. and Rohman, A.

Available Online: 11 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).331

Nurani *et al*. isolated and studied the active compound from *Nephelium lappaceum* L. rind as an antioxidant.

Halal food: a social responsibility on cartel meat issue in Malaysia

Mohd Riza, N.S., Md Ariffin M.F., Hamdan, M.N. and Ramli, N.

Available Online: 11 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).277

Mohd Riza *et al.* evaluated the social responsibility on cartel meat issue on halal in Malaysia.

A comparative study of the physico-chemical properties of prominent cocoa bean in Southern Vietnam

Lam, T.V.H., Phan, T.B.T., Truong, T.N. and Ha, T.T.

Available Online: 14 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).359

Lam *et al*. performed a comparative study on the physico-chemical properites of prominent cocoa bean in Southern Vietnam

Comparison of the mass tissue strength of strawberry fruit between vertical and horizontal compaction

Ansar, A., Murad, M., Sukmawaty, S. and Ilmaknun, L.

Available Online: 14 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).373

The meat tissue strength of strawberry fruit between vertical and horizontal compaction was compared by Ansar *et al.*

Optimum condition of roasting process of Liberica coffee towards the local and international preference

Halim-Lim, S. A., Wan-Mohtar, W.A.A.Q.I., Surapinchai, S. and Azizan, N.A.Z.

Available Online: 14 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).340

The optimum conditions of roasting process of Liberica coffee towards the local and international preference was evaluated by Halim-Lim *et al.*

Optimization of heat treatment and pH of red and white pear cactus [*Opuntia ficus-indica* (l.) mill.] fruit juice using response surface methodology

Abdulkadir, N., Solomon, W.K. and Woldetsadik, K.

Available Online: 14 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).306

Abdulkadir *et al*. optimized the heat treatment and pH of red and white pear cactus [*Opuntia ficus-indica* (l.) mill.] fruit juice using response surface methodology

Meatball model of porcine DNA detection by TaqMan probe real-time PCR

Sajali, N., Ting, S.M.L., Koh, C.C., Desa, M.N.M., Wong, S.C. and Bakar, S.

Available Online: 19 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).384

Sajali *et al*. evaluated the meatball model of porcine DNA detection by TaqMan probe real-time PCR.

Simultaneous determination of nitrite and nitrate in meat and meat products using ion-exchange chromatography

Mazumdar, R.M., Sharif, M., Khan, T.A., Rahman, M.M. and Abdullah A.T.M.

Available Online: 19 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).339

Mazumdat *et al*. performed a simulatenous determination of nitrite in meat and meat products using ion-exchange chromatography.

Prediction of diffusion coefficient for losses of minerals from potato during frying

Samir, Z.T., Saeed, S.K., Mohammed, N.K., and Abdul-Rezzak, R.K.

Available Online: 19 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).382

Samir *et al.* predicted the diffusion coefficient for losses of minerals from potato during frying.

Effects of lyotropic series salts on the functional properties of bambara groundnut (*Voandzeia subterranean*) protein isolate

Lawal, O.S., Sodeinde, K.O., Adediran, A.A., Nishinari, K., Olatunji, O.S., and Ayanda, O.S.

Available Online: 19 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).771

The effects of lyotropic series salts on the functional properties of bambara groundnut (*Voandzeia subterranean*) protein isolate were studied by Lawal *et al.*

Physicochemical properties of post laying hen breast meat thawed using various methods

Dwiloka, B., Setiani, B.E., Pramono Y.B., Prihatiningsih, R., Nurussyifa, S.Y. and Puspitoasih, A.D.

Available Online: 22 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).296

The physicochemical properties of post laying hen breast meat thawed using various methods were studied by Dwiloka *et al.*

Anthropometry indicators that are most related to metabolic profiles in female college students

Dieny, F.F., Rose S., Tsani, A.F.A., Jauharany, F.F. and Fitranti, D.Y.

Available Online: 22 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).250

Dieny *et al.* evaluated the anthropometry indicators that are most related to metabolic profiles in female college students.

Screening of *Lactobacillus rhamnosus*-producing gamma aminobutyric acid (GABA) isolated from Sumbawa mare milk and its potential application to increase GABA content in fermented milk

Nursini, N.W., Antara, N.S., Sugitha, I.M. and Sujaya, I.N.

Available Online: 22 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).380

Nursini *et al.* screened *Lactobacillus rhamnosus*-producing gamma aminobutyric acid (GABA) isolated from Sumbawa mare milk and studied on its potential to increase GABA content in fermented milk.

The effect of rotary drying temperature on drying characteristic and antioxidant activity of *Etlingera elatior* Jack

Simanjuntak, M.E., Ristiarini, S. and Widyawati, P.S.

Available Online: 22 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).333

The effect of rotary drying temperature on the drying characteristics and antioxidant activity of *Etlingera elatior* Jack was studied by Simanjuntak *et al.*

The effect of differences in ozonation time and storage temperature on physical, chemical, and sensory characteristics of Japanese spinach (*Spinacia oleracea* L.)

Prabawa, S., Safitri, D.I., Rofandi, H., Amanto, B. and Yudhistira, B.

Available Online: 26 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).350

Prabawa *et al*. studied the effect of differences in ozonation time and storage temperature on physical, chemical and sensory characteristics of Japanese spinach (*Spinacia oleracea* L.)

Development and acceptability of value-added products from green mussel (*Perna viridis*) in Samar, Philippines

Sorio, J.C. and Arcales, J.A.A.

Available Online: 26 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).320

Sorio and Arcales developed and evaluated the acceptability of value-added products from green mussel (*Perna viridis*) in Samar, Philippines.

Identification and quantification of sodium benzoate in soft drinks available in Tangail region by high-performance liquid chromatography

Esrafil, M., Akter, S., Alam, M.J., Haque, M.A., Zubair, M.A. and Khan, M.S.H

Available Online: 26 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).348

Esrafil *et al*. identified and quantified sodium benzoate in soft drinks available in Tangail region using high-performance liquid chromatography.

Comparison between Polymerase Chain Reaction and Loop Mediated Isothermal Amplification for the detection of *Staphylococcus aureus* in food

Bashar, Q.K., Aziz, A.Z. and Kadhim, N.I.

Available Online: 29 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).335

Bashar *et al*. compared Polymerase Chain Reaction and Loop Mediated Isothermal Amplification for the detection of *Staphylococcus aureus* in food.

Studies on the effect of methionine level on cheese colour as a solid substrate of *Monascus purpureus* JK2 fermentation

Sulandari, L., Utami, T., Hidayat, C. and Rahayu, E.S.

Available Online: 29 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).422

The effect of methionine level on cheese colour as a solid substrate of *Monascus purpureus* JK2 fermentation was study by Sulandari *et al*.

Effectiveness of banana juice (*Musa acuminata* Linn.) on blood pressure, blood sugar levels, and low-density lipoprotein in elderly

Fitri, Y., Suryana, S., Ahmad, A., Hendra, A., Fitrianingsih, E., Arnisam and Yunianto, A.E.

Available Online: 29 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).213

The effectiveness of banana juice (*Musa acuminata* Linn.) on blood pressure, blood sugar levels, and low-density lipoprotein in elderly was studied by Fitri *et al.*

Development and quality evaluation of jelly coated tapai as a cocktail product

Banin, M.M., Azizah, A., Jusni, Farahdina, R., Candra, K.P., Saragih, B. and Yuliani

Available Online: 29 MAY 2022 I https://doi.org/10.26656/fr.2017.6(3).290

Banin *et al.* developed and evaluated the quality of jelly coated tapai as a cocktail product.

Conversion of left-over ice cream into bakery product for food sustainability

Jamaludin, N.S., Baharuddin, A.S., Karim, S., Wakisaka, M. and Rahman, N.A.A.

Available Online: 5 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).410

Jamaludin *et al.* studied on the conversion of left-over ice cream into bakery product for food sustainability.

Simultaneous analysis of patin fish oil (*Pangasius micronemus*) and bandeng (*Chanos chanos*) fish oil using FTIR spectroscopy and chemometrics

Ikhsan, A.N., Irnawati, I. and Rohman, A.

Available Online: 5 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).353

Ikhsan *et al*. performed a simultaneous analysis of patin fish oil (*Pangasius micronemus*) and bandeng (*Chanos chanos*) fish oil using FTIR spectroscopy and chemometrics.

Organoleptic acceptability and nutritional evaluation of innovative *Moringa oleifera* leaves-based herbal teas incorporated various aromatic herbs

Barakat, H.

Available Online: 5 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).411

Barakat studied the organoleptic acceptability and nutritional evaluation of innovative *Moringa oleifera* leaves- based herbal teas incorporated various aromatic herbs.

Optimization of roasting temperature and time of the durian seed (*Durio zibethinus* L.) as coffee substitution and its flavour profile

Natania, K. and Wijaya, E.

Available Online: 5 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).413

Natania and Wijaya optimized of roasting temperature and time of the durian seed (*Durio zibenthinus* L.) as coffee substitution and its flavour profile.

Development of pastilles from flesh and rind of watermelon

Din, S.N., Mubarak, A., Lani, M.N., Yahaya M.Z. and Wan Abdullah, W.Z.

Available Online: 12 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).248

Din *et al*. developed pastilles from flesh and rind of watermelon

The effect of konjac glucomannan and Aloe vera gel concentration on physical and mechanical properties of edible film

Warkoyo, Purnomo, I., Siskawardani, D.D. and Husna, A.

Available Online: 12 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).415

Warkoyo *et al.* evaluated the effect of konjac glucomannan and Aloe vera gel concentration on physical and mechanical properties of edible film.

The effects of adding lysine to sap on chemical characteristics and antioxidant activity of granulated coconut sugar

Haryanti, P. and Sulistyo, S.B.

Available Online: 12 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).420

The effects of adding lysine to sap on chemical characteristics and antioxidant activity of granulated coconut sugar were studied by Haryanti and Sulistyo.

Siam orange (*Citrus nobilis* L.) nectar characteristics with variations in stabilizer and sucrose level

Aini, N., Dwiyanti, H., Setyawati, R., Handayani, I., Septiana, A.T., Sustriawan, B. and Aena, D.A.Q.

Available Online: 16 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).386

Aini *et al.* studied on the Siam orange (*Citrus nobilis* L.) nectar characteristics with variations in stabilizer and sucrose level.

Chemical and microbiological analysis of fermented probiotic watermelon juice

Lani, M.N, MohdMangsor, N.H., Sharifudin, S.A., Abdullah, W.Z.W., MohdIsa, N.S., Jamzuri, M.N.S. and MohdMaidin, N.

Available Online: 16 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).402

The chemical and microbiological analysis of fermented probiotic watermelon juice were studied by Lani *et al.*

Phytochemical content and antioxidant activity of Komba-komba (*Eupatorium odoratum* L)

Sabarudin, Nuralifah, Zubaydah, W.O.S., Sahumena, M.H., Sari, F.N., Nelisa and Yamin

Available Online: 16 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).495

The phytochemical content and antioxidant activity of Komba-komba (*Eupatorim odoratum* L) were evaluated by Sabarudin *et al*.

Effect of operational conditions on physicochemical profiles of spray-dried powder of mango (*Mangifera indica* L.) juice from Tu Quy variety in Vietnam

Pham, T.V., Nguyen, M.T.P., Do, L.V., Truong, M.N., Vo, A.N., Van, K.C. and Le, T.D.

Available Online: 16 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).319

Pham *et al*. studied on the effect of operational conditions on physicochemical profiles of spray-dried powder of mango (*Mangifera indica* L.) juice from Tu Quy variety in Vietnam.

The characterization of Enterobacteriaceae and Pseudomonadaceae isolated from natural salt licks in Sarawak Borneo

Lihan, S., Jalin, F.J.E., Mohd-Azlan, J., Chiew, S.T. and Chai, L.C.

Available Online: 19 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).208

Lihan *et al*. characterized Enterobacteriaceae and Pseudomonadaceae isolated from natural salt licks in Sarawak Borneo.

Cryogenic freezing preserves the quality of whole durian fruit for the export market

Razali, N.A., Wan Ibrahim, W.M., Safari, S., Rosly, N.K., Hamzah, F.A. and Wan Husin, W.M.R.

Available Online: 19 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).428

Razali *et al*. studied on the quality of cryogenic freezing of whole durian fruit for the export market.

Effect of jambu mawar [*Syzygium jambos* (L.) Alston] leaves extract on natural microbial populations in food

Ali, S.K., Son, R., Nor Khaizura, M.A.R. and Rukayadi, Y.

Available Online: 19 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).446

The effect of jambu mawar [*Syzgium jambos* (L.) Alston] leaves extract on the natural microbial populations in food was evaluated by Ali *et al*.

Effects of extraction methods on antioxidants and methoxyflavones of *Kaempferia parviflora*

Chaisuwan, V., Dajanta, K. and Srikaeo, K.

Available Online: 19 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).408

The effects of extraction methods on the antioxidants and methoxyflavones of *Kaempferia parviflora* were studied by Chaisuwan *et al.*

The effect of red guava (*Psidium guajava* L.) juice on pregnant women's hemoglobin level

Olii, N., Sukaisi, Asriah, Kusika, S.Y., Situmorang, C.C., Haumahu, C.M., Tompunuh, M.M. and Zuraidah

Available Online: 26 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).435

The effect of red guava (*Psidium guajava* L.) juice on pregnant women's haemoglobin levels was stuided by Olii et al.

Effect of conventional and ultrasonic-assisted extracts on betacyanin content of red dragon fruit (*Hylocereus polyrhizus*)

Thuy, N.M., Ngoc, P.T.B. and Tai, N.V.

Available Online: 26 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).754

The effect of conventional an ultrasonic-assisted extracts on betacyanin content of red dragon fruit (*Hylocereus polyrhizus*) was studied by Thuy *et al.*

Replacing a part of wheat flour with starchy food containing high levels of resistant starch in noodles processing

Vuong, K.M., Tram, N.B., Tuyen, L.N., Vy, L.T.T., Tai, N.V. and Thuy, N.M.

