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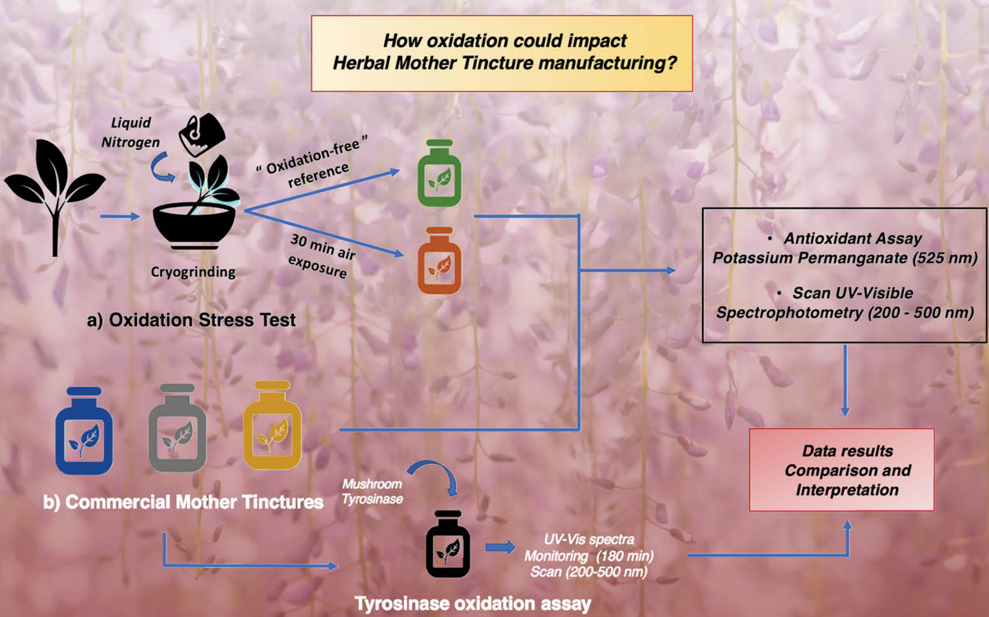

Oxidation during Fresh Plant Processing: A Race against Time

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Editor-in-Chief
Department of Drug Science and Technology, University of Turin, Via P. Giuria 9, 10125 Turin, Italy
Interests: green chemistry; process intensification; green extraction; enabling technologies (ultrasound, microwaves, hydrodynamic cavitation, ball milling, flow chemistry); sustainable chemical processes
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Prof. Dr. Fausto Gallucci *
Website (https://www.tue.nl/en/research/researchers/fausto-gallucci/)
Section Editor-in-Chief
Inorganic Membranes and Membrane Reactors, Sustainable Process Engineering, Department of Chemical Engineering and Chemistry, Eindhoven University of Technology, 5612 AZ Eindhoven, The Netherlands

Interests: process design and intensification; membranes and membrane reactors; separation technologies
* Section: Catalysis Enhanced Processes
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(/)

Prof. Dr. Krist V. Gernaey *

Website (http://www.dtu.dk/english/service/phonebook/person?id=10316&tab=1) **SciProfiles (https://sciprofiles.com/profile/411882)**

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Department of Chemical and Biochemical Engineering, Technical University of Denmark, Søltofts Plads, Building 228 A, 2800 Kgs. Lyngby, Denmark

Interests: industrial fermentation technology; scale-up/scale-down; resource recovery; continuous production processes; mathematical modeling; process analytical technology (PAT)

* Section: Biological Processes and Systems

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Website (https://www.ovgu.de/Tsotsas-path-2,9459,14965,15761,15763.html) **SciProfiles (https://sciprofiles.com/profile/1204906)**

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Thermal Process Engineering, Otto-von-Guericke University Magdeburg, Universitaetsplatz 2, 39106 Magdeburg, Germany

Interests: particle technology (granulation, agglomeration, and coating); drying; porous media; fluidization; discrete modeling

* Section: Particle Processes

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Website (https://www.uab.cat/web/el-departament/personal-del-departament/directori-personal-docent/pqrst-1345679455494.html?param1=pqrst¶m2=1345681772904)

Section Editor-in-Chief

Department of Chemical, Biological and Environmental Engineering, Universitat Autònoma de Barcelona, 08193-Bellaterra, Spain

Interests: design and use of biological systems for the treatment of organic waste (composting and anaerobic digestion); nanotechnology for environmental remediation; solid-state fermentation to convert wastes into bio-products

* Section: Environmental and Green Processes

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Website (https://www.ki.si/) **SciProfiles (https://sciprofiles.com/profile/636031)**

Section Editor-in-Chief

Department of Catalysis and Chemical Reaction Engineering, National Institute of Chemistry, Hajdrihova 19, SI-1001 Ljubljana, Slovenia

Interests: reaction engineering; reactor engineering; heterogeneous catalysis; process optimization; process intensification; valorization; multiscale modeling; density functional theory; kinetic Monte Carlo; computational fluid dynamics; thermodynamics; reaction kinetics; microkinetics; transport phenomena; heat transfer; mass transfer; fluid mechanics; unit operations; separations

* Section: Chemical Processes and Systems

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Website (https://www.iri.upc.edu/staff/vpuig) **SciProfiles (https://sciprofiles.com/profile/54708)**

Section Editor-in-Chief

Institute of Robotics and Industrial Informatics, Technical University of Catalonia, Barcelona 08028, Spain

Interests: process modeling, simulation, optimization and control; diagnosis and fault tolerant control; sensor data validation and reconstruction; sensor placement

* Section: Process Control and Supervision

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Website (https://www.aalto.fi/en/people/matti-lehtonen) **SciProfiles (https://sciprofiles.com/profile/317147)**

Section Editor-in-Chief

Department of Electrical Engineering and Automation, Aalto University, 02150 Espoo, Finland

Interests: power and energy systems; demand response; power grids; renewable energy sources; power system economics; electrical load modeling; electric vehicle charging; energy storages; heating system electrification

* Section: Energy Systems

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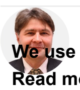

Prof. Dr. Dariusz Dziki *

Website (https://www.researchgate.net/profile/Dariusz_Dziki) **SciProfiles (https://sciprofiles.com/profile/407434)**