Available Online: 26 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).1020

Vuong *et al.* evaluated the effects of replacing a part of wheat flour with starchy food containing high levels of resistant starch in noodles processing.

Antioxidant, anti-tyrosinase, and anti-angiogenic activities of dragon fruit (*Hylocereus* spp.)

Cruz, M.M., Reyes, S.B., Angeles, H.G., Del Rosario, J.M., Lirazan, M.B., Estacio, R.C., Corales, L.M. and Dalmacio, L.M.

Available Online: 26 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).400

Cruz *et al*. studied on the antioxidant, anti-tyrosinase, and anti-angiogenic activities of dragon fruit (*Hylocereus* spp.)

Comparative study of nutritional and functional characteristics of pearl millet, buckwheat, amaranth and unripe banana flours for gluten-free bakery products

Rustagi, S., Khan, S. and Jain, T.

Available Online: 30 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).624

Rustagi *et al*. performed a comparative study on the nutritional and functional characteristics of pearl millet, buckwheat, amaranth and unripe banana flours for gluten-free bakery products.

Optimization of enzymatic hydrolysis of boso fish (*Oxyeleotris marmorata*) protein based on the degree of hydrolysis and the physical properties of the resultant hydrolysates

Priatni, S., Ratnaningrum, D., Kosasih, W., Eriska, H., Devi, A.F. and Budiari, S.

Available Online: 30 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).593

Priatni *et al*. optimized the enzymatic hydrolysis of boso fish (*Oxyeleotris marmorata*) protein based on the degree of hydrolysis and the physical properties of the resultant hydrolysates.

Immunonutrition as a potential strategy to prevent and cope with coronavirus disease (COVID-19)

Acevedo-Espinola, R. and Torres-Obregón, S.E.B.

Available Online: 12 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).346

Acevedo-Espinoala and Torres-Obregón studied on immunonutrition as a potential strategy for COVID-19 prevention.

Analysis of amino acids in food using High Performance Liquid Chromatography with derivatization techniques: a review

Lestari, L.A., Rohman, A., Riswahyuli, Purwaningsih, S., Kurniawati, F. and Irnawati

Available Online: 30 JUNE 2022 I https://doi.org/10.26656/fr.2017.6(3).442

Lestari *et al*. reviewed on the analysis of amino acids in food using High Performance Liquid Chromatography (HPLC) with derivatization techniques.

VOL. 6 I ISSUE 2

VOL. 6 I ISSUE 4

Food Research 6 (3) : 306 - 314 (June 2022)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

The effects of adding lysine to sap on chemical characteristics and antioxidant activity of granulated coconut sugar

[1]Haryanti, P. and [2,]*Sulistyo, S.B.

[1]*Food Technology Study Program, Department of Agricultural Technology, Faculty of Agriculture, Jenderal Soedirman University, Purwokerto 53123, Indonesia*

[2]*Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Jenderal Soedirman University, Purwokerto 53123, Indonesia*

Article history:
Received: 12 June 2021
Received in revised form: 24 July 2021
Accepted: 4 November 2021
Available Online: 12 June 2022

Keywords:
Browning intensity,
Chelating activity,
Coconut sap,
Maillard reaction,
Radical scavenging activity

DOI:
https://doi.org/10.26656/fr.2017.6(3).420

Abstract

Reducing sugar and amino acid are chemical features of coconut sap that are critical in the development of the typical colour and flavour of coconut sugar. This study aimed to discover how adding lysine to sap affected the chemical characteristics and antioxidant activity of granulated coconut sugar. The results showed that adding lysine to sap had no considerable influence on water and ash content, total sugar, reducing sugar, sucrose content, free amino acid, or total phenolic content of granulated coconut sugar. The amount of lysine added to coconut sap, on the other hand, had a substantial impact on the browning intensity, radical scavenging, and chelating activities of granulated coconut sugar. The highest radical scavenging activity was obtained in granulated coconut sugar added with 0.5 mM lysine, i.e., 73.96%, while the 0.25 mM of lysine concentration produced sugar with the highest chelating activity i.e., 7.01%.

1. Introduction

Coconut sap is a sweet and lucent liquid with a pH of almost neutral that can be produced by tapping the stem of a coconut flower bloom (Borse *et al*., 2007). Coconut sap contains many sugars as well as vitamins and minerals. Due to the high nutritious content, coconut sap tends to endure spontaneous fermentation. According to Hariharan *et al*. (2014), fermented sap in consequence will contain alcohol and acid liquid due to bacterial activity in the sap. As a result, a variety of natural and synthetic preservatives are routinely used to counteract the detrimental effects of sap fermentation. Haryanti *et al*. (2017) suggested that rather than a single material of the mixture, a blend of mangosteen peel powder and lime could enhance the preservation effect. Furthermore, as a sap preservative, the optimum quantities of mangosteen peel powder and lime in the mixture were 0.56 g/L and 1.7 g/L, respectively. Moreover, the chemical characteristics of coconut sap are altered by the weather. Coconut sap tapped on a sunlit day has superior chemical qualities than sap tapped on a rainy day (Haryanti *et al*, 2018).

Coconut sap is commonly used to make beverages or make coconut sugar. Granulated coconut sugar is one of the products made from coconut sap that has high economic value. Several processes are usually applied to produce granulated coconut sugar. Sap heating is the initial and most critical step of coconut sugar production. The improper procedure of sap heating will lead to the failure of sugar production. Coconut sap becomes thicker during the heating process, and browning commonly exists.

Basically, the browning reaction in food processing might be caused by the Maillard reaction, ascorbic acid oxidation or caramelization. Numerous research has found that during sap heating, the Maillard reaction plays a substantial role in browning, resulting in distinctive coconut sugar characteristics such as flavour, colour, and aroma (Ho *et al*., 2008; Asikin *et al*., 2014). The limy pH and appropriate sap boiling temperature induce the Maillard reaction in sap heating. On the other hand, both ascorbic acid oxidation and caramelization do not exist in coconut sugar processing. These reactions optimally occur in low pH substances. Moreover, caramelization may also occur in alkaline conditions, however, it requires a high heating temperature (higher than 120^{o}C) (Eskin and Shahidi, 2013).

Reducing the sugar and amino acid content of coconut sap affects the strength of the Maillard reaction (Nagai *et al*., 2018). In addition, the Maillard reaction is also influenced by the heating temperature (Carciochi *et*

*Corresponding author.
Email: *susanto.sulistyo@unsoed.ac.id*

eISSN: 2550-2166 /
Published by Rynnye Lyan Resources

al., 2016). Amino groups, free ammonia, and nitrogen atoms can also be made from free amino acids through deamination and retro-aldol reactions (Ho *et al*., 2008). In the meanwhile, monosaccharides like glucose and fructose influence the initial Maillard process by creating a large pool of high-reactive C2, C3, and C4 dicarbonyl molecules.

In the Maillard reaction, amino acids and reducing sugar play an important role in the production of food colour, flavour, and antioxidants (Wijewickreme *et al*., 1999). Moreover, Kim (2013) found antioxidant activity in Maillard reaction products (MRPs) since MRPs can operate as metal chelators and radical scavengers. MRPs generated from chitooligosaccharide and glycine model systems also demonstrated excellent antioxidant activity, according to Yan *et al*. (2018). Karseno *et al*. (2018) discovered that DPPH radical scavenging activity and browning intensity have a strong correlation as indicated by the coefficient of correlation of 0.93. Furthermore, Maillard reaction duration and temperature affect browning intensity as well as fragrance components (Zhou *et al*., 2016).

The addition of lysine can increase the generation of basic amino groups. The 2.3-enolization track will yield intermediate products from the Maillard reaction, which occurs at a pH greater than 7. As a result of this action, a reductone chemical with antioxidant properties is formed. Additionally, the addition of 0.75 mM lysine to coconut sap and a heating temperature of 118°C not only resulted in a considerable increase in total phenolic content but also in radical scavenging activity in the sap (Sulistyo and Haryanti, 2020).

During the boiling of the sap, the Maillard reaction occurs, producing MRPs (such as reductones) and melanoidin, both of which include phenolic groups (Brudzynski and Miotto, 2011). Melanoidin is a brown polymeric macromolecule made up of carbohydrate and nitrogen-based polymeric macromolecules that are generated in the final step of the Maillard reaction. Thus, quantifying browning intensity via spectral absorbance at 405 nm can be used to quantify melanoidin amount (Bekedam *et al*., 2006). However, the mechanism of melanoidin synthesis in the processing of granulated coconut sugar remains unknown. The most logical method for determining such a mechanism is to measure the chemical characteristics and antioxidant activity of granulated coconut sugar. As a result, the current study delved into the chemical characteristics and antioxidant activity of granulated coconut sugar made from sap with varied lysine concentrations.

2. Materials and methods

2.1 Materials

Materials used in this research, in general, were divided into two categories, i.e. raw material and chemical. Coconut sap was collected from coconut trees in Banyumas Regency, Indonesia, as the raw ingredient. A number of chemical substances were utilized to analyze the chemical properties and antioxidant activities of coconut sap and granulated coconut sugar. The chemicals were obtained from Merck (Darmstadt, Germany), i.e. potassium hydrogen tartrate, phenol, sodium sulfite, sodium hydroxide, hydrochloric acid, D-glucose, ninhydrin, dipotassium hydrogen phosphate, potassium dihydrogen phosphate, stannous chloride, L-glutamic acid, ethanol, Folin-Ciocalteu, sodium carbonate, ammonium thiocyanate, ferrous chloride and hydrochloric acid. In addition, a chemical namely ferrozine was obtained from Fluka Chemical. Co. (Buchs, Switzerland) while 3,5-dinitrosalicylic acid and 2,2-diphenyl-1-picrylhydrazyl were from Sigma Chemical Co. (St. Louis, MO, USA).

2.2 Coconut sap preparation

First, plastic containers for sap collecting were prepared. A blend of mangosteen peel powder and lime with concentrations of 0.56 g/L and 1.7 g/L, respectively, was put as the natural preservative into the containers to avoid spontaneous fermentation in sap. After that, coconut sap was collected by tapping coconut inflorescence from 15 coconut trees into the containers. Sap tapping took place during the day, from 6 a.m. to 3 p.m., in pleasant weather with air temperature and relative humidity ranging from 24-27°C and 91%-92%, respectively.

2.3 Chemical analysis of coconut sap

2.3.1 Total soluble solid and pH value

After sap collection, the total soluble solids and pH value of the collected sap were immediately measured using a portable refractometer and pH meter, respectively.

2.3.2 Reducing sugar

To determine reducing sugar, we employed the procedure introduced by Miller (1959) with some small modifications. Firstly, one gram of sap sample was dissolved in 5 mL of distilled water. The sap (3 mL) were then mixed with 3 mL of 1% 3,5-Dinitrosalicylic acid in a test tube. The mixture was afterwards heated in a water bath for 15 mins and the heating temperature was maintained at 90°C. An aliquot (1 mL) of 40% potassium tartrate was then added to stabilize the mixture colour. After 15 mins of heating, the mixture was cooled at room temperature for around 5 mins. The next step was the measurement of spectrum absorbance. Spectrum absorbance of the mixture was determined at a wavelength of 540 nm and to quantify samples a standard glucose solution was utilized.

2.3.3 Free amino acid

Determination of free amino acid of coconut sap was adopted from Yao's procedure (Yao *et al*., 2006). One gram of coconut sap was firstly poured into a volumetric flask and then buffer solution and ninhydrin solution, with the volume of each solution was 0.5 mL, were subsequently added. The mixture in the flask was then heated in a boiling water bath for 15 mins. Subsequently, the flask was cooled at room temperature for 5 mins and 25 mL of distilled water was filled into the flask. Afterwards, the next step was measuring the spectrum absorbance of the solution at a wavelength of 570 nm using a UV-1900 UV-VIS spectrophotometer (Shimadzu; Kyoto, Japan). To quantify the samples we utilized glutamic acid as the standard.

2.3.4 Total phenolic

To evaluate the total phenolic content of the coconut sap, we used the Folin-Ciocalteu technique (Payet *et al*., 2005). The steps were as follows: A volume of 30 µL of sap sample was placed in a test tube, and then 150 µL of Folin-Ciocalteu reagent with a 10% concentration was added. After that, the admixture which was incubated for 8 mins was given a dose of 120 µL Na_2CO_3 dissolved in distilled water at a concentration of 7.5%. This mixture was then treated for a second incubation at 30°C for 1 hr, and the spectrum absorption at 765 nm was then determined. Furthermore, the blank was evaluated by substituting a suitable solvent for the sap sample and subtracting the spectrum absorbance at the same wavelength. Lastly, the result was represented in milligrams of gallic acid equivalent per 100 gram of sample (mg GAE/100 g of sample) as the standard phenolic substance.

2.4 Granulated coconut sugar processing

To begin, 10 L of coconut sap were cleansed by the use of clean filter cloths. After that, the sap was separated into four parts once it was purified. The first sap component was left untreated and served as a treatment control, whilst the second, third, and fourth sap portions were all given lysine at different concentrations, 0.25, 0.5, and 0.75 mM, respectively. After that, each sap part was poured into an aluminium pan and heated on a gas stove. During heating, the sap should be continuously stirred, and when the temperature reaches 118°C, the heating should be turned off. After roughly 50 minutes of heating, this condition can be achieved. The sap was then cooled to room temperature while still being agitated. This process persisted until granulated sugar was formed. In the next step, we performed sun-drying to reduce the water content of the produced granulated sugar. The chemical characteristics and antioxidant activity of 50 g of granulated sugar generated were then tested. The analysis was carried out as detailed in the subsection below.