Section Editor-in-Chief

Department of Thermal Technology and Food Process Engineering, University of Life Sciences in Lublin, 31 Głęboka St., 20-612 Lublin, Poland
Interests: food processing; milling; grinding; drying; baking; extrusion; bioactive compounds of food
* Section: Food Processes
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Prof. Dr. Hoon Kim *
Website (https://orcid.org/0000-0002-7203-3712) **SciProfiles (https://sciprofiles.com/profile/494020)**
Associate Section Editor-in-Chief
College of Pharmacy and Research Institute of Life and Pharmaceutical Sciences, Sunchon National University, Suncheon 57922, Korea
Interests: monoamine oxidase inhibitors; acetylcholinesterase inhibitors; pharmaceutical biochemistry; cell wall lytic enzyme; laccase enzyme; rumen microbial metagenome; microorganism with host
* Section: Pharmaceutical Processes
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Prof. Dr. Orazio Nicolotti *
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Dipartimento di Farmacia-Scienze del Farmaco, Università degli Studi di Bari "Aldo Moro", Bari, Italy
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Interests: enzymatic technology; biofuels; wastewater treatment
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Dr. Ibrahim M. Abu-Reidah
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1. Analytical Chemistry Department, Faculty of Sciences, University of Granada, Avenida, Fuentenueva s/n, 18071 Granada, Spain
2. Memorial University of Newfoundland, St. John's, NL A1B 3X5, Canada
Interests: phytochemicals; functional foods; natural products; plant biodiversity; medicinal plants; food plants; bioactivity; polyphenols; flavonoids; functional foods; secondary metabolite profiling
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Dr. Gitana Maria Aceto
Website (https://www.unich.it/ugov/person/909?__cf_chl_captcha_tk__=K0KQktARdYHSkwD.1s.qlC68WlC6uuX1LFtkER7n.ZE-1637130509-0-gaNycGzNCj0)
SciProfiles (https://sciprofiles.com/profile/646454)
Department of Medical and Oral Sciences and Biotechnologies, University G. d'Annunzio of Chieti-Pescara, 66100 Chieti, Italy
Interests: molecular biology of cancer; germline predisposition; gene expression
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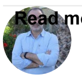

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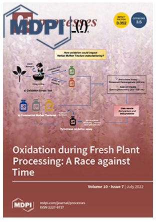

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Modeling of Multiphase Flow, Superheat Dissipation, Particle Transport, and Capture in a Vertical and Bending Continuous Caster (/2227-9717/10/7/1429)

by Mingyi Liang (https://sciprofiles.com/profile/2303688), Seong-Mook Cho (https://sciprofiles.com/profile/561430), Xiaoming Ruan (https://sciprofiles.com/profile/author/dzRkaXRydmN2aG9EY09xaEJRdW5PYk16aUhJdVFqSDlib3BCWWFQWlZ1bz0=) and Brian G. Thomas (https://sciprofiles.com/profile/674914)

Processes **2022**, *10*(7), 1429; https://doi.org/10.3390/pr10071429 (https://doi.org/10.3390/pr10071429) - 21 Jul 2022

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Abstract A new model of particle entrapment during continuous casting of steel is presented, which includes the effects of multiphase flow from argon gas injection and thermal buoyancy from superheat in the strand. The model simulates three different capture mechanisms, including capture by solidified [...] Read more.

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Purification and Characterization of a Novel Factor of Crotoxin Inter-CRO (V-1), a New Phospholipase A_2 Isoform from *Crotalus durissus collilineatus* Snake Venom Using an In Vitro Neuromuscular Preparation (/2227-9717/10/7/1428)

by Corina Vera-Gonzales (https://sciprofiles.com/profile/author/MjJHWUozaUQ5eEdxbDJaS3Z1UTRCTW1WTW5rNG9aWVlNa2J5a1p4eEs2cz0=), Carlos Alberto Arenas-Chávez (https://sciprofiles.com/profile/author/RGorZm1FSlVTMURWNlNBcVVEVlNwazVWS2VUK05JeHk1WXdWbzZ1ZDRtcz0=), Luis A. Ponce-Soto (https://sciprofiles.com/profile/770641), Aldo Alvarez-Risco (https://sciprofiles.com/profile/1401168), Shyla Del-Aguila-Arcentales (https://sciprofiles.com/profile/2380141), Neal M. Davies (https://sciprofiles.com/profile/233061) and Jaime A. Yáñez (https://sciprofiles.com/profile/1075276)

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Abstract The fractionation of *Crotalus durissus collilineatus* whole venom through an HPLC chromatographic method enabled the purification of a new V-1 neurotoxin. Inter-CRO (V-1) presents similarity in its primary structure to crotoxin B (CB), suggesting another isoform of this toxin. The aim of this [...] Read more.

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[An Intelligent Gender Classification System in the Era of Pandemic Chaos with Veiled Faces (/2227-9717/10/7/1427)](/2227-9717/10/7/1427)

by Jawad Rasheed (https://sciprofiles.com/profile/1778471), Sadaf Waziry (https://sciprofiles.com/profile/author/NWRadFFNTm53ZFFNN3pDRnFoVU1xOGRBZ1ZWS0dpd0V2akRZaTlUQXBaST0=), Shtwai Alsubai (https://sciprofiles.com/profile/2261603) and Adnan M. Abu-Mahfouz (https://sciprofiles.com/profile/587836)

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Abstract In the world of chaos, the pandemic has driven individuals around the globe to wear face masks for preventing the virus's transmission, however, this has made it difficult to determine the gender of the person wearing a mask. Gender information is part of [...] Read more.

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[A Bearing Fault Diagnosis Method Based on Spectrum Map Information Fusion and Convolutional Neural Network (/2227-9717/10/7/1426)](/2227-9717/10/7/1426)

by Baiyang Wang (https://sciprofiles.com/profile/2077307), Guifang Feng (https://sciprofiles.com/profile/2344191), Dongyue Huo (https://sciprofiles.com/profile/2340965) and Yuyun Kang (https://sciprofiles.com/profile/2234904)

Processes **2022**, *10*(7), 1426; https://doi.org/10.3390/pr10071426 (https://doi.org/10.3390/pr10071426) - 21 Jul 2022

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Abstract With the development of information technology, it has become increasingly important to use intelligent algorithms to diagnose mechanical equipment faults based on vibration signals of rolling bearings. However, with the application of high-performance sensors in the Internet of Things, the complexity of real-time [...] Read more.

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[Introduction to the Special Issue "Extraction and Fractionation Processes of Functional Components in Food Engineering" (/2227-9717/10/7/1425)](/2227-9717/10/7/1425)

by Blanca Hernández-Ledesma (https://sciprofiles.com/profile/222162), Roberta Claro da Silva (https://sciprofiles.com/profile/561085) and Juliana Maria Leite Nobrega De Moura Bell (https://sciprofiles.com/profile/450983)

Processes **2022**, *10*(7), 1425; https://doi.org/10.3390/pr10071425 (https://doi.org/10.3390/pr10071425) - 21 Jul 2022

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Abstract Diet plays an unquestionable role in the growth, development, and maintenance of all body functions [...] Full article (/2227-9717/10/7/1425)

(This article belongs to the Special Issue Extraction and Fractionation Processes of Functional Components in Food Engineering (/journal/processes/special_issues/functional_components_extraction_processes))

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[Mechanical and Microstructural Properties of Composite Mortars with Lime, Silica Fume and Rice Husk Ash (/2227-9717/10/7/1424)](/2227-9717/10/7/1424)

by Ramalingam Malathy (https://sciprofiles.com/profile/1400521), Ragav Shanmugam (https://sciprofiles.com/profile/author/TlFvQWRONmF0M3QvbHVKcEJabk44T2VhcjhvM3Z2TEVtYXU1R05ydTZkRT0=), Ill-Min Chung (https://sciprofiles.com/profile/489351), Seung-Hyun Kim (https://sciprofiles.com/profile/561503) and Mayakrishnan Prabakaran (https://sciprofiles.com/profile/1524745)

Processes **2022**, *10*(7), 1424; https://doi.org/10.3390/pr10071424 (https://doi.org/10.3390/pr10071424) - 21 Jul 2022

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Abstract A mixture of hydraulic lime and pozzolanic material can be used as a binder in making concrete and mortar for energy-efficient construction purposes. Generally, lime possesses lower strength and higher setting time. By introducing pozzolans in the lime mortar, their cementitious properties could [...] Read more.