2.5 Chemical analysis and antioxidant activities of granulated coconut sugar

2.5.1 Water and ash content

Water and ash content were both determined according to the AOAC method (AOAC, 1990). The thermo-gravimetric method was applied to measure the water content of granulated coconut sugar while ash content was measured by oxidizing organic compounds at high temperatures (500-600°C) and than weighing the residual matters after the combustion.

2.5.2 Reducing sugar, total sugar and sucrose content

To determine the reduction sugar of granulated coconut sugar, we employed a similar procedure as in determining reducing sugar of coconut sap. In this step, 1 g of granulated coconut sugar was dissolved in 10 mL, instead of 5 mL, of distilled water. The next steps were then the same as that in reducing sugar analysis of coconut sap. In the meanwhile, hydrolysis method was applied to determine total sugar content. A volume of 3 mL of 25% HCl was utilized to incubate the sample. The incubation process was performed for 10 mins at a temperature of 70°C. Afterwards, the solution was cooled and neutralized at room temperature with 45% NaOH. Finally, the content of sucrose was ascertained by subtracting reducing sugar from total sugar content.

2.5.3 Free amino acid

The free amino acid of granulated coconut sugar was determined by using a similar procedure as in analyzing the free amino acid of coconut sap. Firstly, 1 g of granulated coconut sugar was added with distilled water until the volume reached 10 mL and then filtered with filtered paper. A volume of 0.5 mL of filtrate was put into a volumetric flask and then the next procedure was the same as that described in determining the free amino acid of coconut sap.

2.5.4 Total phenolic

The total phenolic content of granulated coconut sugar was analyzed using the Folin-Ciocalteu procedure as conducted to determine the total phenolic of coconut sap. The first step was the preparation of a 10% sugar solution and then filtering. A volume of 30 µL of the sugar solution was subsequently treated as a sample. The succeeding steps were then the same as described in the aforementioned procedure of total phenolic analysis of coconut sap.

2.5.5 Browning intensity

The browning colour of coconut sugar samples was determined by slightly modifying the procedure developed by Ajandouz *et al*. (2001). The sap sample was liquefied with distilled water (1:25 w/v), and then centrifuged at 1006×*g* for 15 mins. The spectrum absorbance of the sugar browning was measured using a UV-1900 UV-VIS spectrophotometer (Shimadzu; Kyoto, Japan) at 420 nm.

2.5.6 Radical scavenging activity

To determine the radical scavenging activity (RSA) of coconut sugar, we employed the procedure established by Payet *et al*. (2005). DPPH• methanolic solution with a concentration of 0.1 mM and volume of 280 µL was delivered into a test tube using a pipette and subsequently mixed with a sugar sample. In the meanwhile, the solution in the test tube was mixed with solvent for the blank. Both mixtures were then incubated for 30 mins at room temperature. The spectrum absorbance of the mixtures at a wavelength of 515 nm was then analysed employing a spectrophotometer. Lastly, the antioxidant activity of the granulated coconut sugar can be defined as the percentage of radical scavenging activity according to the following equation:

$$\text{RSA}(\%) = \frac{Ao - As}{Ao} \times 100 \quad (1)$$

where Ao and As are the spectrum absorbance of the blank and the sample, respectively, at 515 nm. The effectiveness of antioxidant activity of the coconut sugar sample according to DPPH radical scavenging was compared with butylated hydroxytoluene (BHT).

2.5.7 Chelating activity

Kim's approach was used to determine the chelating activity of granulated sugar, which is defined as the sugar's ability to chelate metal ions Fe^{2+} (Kim, 2013). A one-gram sample of granulated sugar was diluted before being filtered with filter paper. The sugar solution was then combined with 600 µL of distilled water and 100 µL of 0.2 mM $FeCl_2.4H_2O$ in a volume of 100 µL. The control solution was made by mixing 100 µL of distilled water with 200 µL of 1 mM ferrozine. After 10 mins of cooling at room temperature, the colour changes of the combination were monitored using a UV-1900 UV-VIS spectrophotometer (Shimadzu; Kyoto, Japan) at a spectral wavelength of 562 nm. Following that, the chelating activity was calculated using the following equation:

$$\text{Chelating activity}(\%) = \frac{Ao - As}{Ao} \times 100 \quad (2)$$

where Ao and As are the spectrum absorbance of the control and the sample solutions, respectively, at 562 nm after 10 mins of incubation. The effectiveness of the coconut sugar sample as a chelating agent was compared with ethylenediaminetetraacetic acid (EDTA).

2.5.8 Spectroscopic analysis

To investigate the spectroscopic features of sugar solutions, absorption spectra ranging from 200 nm to 700 nm were used. To begin, 250 mg granulated coconut sugar was dissolved in 10 mL of demineralized water. Prior to taking the measurements, each solution had to be prepared. The UV-1900 UV-VIS spectrophotometer (Shimadzu; Kyoto, Japan) was used to record the absorption spectra (Bekedam *et al*., 2006).

2.6 Statistical analysis

All chemical characteristics and antioxidant activity data were statistically analyzed with IBM SPSS Statistic 20 and represented as mean standard deviation (SD). P<0.05 was used to determine statistical significance. One-way analysis of variance (ANOVA) with Duncan's multiple range test with a significance level of P < 0.05 was used to assess the influence of variation in the added lysine concentration.

3. Results and discussion

3.1 Chemical properties of coconut sap

The chemical properties of coconut sap measured prior to granulated coconut sugar processing are described in Table 1. Coconut sap should have some requirements to be used for further processing into coconut sugar. The requirements are as following: pH higher than 7.2, total soluble solids around 15.1°Bx and reducing sugar lower than 0.48% (Haryanti *et al*., 2017). As seen in Table 1, the sap sample used in this research was suitable as a raw material of granulated coconut sugar since its chemical properties meet the aforementioned requirements.

Table 1. The chemical properties of coconut sap

No.	Chemical properties	Content
1	Total soluble solid (°Bx)	13.5±1.73
2	The pH value	8.6±0.23
3	Reducing sugar (%)	0.14±0.03
4	Amino acid (%)	0.27±0.14
5	Total phenolic content (mg GAE/100 g)	53.37±5.04

3.2 Chemical properties and antioxidant activities of granulated coconut sugar

The effects of different concentrations of lysine on the water and ash content, reducing sugar, total sugar, sucrose content, free amino acid content, and total phenolic content of granulated coconut sugar were not significant. The addition of lysine, on the other hand, had a substantial impact on browning intensity, radical scavenging, and chelating activity.

3.2.1 Water and ash content

Figure 1 shows the water and ash content of granulated coconut sugar made with various concentrations of lysine added to coconut sap. In addition, the water and ash content of granulated coconut sugar varied between 5.94 and 6.57% and 2.17 and 2.30%, respectively.

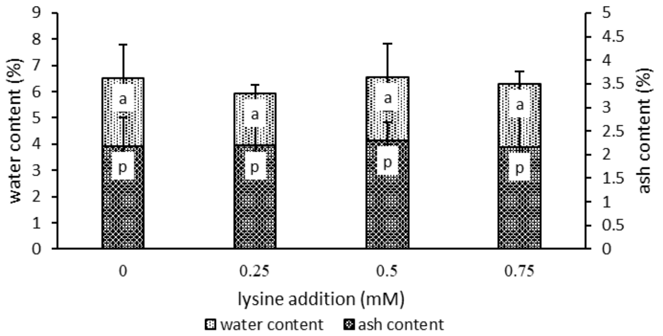


Figure 1. Water content and ash content of granulated coconut sugar. The results are represented in term of mean±SD from six experiments. Bars carrying same letters at the same parameter indicate mean values have no significant difference at P > 0.05.

3.2.2 Reducing sugar, total sugar and sucrose content

The reducing sugar, as well as total sugar and sucrose content of granulated coconut sugar applied with different lysine concentrations on coconut sap, ranged from 2.93 to 3.07% db, 90.21 to 94.37% db, and 87.24 to 91.30% db, respectively. The sugar content of the granulated coconut sugar is depicted in Figure 2.

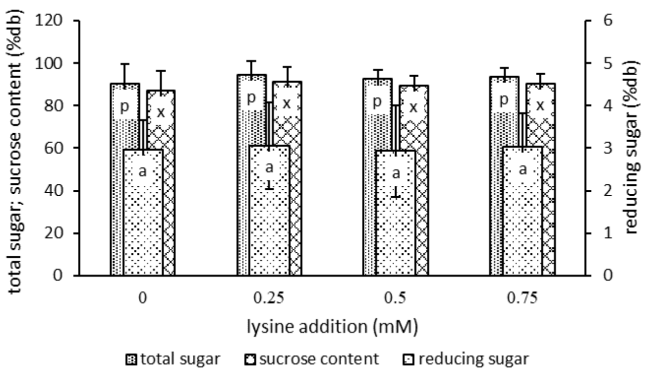


Figure 2. Reducing sugar, total sugar and sucrose content of granulated coconut sugar. The results are represented in term of mean±SD from six experiments. Bars carrying same letters at the same parameter indicate mean values have no significant difference at P > 0.05.

Reducing sugar of coconut sap was lower than that of granulated coconut sugar, i.e. 0.14±0.03% or 1.21±0.19% db. It decreased at the beginning of heating in liquid form, then increased at the end of heating and turned into granulated form. The decrease in reducing sugar of sap at the initial heating was due to the occurrence of the initial Maillard reaction. According to Ho *et al*. (2008), reducing sugar such as glucose and fructose was highly reactive at the initial stage of the heating process. Both glucose and fructose participated in the initial Maillard reaction by creating dicarbonyl compounds. The increment of reducing sugar at the end of heating and in the granulated form was caused by the forming of intermediate products of Maillard reaction bounded ketone or hydroxyl groups, which are highly reactive. Rufian-Henares and De La Cueva (2009) found that intermediate products of the Maillard reaction such as pyranone or pyridone residues contained the ketone or hydroxyl groups.

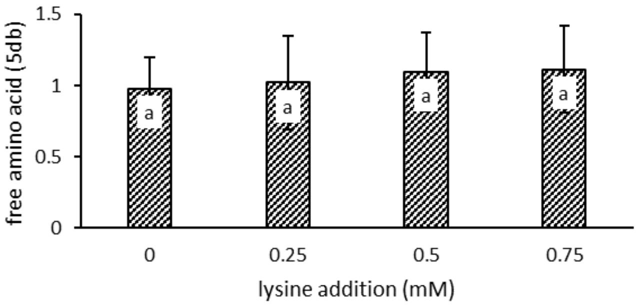


Figure 3. Free amino acid content of granulated coconut sugar. The results are represented in term of mean±SD from six experiments. Bars carrying same letters at the same parameter indicate mean values have no significant difference at P > 0.05.

3.2.3 Total free amino acid

As shown in Figure 3, the amount of lysine added to the sap had no effect on the free amino acid content of granulated coconut sugar (P > 0.05). The free amino acid of granulated coconut sugar measured in this research ranged from 0.98 – 1.11% db. As it possesses two reactive groups, lysine is the most reactive amino acid in the Maillard reaction. In addition, lysine contains nitrogen atoms which affect the pyrazine formation (Ho *et al*., 2008). Pyrazine is a flavoured compound, so lysine addition may have a significant effect on pyrazine content (Eskin and Shahidi, 2013), but not on the amino acid content of granulated coconut sugar.

The amino acid of granulated sugar was higher than that of coconut sap, i.e. 0.27±0.14% or 2.3±1.12%db. The increase in total free amino acids was attributable to the formation of additional compounds during the heating process. Amino acids, such as ammonia, were identified as this substance. According to Ho *et al*.

(2008), free ammonia was created at the start of the heat reaction in palm sugar production. Melanoidin, which is generated during the boiling of coconut sap, is a nitrogen-based polymeric macromolecule that may be identified as an amino acid (Brudzynski and Miotto, 2011).

3.2.4 Total phenolic content and browning intensity

With a range of 0.94 - 1.22% db, the total phenolic content of granulated coconut sugar applied with varying concentrations of lysine on sap was not significantly different (Figure 4). Coconut sap has a total phenolic concentration of 53.37±5.04 mg GAE/100 g, or 0.46±0.07% db. Since the MRPs and melanoidin were generated during the heating process, total phenolic content increased more than twofold from coconut sap to granulated sugar. After thermal heating, the natural phenolic compound in coconut sap diminished. This finding is confirmed by Wiriyawattana *et al*. (2018), who found that thermal heating at temperatures higher than 110^{o}C can reduce the phenolic content of rice berry flour. In this step, however, the amount of melanoidin increased. Indeed, an increase in melanoidin was the most common cause of an increase in phenolic content in coconut sugar. Melanoidin and MRPs both include phenolic groups, which are formed during the heating process (Delgado-Andrade *et al*., 2005; Brudzynski and Miotto, 2011).

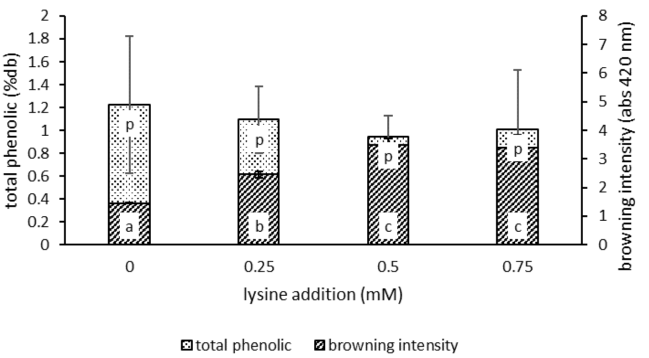


Figure 4. Total phenolic content and browning intensity of granulated coconut sugar. The results are represented in term of mean±SD from six experiments. Bars carrying same letters at the same parameter indicate mean values have no significant difference at P > 0.05.