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Influence of Varying Compression Ratio of a Compression Ignition Engine Fueled with B20 Blends of Sea Mango Biodiesel (/2227-9717/10/7/1423)

by R Rohith Renish (https://sciprofiles.com/profile/2018133), Amala Justus Selvam (https://sciprofiles.com/profile/author/QTg5cDVmdENpOXlyMVl5OTZUUExxb0JybVNHdEhnMUNyL2VRTmdtQVlkWT0=), Robert Čep (https://sciprofiles.com/profile/1027216) and Muniyandy Elangovan (https://sciprofiles.com/profile/2117276)

Processes **2022**, *10*(7), 1423; https://doi.org/10.3390/pr10071423 (https://doi.org/10.3390/pr10071423) - 21 Jul 2022

Abstract The ever-worsening environmental situation brought on by the huge use of fossil fuels has ramped up biodiesel production. Several studies have shown that a 20% biodiesel-diesel blend (B20) could be the best for utility in a compression ignition (CI) engine. The present study [...] Read more.

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Inline Weld Depth Evaluation and Control Based on OCT Keyhole Depth Measurement and Fuzzy Control (/2227-9717/10/7/1422)

by Maximilian Schmoeller (https://sciprofiles.com/profile/1875849), Tony Weiss (https://sciprofiles.com/profile/2294213), Korbinian Goetz (https://sciprofiles.com/profile/author/bXpSK0Fua2VsUlZlRytpT2RiOXp2UU5tTS9HcEdzRkk1UU05T2VEbnhDTT0=), Christian Stadter (https://sciprofiles.com/profile/1875204), Christian Bernauer (https://sciprofiles.com/profile/1581886) and Michael F. Zaeh (https://sciprofiles.com/profile/1500513)

Processes **2022**, *10*(7), 1422; https://doi.org/10.3390/pr10071422 (https://doi.org/10.3390/pr10071422) - 21 Jul 2022

Abstract In an industrial joining process, exemplified by deep penetration laser beam welding, ensuring a high quality of welds requires a great effort. The quality cannot be fully established by testing, but can only be produced. The fundamental requirements for a high weld seam [...] Read more.

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Determination of Gas Extraction Borehole Parameters in Fractured Zone on 'Borehole in Place of Roadway' Based on RSM-GRA-GA (/2227-9717/10/7/1421)

by Zhenghan Qin (https://sciprofiles.com/profile/2298214), Haisheng Shen (https://sciprofiles.com/profile/2314697), Yong Yuan (https://sciprofiles.com/profile/517021), Zhixiong Gong (https://sciprofiles.com/profile/author/R0ZORS9XWGNic3M2emdlZTlVK3p5WDBrbDRnbk1BQXZvK2R4RHVsaGg3cz0=), Zhongshun Chen (https://sciprofiles.com/profile/405680) and Yongqi Xia (https://sciprofiles.com/profile/author/ekhua2tYZHZ1Qm1lZWtLYUc1VzRpV1paZUd5MzkwRUpTQnRKM3lDcVk3VT0=)

Processes **2022**, *10*(7), 1421; https://doi.org/10.3390/pr10071421 (https://doi.org/10.3390/pr10071421) - 21 Jul 2022

Abstract Large-diameter gas extraction borehole is considered an effective method by which to realize coal mine methane exploitation and outburst prevention. Efficient gas extraction can be achieved by selecting the right borehole parameters. In this paper, by comparing several conventional objective weighting methods, the [...] Read more.

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[Virtual Screening of Drug Proteins Based on the Prediction Classification Model of Imbalanced Data Mining (/2227-9717/10/7/1420)]

by Lili Yin (https://sciprofiles.com/profile/836378), Xiaokang Du (https://sciprofiles.com/profile/2305254), Chao Ma (https://sciprofiles.com/profile/1173445) and Hengwen Gu (https://sciprofiles.com/profile/author/TUNXeURad3NITVlDT0lqRGVNYmxBejhjZnVCWXRhQlJrc0RZNndjb3kyTT0=)

Processes **2022**, *10*(7), 1420; https://doi.org/10.3390/pr10071420 (https://doi.org/10.3390/pr10071420) - 21 Jul 2022

Abstract We propose a virtual screening method based on imbalanced data mining in this paper, which combines virtual screening techniques with imbalanced data classification methods to improve the traditional virtual screening process. First, in the actual virtual screening process, we apply k-means and smote [...] Read more.

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[Factor Model for Online Education during the COVID-19 Pandemic Using the IoT (/2227-9717/10/7/1419)]

by Faheem Khan (https://sciprofiles.com/profile/1773021), Ilhan Tarimer (https://sciprofiles.com/profile/2445901) and Whangbo Taekeun (https://sciprofiles.com/profile/525670)

Processes **2022**, *10*(7), 1419; https://doi.org/10.3390/pr10071419 (https://doi.org/10.3390/pr10071419) - 21 Jul 2022

Abstract Coronavirus disease (COVID-19) has spread quickly around the globe. COVID-19 has affected the education sector due to partial or complete lockdowns that were implemented throughout the world between 2019 and 2022. This pandemic severely affected the education sectors in developing countries such as [...] Read more.

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[Use of 2-Ethylhexyl Nitrate for the Slow Pyrolysis of Plastic Waste (/2227-9717/10/7/1418)]

by Jochen Uebe (https://sciprofiles.com/profile/1238707), Audrone Zukauskaite (https://sciprofiles.com/profile/1525634), Zilvinas Kryzevicius (https://sciprofiles.com/profile/1739696) and Gintare Vanagiene (https://sciprofiles.com/profile/author/Sk4rL1ZXUWpnbmwzRzBuckF0L3VudmE1a0RGVTRGSFJoZkpaTjBNY3pWYz0=)

Processes **2022**, *10*(7), 1418; https://doi.org/10.3390/pr10071418 (https://doi.org/10.3390/pr10071418) - 20 Jul 2022

Abstract Plastics are widely used and are part of modern life. Recycling of plastic waste can be achieved by pyrolysis. Conventional pyrolysis of plastic waste takes place at temperatures higher than 450 °C, because the oil yield is higher. In this study, we examined [...] Read more.

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[Regenerable Kiwi Peels as an Adsorbent to Remove and Reuse the Emerging Pollutant Propranolol from Water (/2227-9717/10/7/1417)]

by Jennifer Gubitosa (https://sciprofiles.com/profile/678334), Vito Rizzi (https://sciprofiles.com/profile/678335), Paola Fini (https://sciprofiles.com/profile/678336), Sergio Nuzzo (https://sciprofiles.com/profile/author/QytJVElWeXdXcE9nWkVDa1VBZ2FVTXpVK245bXR5aU9Ud2RVR3l6OVpVTT0=) and Pinalysa Cosma (https://sciprofiles.com/profile/277337)

Processes **2022**, *10*(7), 1417; https://doi.org/10.3390/pr10071417 (https://doi.org/10.3390/pr10071417) - 20 Jul 2022

Abstract This work aims to characterize the adsorption process of propranolol HCl, an emerging pollutant and a widely used β-blocker, onto kiwi peels, an agricultural waste. The use of UV-vis spectroscopy was considered to obtain information about the pollutant removal working in the in-batch [...] Read more.

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Experimental Study on a New Combined Gas–Liquid Separator (/2227-9717/10/7/1416)

by Lei Ji (https://sciprofiles.com/profile/author/R0htd2NKL2NGdVFMSzVYeEhKMGZjN2tuQlJxVjBlaWN0QXM3SnVHdEZ3ND0=), Qin Zhao (https://sciprofiles.com/profile/2270084), Huiming Deng (https://sciprofiles.com/profile/2270044), Lanyue Zhang (https://sciprofiles.com/profile/1694646) and Wanquan Deng (https://sciprofiles.com/profile/author/RmdQSEd1VWh0U3Z3VXBRVGFGOVlGZmMzODVrUlhTSExXSWhNMWdXOS83RT0=)

Processes **2022**, *10*(7), 1416; https://doi.org/10.3390/pr10071416 (https://doi.org/10.3390/pr10071416) - 20 Jul 2022

Abstract Gas–liquid separation at natural gas wellheads has always been a key technical problem in the fields of natural gas transportation and storage. Developing a gas–liquid separation device that is both universal and highly efficient is the current challenge. A new type of combined [...] Read more.

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Influence of Heterogeneous Caprock on the Safety of Carbon Sequestration and Carbon Displacement (/2227-9717/10/7/1415)

by Xiaochen Wang (https://sciprofiles.com/profile/author/NCsrSEJOU1c4QnBXYUQ1MEFYT0Y4amVqUTYrQjBnZ1lvbGxXdDZ5VHEvVT0=), Xinwei Liao (https://sciprofiles.com/profile/869704), Peng Dong (https://sciprofiles.com/profile/author/QzBlTFRyQnBzOEt5NFB6ZzZwZXVkVFBmdWRnZ2RXYmdjUWw3WVBlaFl3Zz0=), Kang Tang (https://sciprofiles.com/profile/author/RVQybGxvNms1RVdMM0dWUkQydGNGeWtYcWl4QmluUG5MNWwvV2krMEliND0=), Xudong Zhao (https://sciprofiles.com/profile/author/QTRYeDQ0S3BTNjh0a0tRYjduZjBOKzVvQkxBeFNUei96b0pET2syaVplVT0=) and Chen Guo (https://sciprofiles.com/profile/author/OUJIL0RWRU9mdDkwalpOaXcrM0JoZTBEOGVua0J5ZnR5SHhPVS9Tek5uQT0=)

Processes **2022**, *10*(7), 1415; https://doi.org/10.3390/pr10071415 (https://doi.org/10.3390/pr10071415) - 20 Jul 2022

Abstract Carbon Capture, Utilization and Storage (CCUS) is a method of burying the captured CO_2 into the reservoir and displacement of crude oil from reservoirs, which considers both economy and environmental protection. At present, it is considered as an important means to deal [...] Read more.

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Study on Speed Planning of Signalized Intersections with Autonomous Vehicles Considering Regenerative Braking (/2227-9717/10/7/1414)

by Ning Li (https://sciprofiles.com/profile/author/S3RlSGx2amxFRlVtVlNGZ0tud043UWRlRVhJS2RlZXh1cXlNbW1EZTFlZz0=), Jiarao Yang (https://sciprofiles.com/profile/author/QVBaVy9rS3pRU1B5cGtqNHV6d2h5Rk9JZWpGbXJUd1JpY2tQRDRQK055ST0=), Junping Jiang (https://sciprofiles.com/profile/author/bGE2Y1AraVJ1Y3dJcGNJWXZNM05qYS9xV2ttWHJQSnJuSExtaCtlckJMYz0=), Feng Hong (https://sciprofiles.com/profile/author/WjhoMkt5dWlyVktNSS9nOVBzd0lpOU13WjFwNUpFaDUxaVgxOGxzenppND0=), Yang Liu (https://sciprofiles.com/profile/714523) and Xiaobin Ning (https://sciprofiles.com/profile/625265)

Processes **2022**, *10*(7), 1414; https://doi.org/10.3390/pr10071414 (https://doi.org/10.3390/pr10071414) - 20 Jul 2022

Abstract In order to reduce the energy consumption caused by the frequent braking of vehicles at signalized intersections, an optimized speed trajectory control method is proposed, based on braking energy recovery efficiency (BERE) in connection with an automated system for vehicle real-time interaction with [...] Read more.

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A Novel Exponential-Weighted Method of the Antlion Optimization Algorithm for Improving the Convergence Rate (/2227-9717/10/7/1413)

by Szu-Chou Chen (https://sciprofiles.com/profile/2215367), Wen-Chen Huang (https://sciprofiles.com/profile/1619452), Ming-Hsien Hsueh (https://sciprofiles.com/profile/670829), Chieh-Yu Pan (https://sciprofiles.com/profile/1619451) and Chih-Hao Chang (https://sciprofiles.com/profile/author/aTA4Ky9RR2ljaWc1MmdxdFBWb0lsOWJWWTFMYVlHSnFRbkhPcHl0aVppTT0=)

Processes **2022**, *10*(7), 1413; https://doi.org/10.3390/pr10071413 (https://doi.org/10.3390/pr10071413) - 20 Jul 2022

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Abstract The antlion optimization algorithm (ALO) is one of the most effective algorithms to solve combinatorial optimization problems, but it has some disadvantages, such as a long runtime. As a result, this problem impedes decision makers. In addition, due to the nature of the [...] Read more.

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Performance Comparison and Optimization of 16V265H Diesel Engine Fueled with Biodiesel Based on Miller Cycle (/2227-9717/10/7/1412)

by Feng Jiang (https://sciprofiles.com/profile/2024967), Junming Zhou (https://sciprofiles.com/profile/2024978), Jie Hu (https://sciprofiles.com/profile/1988607), Xueyou Tan (https://sciprofiles.com/profile/author/MTZtTU1ucWNCRVVTVTJvTHBMekFlbG8xaWx2RGRkV2tOVVZkQmNGeXNqbz0=), Qinglie Mo (https://sciprofiles.com/profile/author/aG1Wek11TFhMdXl3VlBxcStYU0tHQXdSUWJ0b2ZuQ2JCckthVHJHelNKZz0=) and Wentong Cao (https://sciprofiles.com/profile/2048508)

Processes **2022**, *10*(7), 1412; https://doi.org/10.3390/pr10071412 (https://doi.org/10.3390/pr10071412) - 20 Jul 2022

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Abstract This paper introduces the theoretical basis and optimization method of diesel engine working process theory. By comparing two Miller cycle schemes of B20 biodiesel under different load conditions of 1000 rpm (100%, 75%, and 50%), the best Miller cycle scheme and the best [...] Read more.