Browning intensities of sugar generated from sap varied greatly depending on the lysine concentration. The dark hue of granulated coconut sugar increased as the lysine concentration increased. The addition of 0.5 mM of lysine increased the brown colour intensity of the granular coconut sugar. This treatment caused the most intense browning of granulated sugar, up to 42 times that of the initial phase. Furthermore, Sulistyo and Haryanti (2020) found that the changes in sap browning intensity during heating followed an exponential curve. Higher lysine concentrations, on the other hand, did not affect the browning intensity of sugar. The addition of more than 0.5 mM of lysine to sap may result in a lower pH, which may suppress the browning Maillard reaction. Maillard process is often encouraged under higher alkaline circumstances, according to Eskin and Shahidi (2013). Coconut sap's neutral and alkaline pH provided an ideal environment for accelerating C2 and C3 fragments from sugar breakdown, which have high reactivity. The sugar breakdown products were then polymerized and linked by amino compounds to form melanoidin, a brown-coloured substance (Ho *et al*., 2008).

3.2.5 Radical scavenging activity and chelating activity

Figure 5 shows the radical scavenging activity (RSA) and chelating activity of granulated coconut sugar applied to sap with varying lysine concentrations. Granulated coconut sugar made from coconut sap and supplemented with 0.5 mM lysine had a substantially higher RSA (73.96%) than granulated coconut sugar made without lysine (67.45%). The RSA of 10% granulated coconut sugar solution added with 0.5 mM lysine was similar to the RSA of 100 ppm BHT i.e. 74.95%. Lysine is the polar charged side chain of amino acid which might play role in the Maillard reaction by providing nitrogen atom sources (Ho *et al*., 2008). Because of its two reactive amino groups, lysine basic characteristics have a higher activity during the Maillard reaction. According to Delgado-Andrade and Rufian-Henares (2009) and Eskin and Shahidi (2013), lysine contains free amino groups (e-amino) that participate in the Maillard reaction. The Maillard reaction products (MRPs) produced by heating a lactose-lysine model system at 100°C for 8.5 mins have an RSA of 50% (Morales and Jimenez-Perez, 2001). Furthermore, Wiriyawattana *et al*. (2018) discovered that 110^{o}C was the best temperature for producing pregelatinized riceberry flour with the maximum antioxidant activity. Another study by Boonmawat *et al*. (2019) found that heating riceberry bran in superheated steam at a very high temperature did not affect antioxidant activity. Furthermore, compared to other treatments, the addition of 0.5 mM lysine resulted in granulated sugar with a higher browning intensity. The RSA was likewise higher with the granular coconut sugar that had a higher browning intensity. According to Karseno *et al*. (2018), there was a strong link between DPPH radical scavenging activity and browning intensity.

As this treatment also boosted the chelating activity of coconut sap after heating, the chelating activity of sugar obtained from coconut sap combined with 0.25 mM of lysine (7.01%) was much higher than that of other treatments. The addition of a high concentration of lysine raised the concentration of amino groups, which altered the production of pyrazine, a volatile molecule. However, an increase in pyrazine production, which is controlled by nitrogen atoms in lysine, did not result in an increase in granulated coconut sugar chelating ability. As a result, adding more than 0.25 mM of lysine to granulated coconut sugar had no influence on its chelating ability.

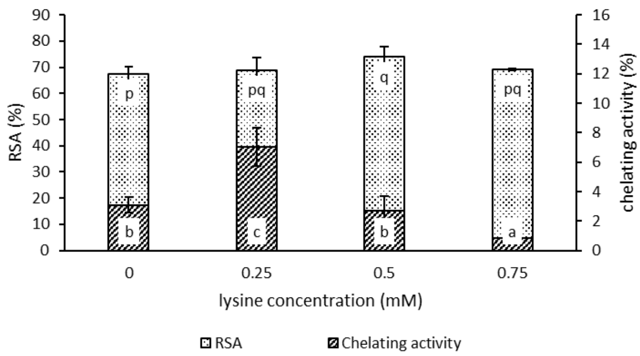


Figure 5. Radical scavenging activity and chelating activity of granulated coconut sugar. The results are represented in term of mean±SD from six experiments. Bars carrying same letters at the same parameter indicate mean values have no significant difference at P > 0.05.

As a comparison, the chelating ability of granulated coconut sugar was much lower than that of ethylenediaminetetraacetic acid (EDTA). The chelating activity of 10% granulated coconut sugar was 7.01%, while 20 ppm EDTA produced a chelating activity of 61.79%. The final stage of the Maillard reaction, melanoidin, may be responsible for the chelating activity of granulated coconut sugar. MRPs have chelating action, according to Delgado-Andrade *et al.* (2004). Furthermore, MRPs ion chelating affinity is crucial to the antioxidant action mechanism (Jing and Kitts, 2004). Melanoidin's chelating activity, according to Verzelloni *et al.* (2010), may help to avoid oxidation. Melanoidin was shown to possess an anionic molecule capable of chelating metal transitions (Daglia *et al.*, 2008; Rufian-Henares and De La Cueva, 2009; Tagliazucchi *et al.*, 2010).

3.2.6 Spectroscopic analysis

Figure 6 shows the absorption spectra of granulated coconut sugar applied with varied concentrations of lysine on sap. As seen in Figure 6, the graph has two peaks, one at 264.5-268.5 nm and the other at 401.5 nm. Proteins, sucrose, reducing sugar, and MRPs like reductone are all detected at wavelengths between 264.5 and 268.5 nm. Meanwhile, the presence of melanoidin is indicated by a peak at a wavelength of 401.5 nm. According to Bekedam *et al.* (2006), a low molecular weight coffee molecule can absorb light at 280 nm, while melanoidin has a 405 nm absorption spectrum. The absorption at wavelengths of 264.5-268.5 and 401.5 nm has been proven to estimate the relative amount of melanoidin and other components in granulated coconut sugar based on these absorption spectra. In comparison to melanoidin (abs value at 401.5 nm = 0.287-0.303), granulated coconut sugar generated from coconut sap combined with all lysine concentrations is dominated by the chemical that absorbs light at 264.5-268.5 nm (abs value = 1.193-1.426).

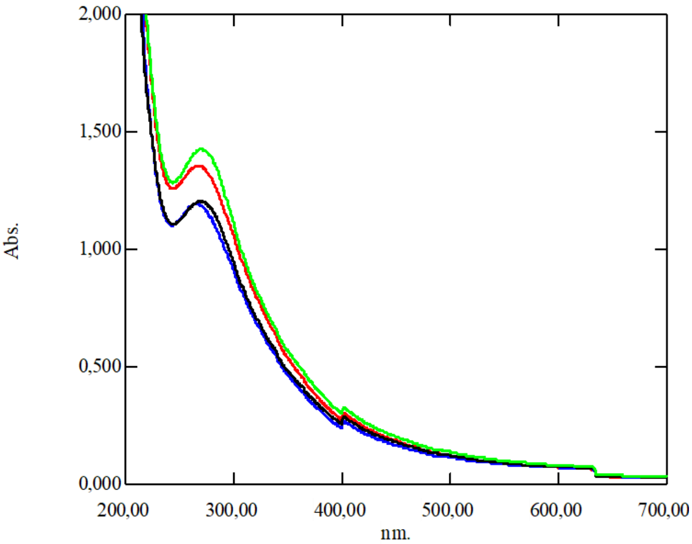


Figure 6. Absorption spectra of 25 mg/mL granulated coconut sugar produced added with 0 (black line); 0.25 (red line); 0.5 (blue line) and 0.75 mM (green line) lysine on sap.

The current study findings confirmed that increasing lysine concentration did not affect granulated coconut sugar's water and ash content, decreasing sugar, total sugar, sucrose content, free amino acid, or total phenolic content. Furthermore, the amount of lysine added to coconut sap has a substantial impact on granulated coconut sugar browning intensity, RSA, and chelating activity. The findings of this study can be used as a starting point for future research into the possibilities of adding amino acids to granulated coconut sugar to improve its health benefits.

Conflict of interest

The authors declare that there are no conflicts of interest.

Acknowledgements

This work was financially supported by the Indonesia Ministry of Research, Technology and Higher Education through Fundamental Research Grant in 2019.

References

Ajandouz, E.H., Tchiakpe, L.S., Ore, F.D., Benajiba, A. and Puigserver, A. (2001). Effects of pH on caramelization and Maillard reaction kinetics in fructose-lysine model systems. *Journal of Food Science*, 66(7), 926-931. https://doi.org/10.1111/j.1365-2621.2001.tb08213.x

AOAC. (1990). Official methods of analysis. 15th ed. Vol. 1. Virginia, USA: Association of Official Analytical Chemists.

Asikin, Y., Kamiya, A., Mizu, M., Takara, K., Tamaki, H. and Wada, K. (2014). Changes in the physicochemical characteristics, including flavour components and Maillard reaction products, of non-centrifugal cane brown sugar during storage. *Food Chemistry*, 149, 170-177. https://doi.org/10.1016/j.foodchem.2013.10.089

Bekedam, E.K., Schols, H.A., Van Boekel, M.A. and Smit, G. (2006). High molecular weight melanoidins from coffee brew. *Journal of Agricultural and Food Chemistry*, 54(20), 7658-7666. https://doi.org/10.1021/jf0615449

Boonmawat, S., Ratphitagsanti, W. and Haruthaitanasan, V. (2019). Effect of superheated steam heating on quality and antioxidant activities of riceberry bran. *Agriculture and Natural Resources*, 53(2), 130–138.

Borse, B.B., Rao, L.J.M., Ramalakshmi, K. and Raghavan, B. (2007). Chemical composition of volatiles from coconut sap (neera) and effect of processing. *Food Chemistry*, 101(3), 877-880. https://doi.org/10.1016/j.foodchem.2006.02.026

Brudzynski, K. and Miotto, D. (2011). The relationship between the content of Maillard reaction-like products and bioactivity of Canadian honeys. *Food Chemistry*, 124(3), 869–874. https://doi.org/10.1016/j.foodchem.2010.07.009

Carciochi, R.A., Dimitrov, K. and D´Alessandro, L.G. (2016). Effect of malting conditions on phenolic content, Maillard reaction products formation, and antioxidant activity of quinoa seeds. *Journal of Food Science and Technology*, 53(11), 3978-3985. https://doi.org/10.1007/s13197-016-2393-7

Daglia, M., Papetti, A., Aceti, C., Sordelli, B., Gregotti, C. and Gazzani, G. (2008). Isolation of high molecular weight components and contribution to the protective activity of coffee against lipid peroxidation in a rat liver microsome system. *Journal of Agricultural and Food Chemistry*, 56(24), 11653-11660. https://doi.org/10.1021/jf802018c

Delgado-Andrade, C., Rufian-Henares, J.A. and Morales, F.J. (2005). Assessing the antioxidant activity of melanoidins from coffee brews by different antioxidant methods. *Journal of Agricultural and Food Chemistry*, 53(20), 7832–7836. https://doi.org/10.1021/jf0512353

Delgado-Andrade, C. and Rufian-Henares, J. (2009). Assessing the Generation and Bioactivity of Neo-Formed Compounds in Thermally Treated Food. Granada, Spain: Editorial Atrio.

Delgado-Andrade, C., Seiquer, I., Nieto, R. and Navarro, M.P. (2004). Effects of heated glucose–lysine and glucose–methionine model-systems on mineral solubility. *Food Chemistry*, 87(3), 329-337. https://doi.org/10.1016/j.foodchem.2003.12.002

Eskin, N.A.M. and Shahidi, F. (2013). Biochemistry of Foods. 3rd ed. Oxford, United Kingdom: Academic Press.

Hariharan, B., Singaravadivel, K. and Alagusundaram, K. (2014). Effect of food grade preservatives on the physicochemical and microbiological properties of coconut toddy during fermentation. *Journal of Nutrition and Food Sciences*, 4(5), 1000299. https://doi.org/10.4172/2155-9600.1000299

Haryanti, P., Supriyadi, Marseno, D.W. and Santoso, U. (2017). Chemical properties of coconut sap obtained at different tapping time and addition of preservatives. *International Journal of Science and Technoledge*, 5(3), 52-59.

Haryanti, P., Supriyadi, Marseno, D.W. and Santoso, U. (2018). Effects of different weather conditions and addition of mangosteen peel powder on chemical properties and antioxidant activity of coconut sap. *Agritech*, 38(3), 295-303. https://doi.org/10.22146/agritech.29844

Ho, C.W., Wan Aida, W.M., Maskat, M.Y. and Osman, H. (2008). Effect of thermal processing of palm sap on the physicochemical composition of traditional sugar. *Pakistan Journal of Biological Sciences*, 1(7), 989-995. https://doi.org/10.3923/pjbs.2008.989.995

Jing, H. and Kitts, D.D. (2004). Antioxidant activity of sugar-lysine Maillard reaction products in cell free and cell culture systems. *Archives of Biochemistry and Biophysics*, 429(2), 154-163. https://doi.org/10.1016/j.abb.2004.06.019

Karseno, Erminawati, Yanto, T., Setyowati, R. and Haryanti, P. (2018). Effect of pH and temperature on browning intensity of coconut sugar and its antioxidant activity. *Food Research*, 2(1), 32-38. https://doi.org/10.26656/fr.2017.2(1).175

Kim, J. (2013). Antioxidant activity of Maillard reaction products derived from aqueous and ethanolic glucose-glycine and its oligomer solutions. *Food Science and Biotechnology*, 22(1), 39-46. https://doi.org/10.1007/s10068-013-0006-z

Miller, G.L. (1959). Use of dinitrosalicylic acid reagent for determination of reducing sugar. *Analytical Chemistry*, 31(3), 426-428. https://doi.org/10.1021/ac60147a030

Morales, F.J. and Jimenez-Perez, S. (2001). Free radical scavenging capacity of Maillard reaction products as related to color and fluorescence. *Food Chemistry*, 72(1), 119-125. https://doi.org/10.1016/S0308-8146(00)00239-9

Nagai, T., Kai, N., Tanoue, Y. and Suzuki, N. (2018). Chemical properties of commercially available honey species and the functional properties of caramelization and Maillard reaction products derived from these honey species. *Journal of Food Science and Technology*, 55(2), 586-597. https://doi.org/10.1007/s13197-017-2968-y

Payet, B., Sing, A.S.C. and Smadja, J. (2005). Assessment of antioxidant activity of cane brown sugars by ABTS and DPPH radical scavenging assays: determination of their polyphenolic and volatile constituents. *Journal of Agricultural and Food Chemistry*, 53(26), 10074-10079. https://doi.org/10.1021/jf0517703

Rufian-Henares, J.A. and De La Cueva, S.P. (2009). Antimicrobial activity of coffee melanoidins—a study of their metal-chelating properties. *Journal of Agricultural and Food Chemistry*, 57(2), 432-438. https://doi.org/10.1021/jf8027842

Sulistyo, S.B. and Haryanti, P. (2020). Regression analysis for determination of antioxidant activity of coconut sap under various heating temperature and concentration of lysine addition. *Food Research*, 4 (4), 976-981. https://doi.org/10.26656/fr.2017.4(4).410

Tagliazucchi, D., Verzelloni, E. and Conte, A. (2010). Effect of dietary melanoidins on lipid peroxidation during simulated gastric digestion: their possible role in the prevention of oxidative damage. *Journal of Agricultural and Food Chemistry*, 58(4), 2513-2519. https://doi.org/10.1021/jf903701h

Verzelloni, E., Tagliazucchi, D. and Conte, A. (2010). From balsamic to healthy: traditional balsamic vinegar melanoidins inhibit lipid peroxidation during simulated gastric digestion of meat. *Food and Chemical Toxicology*, 48(8-9), 2097-2102. https://doi.org/10.1016/j.fct.2010.05.010

Wijewickreme, A.N., Krejpcio, Z. and Kitts, D.D. (1999). Hydroxyl scavenging activity of glucose, fructose, and ribose-lysine model Maillard Products. *Journal of Food Science*, 64(3), 457-461. https://doi.org/10.1111/j.1365-2621.1999.tb15062.x

Wiriyawattana, P., Suwonsichon, S. and Suwonsichon, T. (2018). Effects of drum drying on physical and antioxidant properties of riceberry flour. *Agriculture and Natural Resources*, 52(5), 445-450. https://doi.org/10.1016/j.anres.2018.11.008

Yan, F., Yu, X. and Jing, Y. (2018). Optimized preparation, characterization, and antioxidant activity of chitooligosaccharide–glycine Maillard reaction products. *Journal of Food Science and Technology*, 55(2), 712-720. https://doi.org/10.1007/s13197-017-2982-0

Yao, L., Liu, X., Jiang, Y., Caffin, N., D'Arcy, B., Singanusong, R., Datta, N. and Xu, Y. (2006). Compositional analysis of teas from Australian supermarkets. *Food Chemistry*, 94(1), 115-122. https://doi.org/10.1016/j.foodchem.2004.11.009

Zhou, Y., Li, Y. and and Yu, A. (2016). The effects of reactants ratios, reaction temperatures and times on Maillard reaction products of the L-ascorbic acid/L-glutamic acid system. *Food Science and Technology*, 36(2), 268-274. https://doi.org/10.1590/1678-457X.02415

Food Research

COUNTRY

Malaysia

Universities and research institutions in Malaysia

Media Ranking in Malaysia

SUBJECT AREA AND CATEGORY

Agricultural and Biological Sciences
Food Science

PUBLISHER

H-INDEX

10

PUBLICATION TYPE

Journals

ISSN

25502166

COVERAGE

2017-2021

INFORMATION

Homepage

How to publish in this journal

foodresearch.my@outlook.com

SCOPE

Food Research welcomes submissions that are relevant to food science and technology, food service management, nutrition, nutraceuticals, food innovation and agriculture food science. Manuscript types accepted are reviews, short reviews, original research articles and short communications that discusses on the current research and scientific views of the following scope: Food science and food chemistry; Food technology, food processing, and food engineering; Food safety and quality – microbiological and chemical; Sensory, habits, consumer behaviour/practice and preference; Nutrition and dietetics; Nutraceuticals and functional food/ingredients; Food service management; Food trends, innovation and business; Post-harvest and agribusiness; Food security; Food packaging.

Join the conversation about this journal

Quartiles

FIND SIMILAR JOURNALS

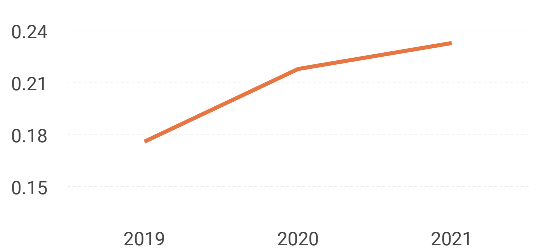
1
International Food Research Journal
MYS
89%
similarity

2
Food Science and Nutrition
GBR
82%
similarity

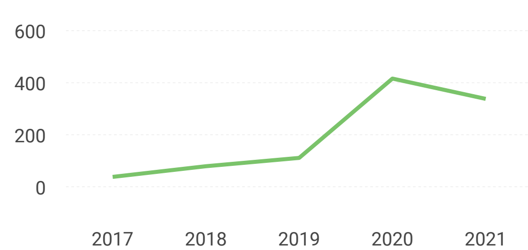
3
Carpathian Journal of Food Science and Technology
ROU
79%
similarity

4
International Jou Science
EGY
79
simila

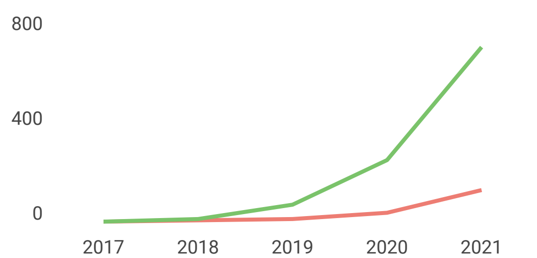
SJR



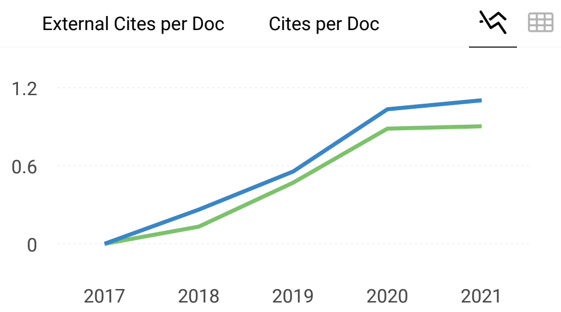
Total Documents

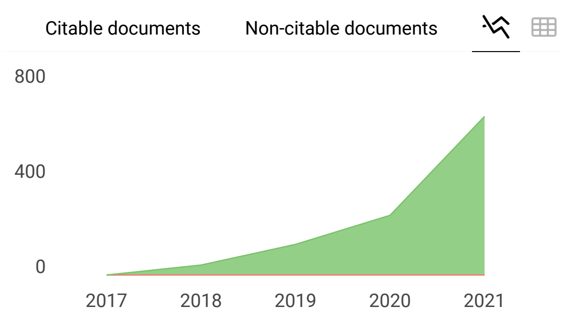


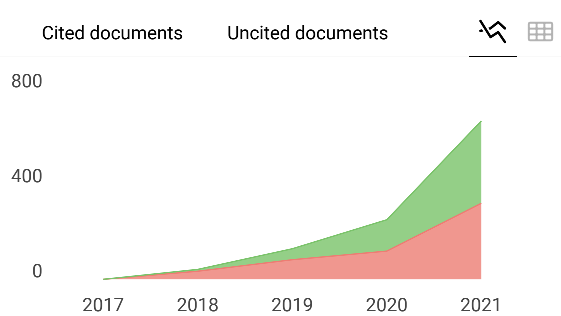
Total Cites Self-Cites



Citations per document







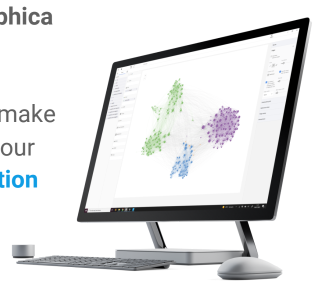
← Show this widget in your own website

Just copy the code below and paste within your html code:

<a href="https://www.scimag

SCImago Graphica

Explore, visually communicate and make sense of data with our **new data visualization tool**.



Metrics based on Scopus® data as of April 2022

T **Tai Ngo Van** 11 months ago

Dear Mr/Mrs,
I am Ngo Van Tai, a researcher in Thailand. I would like to ask the current index status as SJR is a static image of Food Research journal (ISSN: 2550-2166).
Thanks for your support.
Best regards,

reply

SCImago Team

Melanie Ortiz 11 months ago

Dear Tai Ngo Van, thank you very much for your comment. We suggest you consult the Scopus database directly. Keep in mind that the SJR is a static image (the update is made one time per year) of a database (Scopus) which is changing every day.
The Scopus' update list can also be consulted here:
https://www.elsevier.com/solutions/scopus/how-scopus-works/content
Best Regards, SCImago Team

S **Syamsul Rahman** 1 year ago

Please enlighten me, if searching on Scopus Food Research it says 22% it means you are in Q4, but on the Food Research page it says Q3 with SJR 0.2

reply

SCImago Team

Melanie Ortiz 1 year ago

Dear Syamsul,
Thank you for contacting us.
As you probably already know, our data come from Scopus, they annually send us an update of the data. This update is sent to us around April / May every year.
The calculation of the indicators is performed with the copy of the Scopus database provided to us annually. However, the methodology used concerning the distribution of Quartiles by Scopus is different from the one used by SCImago.
For every journal, the annual value of the SJR is integrated into the distribution of SJR values of all the subject categories to which the journal belongs. There are more than 300 subject categories. The position of each journal is different in any category and depends on the performance of the category, in general, and the journal, in particular. The distribution by Quartiles cannot be considered over the journals' total amount within a Category. In the case of SCImago, the distribution has to be considered with the formula Highest-SJR minus Lowest-SJR divided into four.
Best Regards,
SCImago Team

T **Tamiur Yazew** 1 year ago

Dear,

Thank you for your updated and quality journal.

I have submitted two manuscripts in the Food research journal. The editor of this journal sent me the acceptance letter for the two manuscripts. Howevver, they asked me to pay charge for the manuscripts. I am also working as a revierwer of this journla. I have edite two papers and sent it the editor. I am currently revewing a paper and it is ready to send back to the editor of this journal.

But I am from poor country, Ethiopia and I am unable to pay it. the condition in Ethiopia may also not allow me due to lack accessibility of this 150 USD.

So, please would you hel me by considering my issue into considerartion!

reply

SCImago Team

Melanie Ortiz 1 year ago

Dear Tamiur, thank you very much for your comment. Unfortunately, we cannot help you with your request, we suggest you contact the journal's editorial staff so they could inform you more deeply. Best Regards, SCImago Team

K **Kamal** 2 years ago

Hi, Editorial Team members,
I would like to know the topic related to the "hygienic practices along the supply chain of fisheries" is considered or not to review of your Journal. Early response is highly appreciated

reply

SCImago Team

Melanie Ortiz 2 years ago

Dear Kamal,
thank you for contacting us.
We are sorry to tell you that SCImago Journal & Country Rank is not a journal. SJR is a portal with scientometric indicators of journals indexed in Elsevier/Scopus.
Unfortunately, we cannot help you with your request, we suggest you visit the journal's homepage or contact the journal's editorial staff , so they could inform you more deeply.
Best Regards, SCImago Team

Y **yani purbanang** 2 years ago

Hi,
This journal is written with Scopus index from 2017-2019, What is the index status in 2021 ??
Thank you for your explanation

reply

SCImago Team

Melanie Ortiz 2 years ago

Dear Yani,
Thank you very much for your comment.
All the metadata have been provided by Scopus /Elsevier in their last update sent to SCImago, including the Coverage's period data. The SJR for 2019 was released on 11 June 2020. We suggest you consult the Scopus database directly to see the current index status as SJR is a static image of Scopus, which is changing every day.
Best Regards, SCImago Team

S **Sigit Susanto** 3 years ago

Whether the supply chain on Runner products could be submitted to this FR Journal?thanks very much

reply

SCImago Team

Melanie Ortiz 3 years ago

Dear Sigit,
Thank you for contacting us. Could you please expand a little bit your comment?
Best Regards, SCImago Team

Leave a comment

Name

Email
(will not be published)

I'm not a robot
reCAPTCHA
Privacy - Terms

Submit

The users of Scimago Journal & Country Rank have the possibility to dialogue through comments linked to a specific journal. The purpose is to have a forum in which general doubts about the processes of publication in the journal, experiences and other issues derived from the publication of papers are resolved. For topics on particular articles, maintain the dialogue through the usual channels with your editor.

Scopus Preview

Source details

Food Research

Open Access

Scopus coverage years: from 2017 to 2022

Publisher: Rynnye Lyan Resources

E-ISSN: 2550-2166

Subject area: Agricultural and Biological Sciences: Food Science

Source type: Journal

View all documents > Set document alert Save to source list Source Homepage

CiteScore 2021
1.2

SJR 2021
0.233

SNIP 2021
0.708

CiteScore CiteScore rank & trend Scopus content coverage

i Improved CiteScore methodology

CiteScore 2021 counts the citations received in 2018-2021 to articles, reviews, conference papers, book chapters and data papers published in 2018-2021, and divides this by the number of publications published in 2018-2021. Learn more >

CiteScore 2021

1.2 = 1,069 Citations 2018 - 2021 / 924 Documents 2018 - 2021

Calculated on 05 May, 2022

CiteScoreTracker 2022

1.4 = 1,678 Citations to date / 1,164 Documents to date

Last updated on 05 March, 2023 • Updated monthly

CiteScore rank 2021

Category	Rank	Percentile
Agricultural and Biological Sciences — Food Science	#236/338	30th

View CiteScore methodology > CiteScore FAQ > Add CiteScore to your site

4.__38__fr-2021-420_haryanti

by Susanto Budi Sulistyo

Food Research 6 (3) : 306 - 314 (June 2022)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

The effects of adding lysine to sap on chemical characteristics and antioxidant activity of granulated coconut sugar

[1]Haryanti, P. and [2,]*Sulistyo, S.B.