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Photovoltaic Fuzzy Logical Control MPPT Based on Adaptive Genetic Simulated Annealing Algorithm-Optimized BP Neural Network (/2227-9717/10/7/1411)

by Yan Zhang (https://sciprofiles.com/profile/author/dWhuVkl4cjZvT3dGZFAvVTVmeGEwUT09), Ya-Jun Wang (https://sciprofiles.com/profile/2309883), Yong Zhang (https://sciprofiles.com/profile/author/dHBUWnUvTXJTd2U4RHVjOWovWjZXVVFsZ1hKY293VmgwcHYyZFRLeGNkQT0=) and Tong Yu (https://sciprofiles.com/profile/author/QVNlQWxvQnZIVmRuOEhBdE9BRExEN01nMXQrRGZhTGxpSjlkR1pDcmluST0=)

Processes **2022**, *10*(7), 1411; https://doi.org/10.3390/pr10071411 (https://doi.org/10.3390/pr10071411) - 20 Jul 2022

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Abstract The P–U characteristic curve of the photovoltaic (PV) cell is a single peak curve with only one maximum power point (MPP). However, the fluctuation of the irradiance level and ambient temperature will cause the drift of MPP. In the maximum power point tracking [...] Read more.

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Hongliang Zhang (https://sciprofiles.com/profile/author/U1hzR0RSeHk5a2pTYjBlbXh1dzFQdjZNa2hUVjVncEcrQzlOSzl1aERwaz0=)
Processes **2022**, *10*(7), 1343; **https://doi.org/10.3390/pr10071343 (https://doi.org/10.3390/pr10071343)** - 10 Jul 2022
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Abstract The product's manufacturing process has an evident influence on product quality. In order to control the quality and identify the critical procedure of the product manufacturing process reasonably and effectively, a method combining genetic back-propagation (BP) neural network algorithm and grey relational analysis **[...] Read more.**
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Study on the Plugging Limit and Combination of CO_2 Displacement Flow Control System Based on Nuclear Magnetic Resonance (NMR) (/2227-9717/10/7/1342)

by Chang-Hua Yang (https://sciprofiles.com/profile/2282625),
Pan-Pan Lu (https://sciprofiles.com/profile/author/bDY0a3o4RDdhOFI2NUR3K3Y1R0s4QTZ0blV5VGdKVmQ1QnhNZnlwcjA0dz0=),
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Peng-Fei Cheng (https://sciprofiles.com/profile/author/ZzQrd2U0MVM0bkVObnlRL0ZwMTFWMHQ5OXBGRkdlSlJONDQwNm51Q3J6bz0=)
Processes **2022**, *10*(7), 1342; **https://doi.org/10.3390/pr10071342 (https://doi.org/10.3390/pr10071342)** - 10 Jul 2022
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Abstract CO_2 displacement is an important technology to reduce emissions and improve crude oil recovery, as well as prevent CO_2 escape. Effective storage is key to the successful implementation of this technology, especially for medium and high permeability reservoirs. The current flow **[...] Read more.**
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Machine Learning Model for Quality Parameters Prediction and Control System Design in the Kecombrang Flower (*Etlingera elatior*) Extraction Process (/2227-9717/10/7/1341)

by Ardiansyah Ardiansyah (https://sciprofiles.com/profile/703674),
Rifda Naufalin (https://sciprofiles.com/profile/author/cHZqcndDdUNjMlhPL0FGekJ0TllwTlVTSGNEb25rblV4bXdNSlRHeVlzUT0=),
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Condro Kartiko (https://sciprofiles.com/profile/author/dDFDRE01MEthNjVqVnFiKzVDT28xd2tWNW9lN2p4cWo5aDNaRUVlemVzcm5OUUdHUHhUMEVlc1BHZi93dE5MRw==)
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Sugeng Waluyo (https://sciprofiles.com/profile/author/THZKUXlTM2taMXFXeTBHZ2pKbHVmYUM3QTJmb1VLZ014eXViVyttd095az0=)
Processes **2022**, *10*(7), 1341; **https://doi.org/10.3390/pr10071341 (https://doi.org/10.3390/pr10071341)** - 09 Jul 2022
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Abstract Kecombrang flowers have bioactive components that can be used as food additives. The development of the kecombrang functional food industry for the production of food additives requires information on production parameters. The extraction process for kecombrang to obtain bioactive components, especially phenols and **[...] Read more.**

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Pharmacotechnological Advances for Clinical Translation of Essential Oils for the Treatment of Pain and Agitation in Severe Dementia (/2227-9717/10/7/1340)

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Chizuko Watanabe (https://sciprofiles.com/profile/author/VUJtbEdvUkF3eE5iKzhtb0dlc1FsRjcwZFQ4RTkvc0pzU0xmSmRLTlVZRT0=),
Shinobu Sakurada (https://sciprofiles.com/profile/author/U1FEVHF4M1kyRFVuSG5NSkF4eG5DMDlYTEFGUDhDd0VSVEp4blhkMS9JUT0=),
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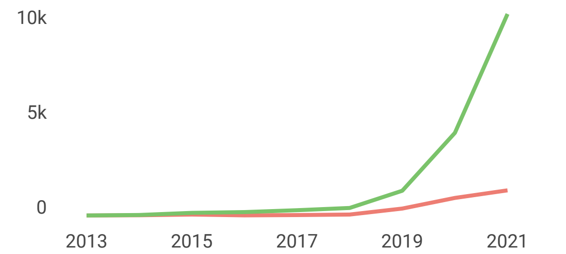

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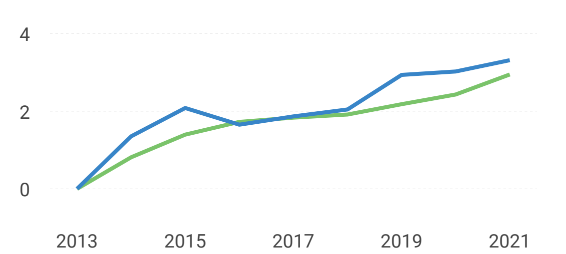

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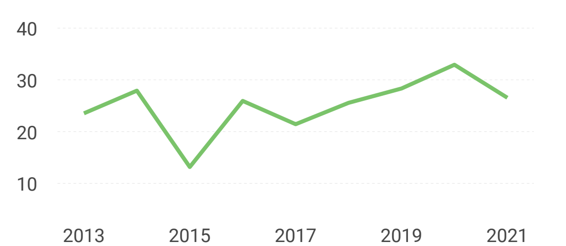

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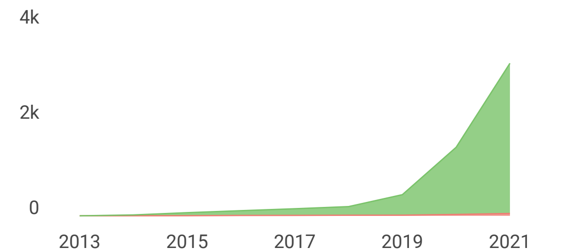

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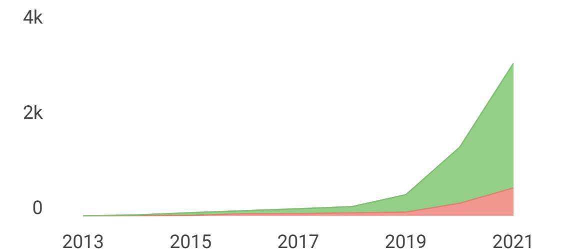

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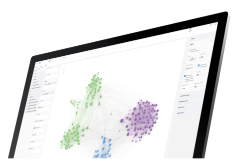

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Machine Learning Model for Quality Parameters Prediction and Control System Design in the Kecombrang Flower (*Etlingera elatior*) Extraction Process