[1]*Food Technology Study Program, Department of Agricultural Technology, Faculty of Agriculture, Jenderal Soedirman University, Purwokerto 53123, Indonesia*

[2]*Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Jenderal Soedirman University, Purwokerto 53123, Indonesia*

Article history:
Received: 12 June 2021
Received in revised form: 24 July 2021
Accepted: 4 November 2021
Available Online: 12 June 2022

Keywords:
Browning intensity,
Chelating activity,
Coconut sap,
Maillard reaction,
Radical scavenging activity

DOI:
https://doi.org/10.26656/fr.2017.6(3).420

Abstract

Reducing sugar and amino acid are chemical features of coconut sap that are critical in the development of the typical colour and flavour of coconut sugar. This study aimed to discover how adding lysine to sap affected the chemical characteristics and antioxidant activity of granulated coconut sugar. The results showed that adding lysine to sap had no considerable influence on water and ash content, total sugar, reducing sugar, sucrose content, free amino acid, or total phenolic content of granulated coconut sugar. The amount of lysine added to coconut sap, on the other hand, had a substantial impact on the browning intensity, radical scavenging, and chelating activities of granulated coconut sugar. The highest radical scavenging activity was obtained in granulated coconut sugar added with 0.5 mM lysine, i.e., 73.96%, while the 0.25 mM of lysine concentration produced sugar with the highest chelating activity i.e., 7.01%.

1. Introduction

Coconut sap is a sweet and lucent liquid with a pH of almost neutral that can be produced by tapping the stem of a coconut flower bloom (Borse *et al*., 2007). Coconut sap contains many sugars as well as vitamins and minerals. Due to the high nutritious content, coconut sap tends to endure spontaneous fermentation. According to Hariharan *et al*. (2014), fermented sap in consequence will contain alcohol and acid liquid due to bacterial activity in the sap. As a result, a variety of natural and synthetic preservatives are routinely used to counteract the detrimental effects of sap fermentation. Haryanti *et al*. (2017) suggested that rather than a single material of the mixture, a blend of mangosteen peel powder and lime could enhance the preservation effect. Furthermore, as a sap preservative, the optimum quantities of mangosteen peel powder and lime in the mixture were 0.56 g/L and 1.7 g/L, respectively. Moreover, the chemical characteristics of coconut sap are altered by the weather. Coconut sap tapped on a sunlit day has superior chemical qualities than sap tapped on a rainy day (Haryanti *et al*, 2018).

Coconut sap is commonly used to make beverages or make coconut sugar. Granulated coconut sugar is one of the products made from coconut sap that has high economic value. Several processes are usually applied to produce granulated coconut sugar. Sap heating is the initial and most critical step of coconut sugar production. The improper procedure of sap heating will lead to the failure of sugar production. Coconut sap becomes thicker during the heating process, and browning commonly exists.

Basically, the browning reaction in food processing might be caused by the Maillard reaction, ascorbic acid oxidation or caramelization. Numerous research has found that during sap heating, the Maillard reaction plays a substantial role in browning, resulting in distinctive coconut sugar characteristics such as flavour, colour, and aroma (Ho *et al*., 2008; Asikin *et al*., 2014). The limy pH and appropriate sap boiling temperature induce the Maillard reaction in sap heating. On the other hand, both ascorbic acid oxidation and caramelization do not exist in coconut sugar processing. These reactions optimally occur in low pH substances. Moreover, caramelization may also occur in alkaline conditions, however, it requires a high heating temperature (higher than 120°C) (Eskin and Shahidi, 2013).

Reducing the sugar and amino acid content of coconut sap affects the strength of the Maillard reaction (Nagai *et al*., 2018). In addition, the Maillard reaction is also influenced by the heating temperature (Carciochi *et*

*Corresponding author.
Email: *susanto.sulistyo@unsoed.ac.id*

eISSN: 2550-2166 / © 2022 The Authors.
Published by Rynnye Lyan Resources

al., 2016). Amino groups, free ammonia, and nitrogen atoms can also be made from free amino acids through deamination and retro-aldol reactions (Ho *et al*., 2008). In the meanwhile, monosaccharides like glucose and fructose influence the initial Maillard process by creating a large pool of high-reactive C2, C3, and C4 dicarbonyl molecules.

In the Maillard reaction, amino acids and reducing sugar play an important role in the production of food colour, flavour, and antioxidants (Wijewickreme *et al*., 1999). Moreover, Kim (2013) found antioxidant activity in Maillard reaction products (MRPs) since MRPs can operate as metal chelators and radical scavengers. MRPs generated from chitooligosaccharide and glycine model systems also demonstrated excellent antioxidant activity, according to Yan *et al*. (2018). Karseno *et al*. (2018) discovered that DPPH radical scavenging activity and browning intensity have a strong correlation as indicated by the coefficient of correlation of 0.93. Furthermore, Maillard reaction duration and temperature affect browning intensity as well as fragrance components (Zhou *et al*., 2016).

The addition of lysine can increase the generation of basic amino groups. The 2.3-enolization track will yield intermediate products from the Maillard reaction, which occurs at a pH greater than 7. As a result of this action, a reductone chemical with antioxidant properties is formed. Additionally, the addition of 0.75 mM lysine to coconut sap and a heating temperature of 118°C not only resulted in a considerable increase in total phenolic content but also in radical scavenging activity in the sap (Sulistyo and Haryanti, 2020).

During the boiling of the sap, the Maillard reaction occurs, producing MRPs (such as reductones) and melanoidin, both of which include phenolic groups (Brudzynski and Miotto, 2011). Melanoidin is a brown polymeric macromolecule made up of carbohydrate and nitrogen-based polymeric macromolecules that are generated in the final step of the Maillard reaction. Thus, quantifying browning intensity via spectral absorbance at 405 nm can be used to quantify melanoidin amount (Bekedam *et al*., 2006). However, the mechanism of melanoidin synthesis in the processing of granulated coconut sugar remains unknown. The most logical method for determining such a mechanism is to measure the chemical characteristics and antioxidant activity of granulated coconut sugar. As a result, the current study delved into the chemical characteristics and antioxidant activity of granulated coconut sugar made from sap with varied lysine concentrations.

2. Materials and methods

2.1 Materials

Materials used in this research, in general, were divided into two categories, i.e. raw material and chemical. Coconut sap was collected from coconut trees in Banyumas Regency, Indonesia, as the raw ingredient. A number of chemical substances were utilized to analyze the chemical properties and antioxidant activities of coconut sap and granulated coconut sugar. The chemicals were obtained from Merck (Darmstadt, Germany), i.e. potassium hydrogen tartrate, phenol, sodium sulfite, sodium hydroxide, hydrochloric acid, D-glucose, ninhydrin, dipotassium hydrogen phosphate, potassium dihydrogen phosphate, stannous chloride, L-glutamic acid, ethanol, Folin-Ciocalteu, sodium carbonate, ammonium thiocyanate, ferrous chloride and hydrochloric acid. In addition, a chemical namely ferrozine was obtained from Fluka Chemical. Co. (Buchs, Switzerland) while 3,5-dinitrosalicylic acid and 2,2-diphenyl-1-picrylhydrazyl were from Sigma Chemical Co. (St. Louis, MO, USA).

2.2 Coconut sap preparation

First, plastic containers for sap collecting were prepared. A blend of mangosteen peel powder and lime with concentrations of 0.56 g/L and 1.7 g/L, respectively, was put as the natural preservative into the containers to avoid spontaneous fermentation in sap. After that, coconut sap was collected by tapping coconut inflorescence from 15 coconut trees into the containers. Sap tapping took place during the day, from 6 a.m. to 3 p.m., in pleasant weather with air temperature and relative humidity ranging from 24-27°C and 91%-92%, respectively.

2.3 Chemical analysis of coconut sap

2.3.1 Total soluble solid and pH value

After sap collection, the total soluble solids and pH value of the collected sap were immediately measured using a portable refractometer and pH meter, respectively.

2.3.2 Reducing sugar

To determine reducing sugar, we employed the procedure introduced by Miller (1959) with some small modifications. Firstly, one gram of sap sample was dissolved in 5 mL of distilled water. The sap (3 mL) were then mixed with 3 mL of 1% 3,5-Dinitrosalicylic acid in a test tube. The mixture was afterwards heated in a water bath for 15 mins and the heating temperature was maintained at 90°C. An aliquot (1 mL) of 40% potassium tartrate was then added to stabilize the mixture colour. After 15 mins of heating, the mixture was cooled at room

eISSN: 2550-2166

temperature for around 5 mins. The next step was the measurement of spectrum absorbance. Spectrum absorbance of the mixture was determined at a wavelength of 540 nm and to quantify samples a standard glucose solution was utilized.

2.3.3 Free amino acid

Determination of free amino acid of coconut sap was adopted from Yao's procedure (Yao *et al*., 2006). One gram of coconut sap was firstly poured into a volumetric flask and then buffer solution and ninhydrin solution, with the volume of each solution was 0.5 mL, were subsequently added. The mixture in the flask was then heated in a boiling water bath for 15 mins. Subsequently, the flask was cooled at room temperature for 5 mins and 25 mL of distilled water was filled into the flask. Afterwards, the next step was measuring the spectrum absorbance of the solution at a wavelength of 570 nm using a UV-1900 UV-VIS spectrophotometer (Shimadzu; Kyoto, Japan). To quantify the samples we utilized glutamic acid as the standard.

2.3.4 Total phenolic

To evaluate the total phenolic content of the coconut sap, we used the Folin-Ciocalteu technique (Payet *et al*., 2005). The steps were as follows: A volume of 130 µL of sap sample was placed in a test tube, and then 150 µL of Folin-Ciocalteu reagent with a 10% concentration was added. After that, the admixture which was incubated for 8 mins was given a dose of 120 µL Na_2CO_3 dissolved in distilled water at a concentration of 7.5%. This mixture was then treated for a second incubation at 30°C for 1 hr, and the spectrum absorption at 765 nm was then determined. Furthermore, the blank was evaluated by substituting a suitable solvent for the sap sample and subtracting the spectrum absorbance at the same wavelength. Lastly, the result was represented in milligrams of gallic acid equivalent per 100 gram of sample (mg GAE/100 g of sample) as the standard phenolic substance.

2.4 Granulated coconut sugar processing

To begin, 10 L of coconut sap were cleansed by the use of clean filter cloths. After that, the sap was separated into four parts once it was purified. The first sap component was left untreated and served as a treatment control, whilst the second, third, and fourth sap portions were all given lysine at different concentrations, 0.25, 0.5, and 0.75 mM, respectively. After that, each sap part was poured into an aluminium pan and heated on a gas stove. During heating, the sap should be continuously stirred, and when the temperature reaches 118°C, the heating should be turned off. After roughly 50 minutes of heating, this condition can be achieved. The sap was then cooled to room temperature while still being agitated. This process persisted until granulated sugar was formed. In the next step, we performed sun-drying to reduce the water content of the produced granulated sugar. The chemical characteristics and antioxidant activity of 50 g of granulated sugar generated were then tested. The analysis was carried out as detailed in the subsection below.

2.5 Chemical analysis and antioxidant activities of granulated coconut sugar

2.5.1 Water and ash content

Water and ash content were both determined according to the AOAC method (AOAC, 1990). The thermo-gravimetric method was applied to measure the water content of granulated coconut sugar while ash content was measured by oxidizing organic compounds at high temperatures (500-600°C) and than weighing the residual matters after the combustion.

2.5.2 Reducing sugar, total sugar and sucrose content

To determine the reduction sugar of granulated coconut sugar, we employed a similar procedure as in determining reducing sugar of coconut sap. In this step, 1 g of granulated coconut sugar was dissolved in 10 mL, instead of 5 mL, of distilled water. The next steps were then the same as that in reducing sugar analysis of coconut sap. In the meanwhile, hydrolysis method was applied to determine total sugar content. A volume of 3 mL of 25% HCl was utilized to incubate the sample. The incubation process was performed for 10 mins at a temperature of 70°C. Afterwards, the solution was cooled and neutralized at room temperature with 45% NaOH. Finally, the content of sucrose was ascertained by subtracting reducing sugar from total sugar content.

2.5.3 Free amino acid

The free amino acid of granulated coconut sugar was determined by using a similar procedure as in analyzing the free amino acid of coconut sap. Firstly, 1 g of granulated coconut sugar was added with distilled water until the volume reached 10 mL and then filtered with filtered paper. A volume of 0.5 mL of filtrate was put into a volumetric flask and then the next procedure was the same as that described in determining the free amino acid of coconut sap.

2.5.4 Total phenolic

The total phenolic content of granulated coconut sugar was analyzed using the Folin-Ciocalteu procedure as conducted to determine the total phenolic of coconut sap. The first step was the preparation of a 10% sugar

eISSN: 2550-2166

solution and then filtering. A volume of 30 µL of the sugar solution was subsequently treated as a sample. The succeeding steps were then the same as described in the aforementioned procedure of total phenolic analysis of coconut sap.

2.5.5 Browning intensity

The browning colour of coconut sugar samples was determined by slightly modifying the procedure developed by Ajandouz *et al*. (2001). The sap sample was liquefied with distilled water (1:25 w/v), and then centrifuged at 1006×*g* for 15 mins. The spectrum absorbance of the sugar browning was measured using a UV-1900 UV-VIS spectrophotometer (Shimadzu; Kyoto, Japan) at 420 nm.