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Abstract: Kecombrang flowers have bioactive components that can be used as food additives. The development of the kecombrang functional food industry for the production of food additives requires information on production parameters. The extraction process for kecombrang to obtain bioactive components, especially phenols and flavonoids, requires maximum temperature treatment and extraction time. This study aims to determine the standard for the kecombrang flower extraction process, create a machine learning model to estimate the quality parameters of the extraction results (phenol, flavonoid, pH, color, and viscosity), and design a strategy for controlling the extraction machine work to maintain the quality of the extraction, especially of phenols and flavonoids. This research was conducted at extraction temperatures of 60 °C, 65 °C, 70 °C, and 75 °C. During the extraction process, the quality of the material was checked by measuring phenol and flavonoid contents, as well as color, pH, and viscosity. Sampling was carried out at 5 min intervals. The data on the quality parameters during the extraction process were analyzed for trends. A machine learning model, which is an artificial neural network, was developed using a 2–6–1 architecture for each quality parameter. The two inputs of ANN were temperature of extraction and extraction time (duration). The output was the quality parameters of the products (phenols, flavonoids, pH, viscosity, and color), which were evaluated separately. The results show a good correlation between the model and the experimental data, with both the training dataset and the testing dataset. These results were then used to formulate a strategy for controlling the extraction process. A neuro-control system was used as a strategy. This control system was adaptive to changes that occurred during the extraction process so that phenols and flavonoids could be maintained.

Keywords: kecombrang flower; extraction process; quality parameters; machine learning model; neuro-control system

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1. Introduction

Plant-based bioactive compounds have attracted great interest as viable alternatives to synthetic materials due to their antibacterial, anti-inflammatory, and antioxidant properties. The extraction and processing of several parts of kecombrang, or torch ginger (*Etlingera elatior*), such as the leaves, torches, stems, flowers, and rhizomes, have also been the subject of extensive investigation. The earliest stages of the study focused on identifying the bioactive components found in the kecombrang plant and defining the function and application of each discovered compound [1–4]. Kecombrang is a plant that is native to Indonesia and Malaysia and is widespread in Southeast Asia. For generations, local people have used and exploited the plant for food, condiments, medicine, and food flavoring [5].

The active chemicals in the kecombrang plant are considered to be less effective and to have a shorter shelf life when the plant parts are used fresh. Thus, the contents of kecombrang plants need to be extracted, dried, modified, and further processed to preserve their bioactive components [6]. While drying kecombrang powder increases its durability by reducing its water content, it also damages the bioactive components found in fresh kecombrang flowers [7]. As a result, the ideal drying temperature and duration for powdering kecombrang must be determined to avoid the degradation of some of its bioactive components, such as phenols, flavonoids, and vitamin C, which results in a loss of its antioxidant action.

Extraction is critical for obtaining a desired bioactive component from kecombrang, as the chemicals are present in trace amounts in plants. According to [8], there are two primary approaches for extracting bioactive compounds from plants: traditional methods and nonconventional methods. Hydrodistillation [2], column chromatography [9], Soxhlet extraction, and maceration are all examples of classical extraction methods. Conventional methods have disadvantages in terms of increased reliance on high-purity organic solvents, increased cost, decreased extraction efficiency, prolonged processing time, and increased temperature [10]. To address these issues, non-traditional technologies, such as microwave-assisted extraction and supercritical carbon dioxide (SC-CO_2), are used [11]. According to [2], the leaves contain more volatile components (essential oils) than the stems, flowers, and rhizomes. The antioxidant component extracts from kecombrang flowers range from 61.61 to 83.17 percent, those from the stems range from 57.42 to 84.65 percent, those from the leaves range from 40.64 to 60.40 percent, and those from the rhizomes range from 58.40 to 69.66 percent [12]. This shows that the flowers and stems contain a greater concentration of bioactive chemicals with antioxidant activity than the leaves and rhizomes.

Of the various extraction methods, conventional or traditional methods are still attractive for use in the industry. The industry and researchers still rely on traditional or solvent extraction techniques to generate high quantities of chemicals with relatively simple and inexpensive equipment [13]. For example, maceration, percolation, and reflux extraction do not require expensive solvents and can be conducted at atmospheric pressure. When it comes to solvent extraction, the choice of solvent is critical. When choosing a solvent, selectivity, solubility, cost, and safety should be taken into account [14].

The extraction will be more efficient if the diffusivity and solubility of the solute is increased. Important factors that can influence the extraction are particle size, type of solvent, ratio of solvent to solid, temperature, and extraction time (duration) [15–17].

Several studies on natural product extraction suggest temperatures ranging from 40 °C to 100 °C and extraction times ranging between 10 min and more than 2 h [16,18,19]. These two factors can be controlled by applying automatic control to the extraction machine. Automatic control with electronic principles for processing machines is easy to implement practically [20–22].

On an industrial scale, this powdered form typically preserves the natural flavor of the raw material, making it impractical. However, few studies have been conducted to standardize the manufacturing process, which is a vital stage in the production of kecombrang powder or extract. Numerous studies have indicated that there is currently no way to standardize the manufacturing process, which is a vital stage in processing kecombrang plants. Before the powder enters the industrial process, a method of process control is required to produce kecombrang powder with the highest standardized bioactive component. However, research on the quality parameter related to processing each kecombrang plant component is lacking, even in Indonesia.. Therefore, this study was conducted with the objective of standardizing process quality in kecombrang powder in order to achieve high-quality bioactive components.

To date, there has been no standardization of the kecombrang plant's processing to manufacture phenol and flavonoid components on an industrial scale. Because the flavonoid and phenol concentrations vary throughout processing, we applied a machine learning technique to model the temperature and time processing to standardize the procedure of the extraction process. Artificial neural networks (ANNs) were used to obtain the optimal value by inputting previous research data in the learning process (training).

Currently, the use of ANNs in food science as well as their practical application in food processing is common [23–26]. The objective of this study was to standardize the quality of the kecombrang flower extraction process before the extract enters industrial processes. Specifically, the purpose of this study was to determine the effect of temperature and extraction process time on the quality parameters of kecombrang flower extract preparations using an artificial neural network (ANN). Time and temperature were used as inputs for the ANN. The output to be produced was the quality parameters, namely the levels of phenols and flavonoids. This ANN modeling process is important for designing control systems. The temperature and the extraction time can be used directly as set-points for designing the control system, which is common. Moreover, to directly use phenol and flavonoid levels as set-points, we need a control algorithm that includes machine learning. The work in this paper involves two stages. First, we create a machine learning model using an artificial neural network to estimate the quality parameters of the extraction process of kecombrang flowers. Second, the ANN model is used to formulate a strategy for controlling the extraction process to produce the best-quality kecombrang extract.

2. Materials and Methods

The overall process in a kecombrang processing plant is shown in Figure 1. The process of extraction occurs after the milling of dried samples (appears in the dashed red line box). The maceration method is used for extraction. It involves water, a temperature range of 60–75 °C, and mixing for 4 h (240 min).