2.5.6 Radical scavenging activity

To determine the radical scavenging activity (RSA) of coconut sugar, we employed the procedure established by Payet *et al*. (2005). DPPH• methanolic solution with a concentration of 0.1 mM and volume of 280 µL was delivered into a test tube using a pipette and subsequently mixed with a sugar sample. In the meanwhile, the solution in the test tube was mixed with solvent for the blank. Both mixtures were then incubated for 30 mins at room temperature. The spectrum absorbance of the mixtures at a wavelength of 515 nm was then analysed employing a spectrophotometer. Lastly, the antioxidant activity of the granulated coconut sugar can be defined as the percentage of radical scavenging activity according to the following equation:

$$\text{RSA}\ (\%) = \frac{Ao - As}{Ao} \times 100 \quad (1)$$

where Ao and As are the spectrum absorbance of the blank and the sample, respectively, at 515 nm. The effectiveness of antioxidant activity of the coconut sugar sample according to DPPH radical scavenging was compared with butylated hydroxytoluene (BHT).

2.5.7 Chelating activity

Kim's approach was used to determine the chelating activity of granulated sugar, which is defined as the sugar's ability to chelate metal ions Fe^{2+} (Kim, 2013). A one-gram sample of granulated sugar was diluted before being filtered with filter paper. The sugar solution was then combined with 600 µL of distilled water and 100 µL of 0.2 mM $FeCl_2.4H_2O$ in a volume of 100 µL. The control solution was made by mixing 100 µL of distilled water with 200 µL of 1 mM ferrozine. After 10 mins of cooling at room temperature, the colour changes of the combination were monitored using a UV-1900 UV-VIS spectrophotometer (Shimadzu; Kyoto, Japan) at a spectral wavelength of 562 nm. Following that, the chelating activity was calculated using the following equation:

$$\text{Chelating activity}\ (\%) = \frac{Ao - As}{Ao} \times 100 \quad (2)$$

where Ao and As are the spectrum absorbance of the control and the sample solutions, respectively, at 562 nm after 10 mins of incubation. The effectiveness of the coconut sugar sample as a chelating agent was compared with ethylenediaminetetraacetic acid (EDTA).

2.5.8 Spectroscopic analysis

To investigate the spectroscopic features of sugar solutions, absorption spectra ranging from 200 nm to 700 nm were used. To begin, 250 mg granulated coconut sugar was dissolved in 10 mL of demineralized water. Prior to taking the measurements, each solution had to be prepared. The UV-1900 UV-VIS spectrophotometer (Shimadzu; Kyoto, Japan) was used to record the absorption spectra (Bekedam *et al*., 2006).

2.6 Statistical analysis

All chemical characteristics and antioxidant activity data were statistically analyzed with IBM SPSS Statistic 20 and represented as mean standard deviation (SD). $P<0.05$ was used to determine statistical significance. One-way analysis of variance (ANOVA) with Duncan's multiple range test with a significance level of $P < 0.05$ was used to assess the influence of variation in the added lysine concentration.

3. Results and discussion

3.1 Chemical properties of coconut sap

The chemical properties of coconut sap measured prior to granulated coconut sugar processing are described in Table 1. Coconut sap should have some requirements to be used for further processing into coconut sugar. The requirements are as following: pH higher than 7.2, total soluble solids around 15.1°Bx and reducing sugar lower than 0.48% (Haryanti *et al*., 2017). As seen in Table 1, the sap sample used in this research was suitable as a raw material of granulated coconut sugar since its chemical properties meet the aforementioned requirements.

Table 1. The chemical properties of coconut sap

No.	Chemical properties	Content
1	Total soluble solid (°Bx)	13.5±1.73
2	The pH value	8.6±0.23
3	Reducing sugar (%)	0.14±0.03
4	Amino acid (%)	0.27±0.14
5	Total phenolic content (mg GAE/100 g)	53.37±5.04

3.2 Chemical properties and antioxidant activities of granulated coconut sugar

The effects of different concentrations of lysine on the water and ash content, reducing sugar, total sugar, sucrose content, free amino acid content, and total phenolic content of granulated coconut sugar were not significant. The addition of lysine, on the other hand, had a substantial impact on browning intensity, radical scavenging, and chelating activity.

3.2.1 Water and ash content

Figure 1 shows the water and ash content of granulated coconut sugar made with various concentrations of lysine added to coconut sap. In addition, the water and ash content of granulated coconut sugar varied between 5.94 and 6.57% and 2.17 and 2.30%, respectively.

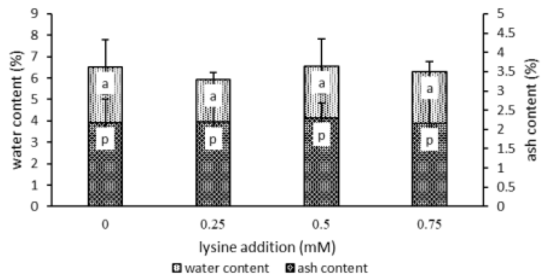


Figure 1. Water content and ash content of granulated coconut sugar. The results are represented in term of mean±SD from six experiments. Bars carrying same letters at the same parameter indicate mean values have no significant difference at P > 0.05.

3.2.2 Reducing sugar, total sugar and sucrose content

The reducing sugar, as well as total sugar and sucrose content of granulated coconut sugar applied with different lysine concentrations on coconut sap, ranged from 2.93 to 3.07% db, 90.21 to 94.37% db, and 87.24 to 91.30% db, respectively. The sugar content of the granulated coconut sugar is depicted in Figure 2.

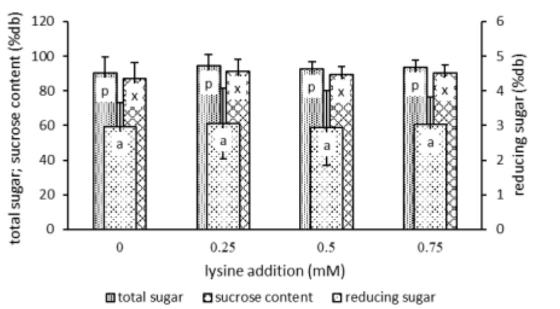


Figure 2. Reducing sugar, total sugar and sucrose content of granulated coconut sugar. The results are represented in term of mean±SD from six experiments. Bars carrying same letters at the same parameter indicate mean values have no significant difference at P > 0.05.

Reducing sugar of coconut sap was lower than that of granulated coconut sugar, i.e. 0.14±0.03% or 1.21±0.19% db. It decreased at the beginning of heating in liquid form, then increased at the end of heating and turned into granulated form. The decrease in reducing sugar of sap at the initial heating was due to the occurrence of the initial Maillard reaction. According to Ho *et al*. (2008), reducing sugar such as glucose and fructose was highly reactive at the initial stage of the heating process. Both glucose and fructose participated in the initial Maillard reaction by creating dicarbonyl compounds. The increment of reducing sugar at the end of heating and in the granulated form was caused by the forming of intermediate products of Maillard reaction bounded ketone or hydroxyl groups, which are highly reactive. Rufian-Henares and De La Cueva (2009) found that intermediate products of the Maillard reaction such as pyranone or pyridone residues contained the ketone or hydroxyl groups.

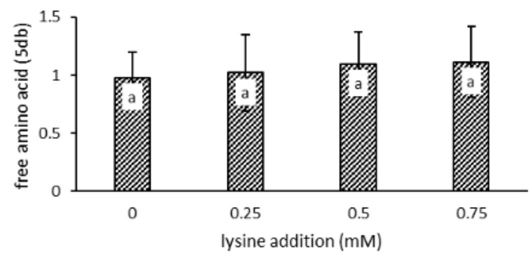


Figure 3. Free amino acid content of granulated coconut sugar. The results are represented in term of mean±SD from six experiments. Bars carrying same letters at the same parameter indicate mean values have no significant difference at P > 0.05.

3.2.3 Total free amino acid

As shown in Figure 3, the amount of lysine added to the sap had no effect on the free amino acid content of granulated coconut sugar (P > 0.05). The free amino acid of granulated coconut sugar measured in this research ranged from 0.98 – 1.11% db. As it possesses two reactive groups, lysine is the most reactive amino acid in the Maillard reaction. In addition, lysine contains nitrogen atoms which affect the pyrazine formation (Ho *et al.*, 2008). Pyrazine is a flavoured compound, so lysine addition may have a significant effect on pyrazine content (Eskin and Shahidi, 2013), but not on the amino acid content of granulated coconut sugar.

The amino acid of granulated sugar was higher than that of coconut sap, i.e. 0.27±0.14% or 2.3±1.12%db. The increase in total free amino acids was attributable to the formation of additional compounds during the heating process. Amino acids, such as ammonia, were identified as this substance. According to Ho *et al.*

eISSN: 2550-2166

(2008), free ammonia was created at the start of the heat reaction in palm sugar production. Melanoidin, which is generated during the boiling of coconut sap, is a nitrogen -based polymeric macromolecule that may be identified as an amino acid (Brudzynski and Miotto, 2011).

3.2.4 Total phenolic content and browning intensity

With a range of 0.94 - 1.22% db, the total phenolic content of granulated coconut sugar applied with varying concentrations of lysine on sap was not significantly different (Figure 4). Coconut sap has a total phenolic concentration of 53.37±5.04 mg GAE/100 g, or 0.46±0.07% db. Since the MRPs and melanoidin were generated during the heating process, total phenolic content increased more than twofold from coconut sap to granulated sugar. After thermal heating, the natural phenolic compound in coconut sap diminished. This finding is confirmed by Wiriyawattana *et al*. (2018), who found that thermal heating at temperatures higher than 110°C can reduce the phenolic content of rice berry flour. In this step, however, the amount of melanoidin increased. Indeed, an increase in melanoidin was the most common cause of an increase in phenolic content in coconut sugar. Melanoidin and MRPs both include phenolic groups, which are formed during the heating process (Delgado-Andrade *et al*., 2005; Brudzynski and Miotto, 2011).

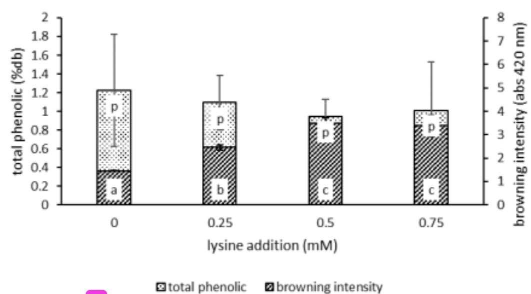


Figure 4. Total phenolic content and browning intensity of granulated coconut sugar. The results are represented in term of mean±SD from six experiments. Bars carrying same letters at the same parameter indicate mean values have no significant difference at P > 0.05.

Browning intensities of sugar generated from sap varied greatly depending on the lysine concentration. The dark hue of granulated coconut sugar increased as the lysine concentration increased. The addition of 0.5 mM of lysine increased the brown colour intensity of the granular coconut sugar. This treatment caused the most intense browning of granulated sugar, up to 42 times that of the initial phase. Furthermore, Sulistyo and Haryanti (2020) found that the changes in sap browning intensity during heating followed an exponential curve. Higher lysine concentrations, on the other hand, did not affect the browning intensity of sugar. The addition of more than 0.5 mM of lysine to sap may result in a lower pH, which may suppress the browning Maillard reaction. Maillard process is often encouraged under higher alkaline circumstances, according to Eskin and Shahidi (2013). Coconut sap's neutral and alkaline pH provided an ideal environment for accelerating C2 and C3 fragments from sugar breakdown, which have high reactivity. The sugar breakdown products were then polymerized and linked by amino compounds to form melanoidin, a brown-coloured substance (Ho *et al*., 2008).

3.2.5 Radical scavenging activity and chelating activity

Figure 5 shows the radical scavenging activity (RSA) and chelating activity of granulated coconut sugar applied to sap with varying lysine concentrations. Granulated coconut sugar made from coconut sap and supplemented with 0.5 mM lysine had a substantially higher RSA (73.96%) than granulated coconut sugar made without lysine (67.45%). The RSA of 10% granulated coconut sugar solution added with 0.5 mM lysine was similar to the RSA of 100 ppm BHT i.e. 74.95%. Lysine is the polar charged side chain of amino acid which might play role in the Maillard reaction by providing nitrogen atom sources (Ho *et al*., 2008). Because of its two reactive amino groups, lysine basic characteristics have a higher activity during the Maillard reaction. According to Delgado-Andrade and Rufian-Henares (2009) and Eskin and Shahidi (2013), lysine contains free amino groups (e-amino) that participate in the Maillard reaction. The Maillard reaction products (MRPs) produced by heating a lactose-lysine model system at 100°C for 8.5 mins have an RSA of 50% (Morales and Jimenez-Perez, 2001). Furthermore, Wiriyawattana *et al*. (2018) discovered that 110°C was the best temperature for producing pregelatinized riceberry flour with the maximum antioxidant activity. Another study by Boonmawat *et al*. (2019) found that heating riceberry bran in superheated steam at a very high temperature did not affect antioxidant activity. Furthermore, compared to other treatments, the addition of 0.5 mM lysine resulted in granulated sugar with a higher browning intensity. The RSA was likewise higher with the granular coconut sugar that had a higher browning intensity. According to Karseno *et al*. (2018), there was a strong link between DPPH radical scavenging activity and browning intensity.

As this treatment also boosted the chelating activity of coconut sap after heating, the chelating activity of sugar obtained from coconut sap combined with 0.25 mM of lysine (7.01%) was much higher than that of

eISSN: 2550-2166

other treatments. The addition of a high concentration of lysine raised the concentration of amino groups, which altered the production of pyrazine, a volatile molecule. However, an increase in pyrazine production, which is controlled by nitrogen atoms in lysine, did not result in an increase in granulated coconut sugar chelating ability. As a result, adding more than 0.25 mM of lysine to granulated coconut sugar had no influence on its chelating ability.