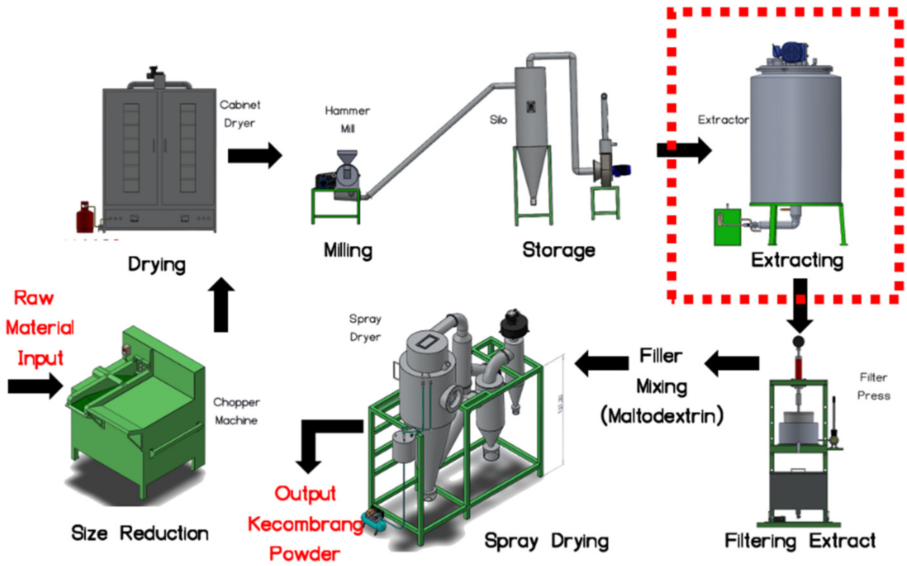

Figure 1. Design of the kecombrang processing plant.

Kecombrang flower extraction machines that are applied in industrial plants are batch extraction machines. Figure 2 shows the scheme of a conventional extraction machine modified from [27], which is the machine used in this study. This extraction does not require cooling in the same way as a common distillation process. Output substances are further processed via filtering without cooling.

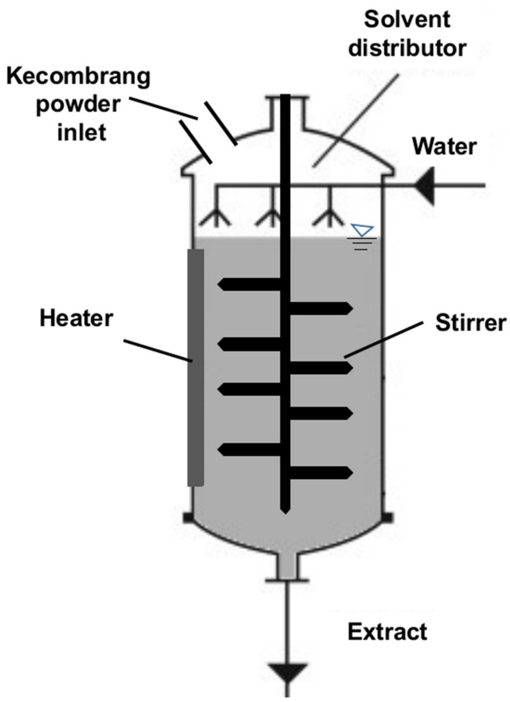

Figure 2. Industrial extraction machine.

Making a kecombrang flower extract requires kecombrang flowers that have been dried and ground into powder. Kecombrang flower powder is placed in the extractor with water at a ratio of 1:14. In the extractor machine, the water is heated to a temperature above 50 °C. Extraction is carried out in the machine for 3 h or more.

Extraction using four different temperatures was conducted in order gather data. The temperature treatments included 60 °C, 65 °C, 70 °C, and 75 °C. Four quality parameters, namely color, viscosity, and phenol and flavonoid contents, were measured every 5 min during extraction as a time series. Phenol and flavonoid contents were determined by laboratory measurement of the sample. Color was measured using Color Reader C10 from Minolta, and viscosity was measured using Brookfield's Viscometer.

Color reader outputs used the CIE L*a*b system. In the measuring unit, the higher the value of L, the greater the lightness of a color and vice versa. Color measurements took only L and *a* parameters. The higher the value of a, the higher the redness of the color. Conversely, the lower it is, the higher the greenness of the color. [28]. Viscosity data were presented in the form of cP and tor.

Machine Learning Model and Control System Design

The machine learning model was developed using an artificial neural network [29] . The model used the backpropagation method for data learning. A network structure of 2–6–1 (2 nodes in input layer, 6 nodes in hidden layer, and 1 node in output layer) was chosen. This structure was chosen after experiments using more complex structures did not show different result. A structure that uses 1 hidden layer only is good for simplicity (Figure 3). The data were split into two sets: a training dataset and a testing dataset. The 70–30 rule of training–testing was applied. Each quality parameter dataset was trained separately. The performance of the ANN model was evaluated for each quality parameter using correlations between observed and ANN model outputs. If the correlation between the training dataset and the testing dataset was medium or strong, then the model was used as a predictor for the quality parameter of kecombrang extraction. Furthermore, if the correlation between the training dataset and the testing dataset was weak, a new ANN architecture was used by adding nodes to the hidden layer or by increasing the number of hidden layers.

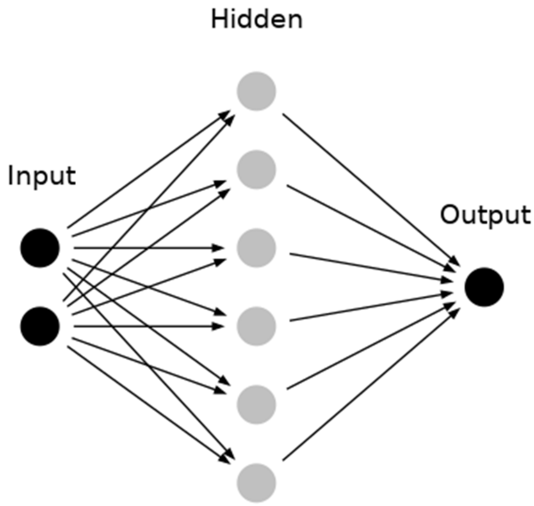

Figure 3. The structure of the 2 (inputs)–6 (hidden layer nodes)–1 (output) ANN.

The ANN model produced in the previous step was used to design the adaptive control system of the extraction machine [30].

3. Results and Discussion

3.1. Quality Parameters

The quality parameters that are discussed in this paper are flavonoid content, phenol content, color, viscosity, and pH. Antioxidants are the main focus in the content, as they are important components of functional ingredients. For the production of functional ingredients, the process must be able to maintain consistent maximal levels of phenols and flavonoids. The process settings that can be set on the extraction machine are time and temperature. However, time and temperature may also change other quality parameters, such as viscosity, color, and pH. Viscosity, color, and pH are parameters that are related to human preferences.

Data on the dynamics of phenol, flavonoid, pH, viscosity, and color at various temperatures (60 °C, 65 °C, 70 °C, and 75 °C) during the extraction process are described below.

3.1.1. Phenols

From Figure 4, we can see that both the extraction time and the extraction temperature influenced the phenol content. The extraction time shows a rising trend after 100 min for all temperatures except 75 °C. An increase in temperature also increased the phenol content. The optimum operation for obtaining the highest phenol content involved using a temperature of 70 °C and an extraction time of 163 min (125 mg TAE/100 g).