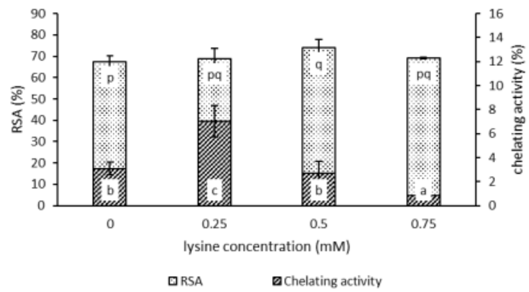


Figure 5. Radical scavenging activity and chelating activity of granulated coconut sugar. The results are represented in term of mean±SD from six experiments. Bars carrying same letters at the same parameter indicate mean values have no significant difference at P > 0.05.

As a comparison, the chelating ability of granulated coconut sugar was much lower than that of ethylenediaminetetraacetic acid (EDTA). The chelating activity of 10% granulated coconut sugar was 7.01%, while 20 ppm EDTA produced a chelating activity of 61.79%. The final stage of the Maillard reaction, melanoidin, may be responsible for the chelating activity of granulated coconut sugar. MRPs have chelating action, according to Delgado-Andrade *et al*. (2004). Furthermore, MRPs ion chelating affinity is crucial to the antioxidant action mechanism (Jing and Kitts, 2004). Melanoidin's chelating activity, according to Verzelloni *et al*. (2010), may help to avoid oxidation. Melanoidin was shown to possess an anionic molecule capable of chelating metal transitions (Daglia *et al*., 2008; Rufian-Henares and De La Cueva, 2009; Tagliazucchi *et al*., 2010).

3.2.6 Spectroscopic analysis

Figure 6 shows the absorption spectra of granulated coconut sugar applied with varied concentrations of lysine on sap. As seen in Figure 6, the graph has two peaks, one at 264.5-268.5 nm and the other at 401.5 nm. Proteins, sucrose, reducing sugar, and MRPs like reductone are all detected at wavelengths between 264.5 and 268.5 nm. Meanwhile, the presence of melanoidin is indicated by a peak at a wavelength of 401.5 nm. According to Bekedam *et al*. (2006), a low molecular weight coffee molecule can absorb light at 280 nm, while melanoidin has a 405 nm absorption spectrum. The absorption at wavelengths of 264.5-268.5 and 401.5 nm has been proven to estimate the relative amount of melanoidin and other components in granulated coconut sugar based on these absorption spectra. In comparison to melanoidin (abs value at 401.5 nm = 0.287-0.303), granulated coconut sugar generated from coconut sap combined with all lysine concentrations is dominated by the chemical that absorbs light at 264.5-268.5 nm (abs value = 1.193-1.426).

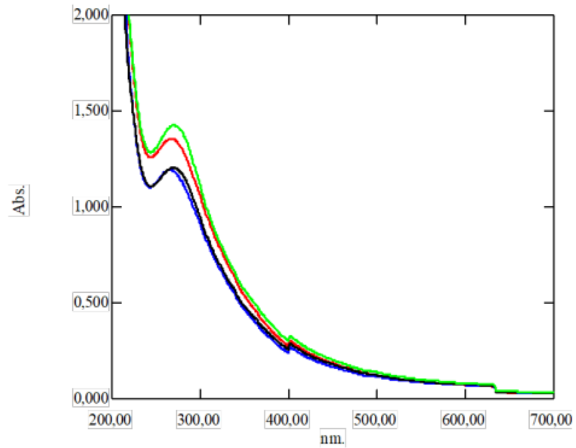


Figure 6. Absorption spectra of 25 mg/mL granulated coconut sugar produced added with 0 (black line); 0.25 (red line); 0.5 (blue line) and 0.75 mM (green line) lysine on sap.

The current study findings confirmed that increasing lysine concentration did not affect granulated coconut sugar's water and ash content, decreasing sugar, total sugar, sucrose content, free amino acid, or total phenolic content. Furthermore, the amount of lysine added to coconut sap has a substantial impact on granulated coconut sugar browning intensity, RSA, and chelating activity. The findings of this study can be used as a starting point for future research into the possibilities of adding amino acids to granulated coconut sugar to improve its health benefits.

Conflict of interest

The authors declare that there are no conflicts of interest.

Acknowledgements

This work was financially supported by the Indonesia Ministry of Research, Technology and Higher Education through Fundamental Research Grant in 2019.

References

Ajandouz, E.H., Tchiakpe, L.S., Ore, F.D., Benajiba, A. and Puigserver, A. (2001). Effects of pH on caramelization and Maillard reaction kinetics in fructose-lysine model systems. *Journal of Food Science*, 66(7), 926-931. https://doi.org/10.1111/j.1365-2621.2001.tb08213.x

AOAC. (1990). Official methods of analysis. 15th ed. Vol. 1. Virginia, USA: Association of Official Analytical Chemists.

Asikin, Y., Kamiya, A., Mizu, M., Takara, K., Tamaki, H. and Wada, K. (2014). Changes in the physicochemical characteristics, including flavour components and Maillard reaction products, of non-centrifugal cane brown sugar during storage. *Food Chemistry*, 149, 170-177. https://doi.org/10.1016/j.foodchem.2013.10.089

Bekedam, E.K., Schols, H.A., Van Boekel, M.A. and Smit, G. (2006). High molecular weight melanoidins from coffee brew. *Journal of Agricultural and Food Chemistry*, 54(20), 7658-7666. https://doi.org/10.1021/jf0615449

Boonmawat, S., Ratphitagsanti, W. and Haruthaitanasan, V. (2019). Effect of superheated steam heating on quality and antioxidant activities of riceberry bran. *Agriculture and Natural Resources*, 53(2), 130–138.

Borse, B.B., Rao, L.J.M., Ramalakshmi, K. and Raghavan, B. (2007). Chemical composition of volatiles from coconut sap (neera) and effect of processing. *Food Chemistry*, 101(3), 877-880. https://doi.org/10.1016/j.foodchem.2006.02.026

Brudzynski, K. and Miotto, D. (2011). The relationship between the content of Maillard reaction-like products and bioactivity of Canadian honeys. *Food Chemistry*, 124(3), 869–874. https://doi.org/10.1016/j.foodchem.2010.07.009

Carciochi, R.A., Dimitrov, K. and D´Alessandro, L.G. (2016). Effect of malting conditions on phenolic content, Maillard reaction products formation, and antioxidant activity of quinoa seeds. *Journal of Food Science and Technology*, 53(11), 3978-3985. https://doi.org/10.1007/s13197-016-2393-7

Daglia, M., Papetti, A., Aceti, C., Sordelli, B., Gregotti, C. and Gazzani, G. (2008). Isolation of high molecular weight components and contribution to the protective activity of coffee against lipid peroxidation in a rat liver microsome system. *Journal of Agricultural and Food Chemistry*, 56(24), 11653-11660. https://doi.org/10.1021/jf802018c

Delgado-Andrade, C., Rufian-Henares, J.A. and Morales, F.J. (2005). Assessing the antioxidant activity of melanoidins from coffee brews by different antioxidant methods. *Journal of Agricultural and Food Chemistry*, 53(20), 7832–7836. https://doi.org/10.1021/jf0512353

Delgado-Andrade, C. and Rufian-Henares, J. (2009). Assessing the Generation and Bioactivity of Neo-Formed Compounds in Thermally Treated Food. Granada, Spain: Editorial Atrio.

Delgado-Andrade, C., Seiquer, I., Nieto, R. and Navarro, M.P. (2004). Effects of heated glucose–lysine and glucose–methionine model-systems on mineral solubility. *Food Chemistry*, 87(3), 329-337. https://doi.org/10.1016/j.foodchem.2003.12.002

Eskin, N.A.M. and Shahidi, F. (2013). Biochemistry of Foods. 3rd ed. Oxford, United Kingdom: Academic Press.

Hariharan, B., Singaravadivel, K. and Alagusundaram, K. (2014). Effect of food grade preservatives on the physicochemical and microbiological properties of coconut toddy during fermentation. *Journal of Nutrition and Food Sciences*, 4(5), 1000299. https://doi.org/10.4172/2155-9600.1000299

Haryanti, P., Supriyadi, Marseno, D.W. and Santoso, U. (2017). Chemical properties of coconut sap obtained at different tapping time and addition of preservatives. *International Journal of Science and Technoledge*, 5(3), 52-59.

Haryanti, P., Supriyadi, Marseno, D.W. and Santoso, U. (2018). Effects of different weather conditions and addition of mangosteen peel powder on chemical properties and antioxidant activity of coconut sap. *Agritech*, 38(3), 295-303. https://doi.org/10.22146/agritech.29844

Ho, C.W., Wan Aida, W.M., Maskat, M.Y. and Osman, H. (2008). Effect of thermal processing of palm sap on the physicochemical composition of traditional sugar. *Pakistan Journal of Biological Sciences*, 1(7), 989-995. https://doi.org/10.3923/pjbs.2008.989.995

Jing, H. and Kitts, D.D. (2004). Antioxidant activity of sugar-lysine Maillard reaction products in cell free and cell culture systems. *Archives of Biochemistry and Biophysics*, 429(2), 154-163. https://doi.org/10.1016/j.abb.2004.06.019

Karseno, Erminawati, Yanto, T., Setyowati, R. and Haryanti, P. (2018). Effect of pH and temperature on browning intensity of coconut sugar and its antioxidant activity. *Food Research*, 2(1), 32-38. https://doi.org/10.26656/fr.2017.2(1).175

Kim, J. (2013). Antioxidant activity of Maillard reaction products derived from aqueous and ethanolic glucose -glycine and its oligomer solutions. *Food Science and Biotechnology*, 22(1), 39-46. https://doi.org/10.1007/s10068-013-0006-z

Miller, G.L. (1959). Use of dinitrosalicylic acid reagent for determination of reducing sugar. *Analytical Chemistry*, 31(3), 426-428. https://doi.org/10.1021/ac60147a030

eISSN: 2550-2166

Morales, F.J. and Jimenez-Perez, S. (2001). Free radical scavenging capacity of Maillard reaction products as related to color and fluorescence. *Food Chemistry*, 72(1), 119-125. https://doi.org/10.1016/S0308-8146(00)00239-9

Nagai, T., Kai, N., Tanoue, Y. and Suzuki, N. (2018). Chemical properties of commercially available honey species and the functional properties of caramelization and Maillard reaction products derived from these honey species. *Journal of Food Science and Technology*, 55(2), 586-597. https://doi.org/10.1007/s13197-017-2968-y

Payet, B., Sing, A.S.C. and Smadja, J. (2005). Assessment of antioxidant activity of cane brown sugars by ABTS and DPPH radical scavenging assays: determination of their polyphenolic and volatile constituents. *Journal of Agricultural and Food Chemistry*, 53(26), 10074-10079. https://doi.org/10.1021/jf0517703

Rufian-Henares, J.A. and De La Cueva, S.P. (2009). Antimicrobial activity of coffee melanoidins—a study of their metal-chelating properties. *Journal of Agricultural and Food Chemistry*, 57(2), 432-438. https://doi.org/10.1021/jf8027842

Sulistyo, S.B. and Haryanti, P. (2020). Regression analysis for determination of antioxidant activity of coconut sap under various heating temperature and concentration of lysine addition. *Food Research*, 4 (4), 976-981. https://doi.org/10.26656/fr.2017.4(4).410

Tagliazucchi, D., Verzelloni, E. and Conte, A. (2010). Effect of dietary melanoidins on lipid peroxidation during simulated gastric digestion: their possible role in the prevention of oxidative damage. *Journal of Agricultural and Food Chemistry*, 58(4), 2513-2519. https://doi.org/10.1021/jf903701h

Verzelloni, E., Tagliazucchi, D. and Conte, A. (2010). From balsamic to healthy: traditional balsamic vinegar melanoidins inhibit lipid peroxidation during simulated gastric digestion of meat. *Food and Chemical Toxicology*, 48(8-9), 2097-2102. https://doi.org/10.1016/j.fct.2010.05.010

Wijewickreme, A.N., Krejpcio, Z. and Kitts, D.D. (1999). Hydroxyl scavenging activity of glucose, fructose, and ribose-lysine model Maillard Products. *Journal of Food Science*, 64(3), 457-461. https://doi.org/10.1111/j.1365-2621.1999.tb15062.x

Wiriyawattana, P., Suwonsichon, S. and Suwonsichon, T. (2018). Effects of drum drying on physical and antioxidant properties of riceberry flour. *Agriculture and Natural Resources*, 52(5), 445-450. https://doi.org/10.1016/j.anres.2018.11.008

Yan, F., Yu, X. and Jing, Y. (2018). Optimized preparation, characterization, and antioxidant activity of chitooligosaccharide–glycine Maillard reaction products. *Journal of Food Science and Technology*, 55(2), 712-720. https://doi.org/10.1007/s13197-017-2982-0

Yao, L., Liu, X., Jiang, Y., Caffin, N., D'Arcy, B., Singanusong, R., Datta, N. and Xu, Y. (2006). Compositional analysis of teas from Australian supermarkets. *Food Chemistry*, 94(1), 115-122. https://doi.org/10.1016/j.foodchem.2004.11.009

Zhou, Y., Li, Y. and and Yu, A. (2016). The effects of reactants ratios, reaction temperatures and times on Maillard reaction products of the L-ascorbic acid/L-glutamic acid system. *Food Science and Technology*, 36(2), 268-274. https://doi.org/10.1590/1678-457X.02415

FULL PAPER

eISSN: 2550-2166

4._38_fr-2021-420_haryanti

ORIGINALITY REPORT

10%	10%	4%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	jurnal.ugm.ac.id Internet Source	5%
2	www.rasayanjournal.co.in Internet Source	4%
3	Ulku Ertugrul, Ozan Tas, Serap Namli, Mecit H. Oztop. "A preliminary investigation of caramelisation and isomerisation of allulose at medium temperatures and alkaline pHs: A comparison study with other monosaccharides", International Journal of Food Science & Technology, 2021 Publication	1%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		