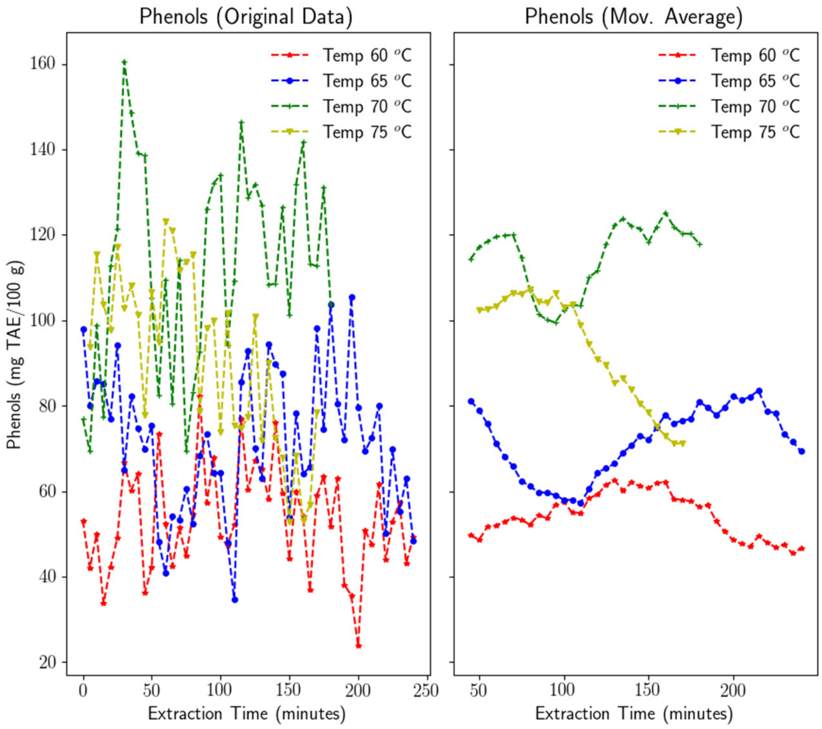

Figure 4. Phenol content with different extraction times and at different temperatures.

3.1.2. Flavonoids

Figure 5 shows that the flavonoid content increases with the extraction time. Each temperature treatment shows the same trend. However, at 240 min, when the extraction ended, higher flavonoid levels were obtained at the lowest temperature (60 °C). At 110 min, higher temperatures (70 and 75 °C) resulted in higher flavonoid levels. This creates a dilemma whereby the best results are obtained with low temperature–long time (LT–LT) or high temperature–short time (HT–ST) processes. The process that results in the highest flavonoid content should be considered as the operating standard for extraction.

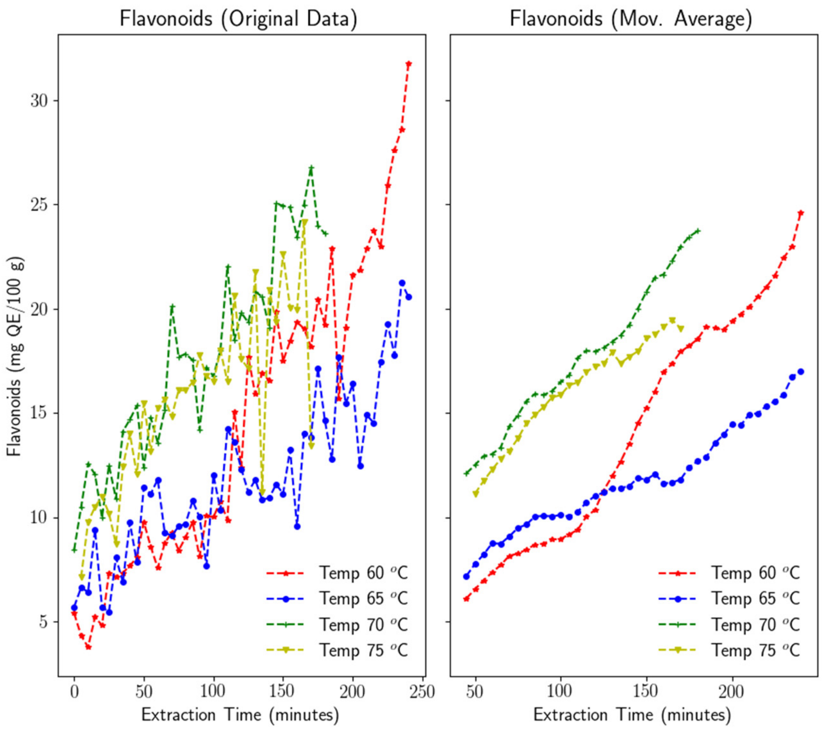

Figure 5. Flavonoid content with different extraction times and at different temperatures.

3.1.3. pH

There was no remarkable change in pH at different extraction temperatures or with different extraction times. The values ranged between 3.3 and 3.6, with both representing low pH values (acidic conditions) (Figure 6). A constant pH level was observed at an extraction temperature of 60 °C. An increase in pH was observed over time at 65 °C until it was close to that of 60 °C. At 70 and 75 °C, the pH decreased as the extraction time increased. Thus, we conclude that temperature treatment and extraction time do not have much of an effect on pH. However, extraction results with a pH close to neutral are preferred.

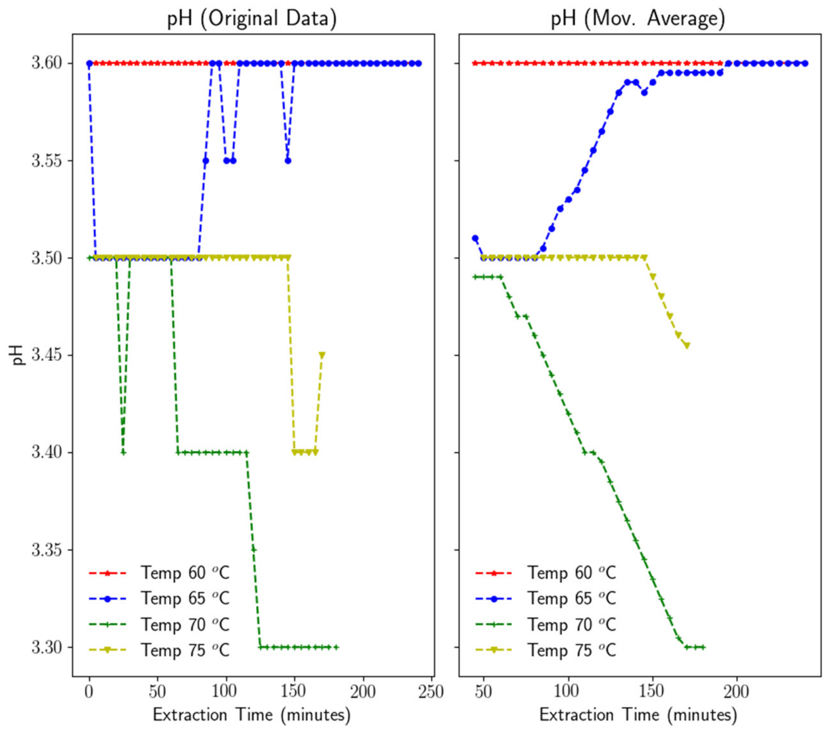

Figure 6. pH with different extraction times and at different temperatures.

3.1.4. Viscosity

Viscosity showed a trend of decreasing as the extraction time increased (Figure 7). The steepest decrease occurred at 75 °C, the highest temperature. The value ranged from 3.5 to 7.0 cP.

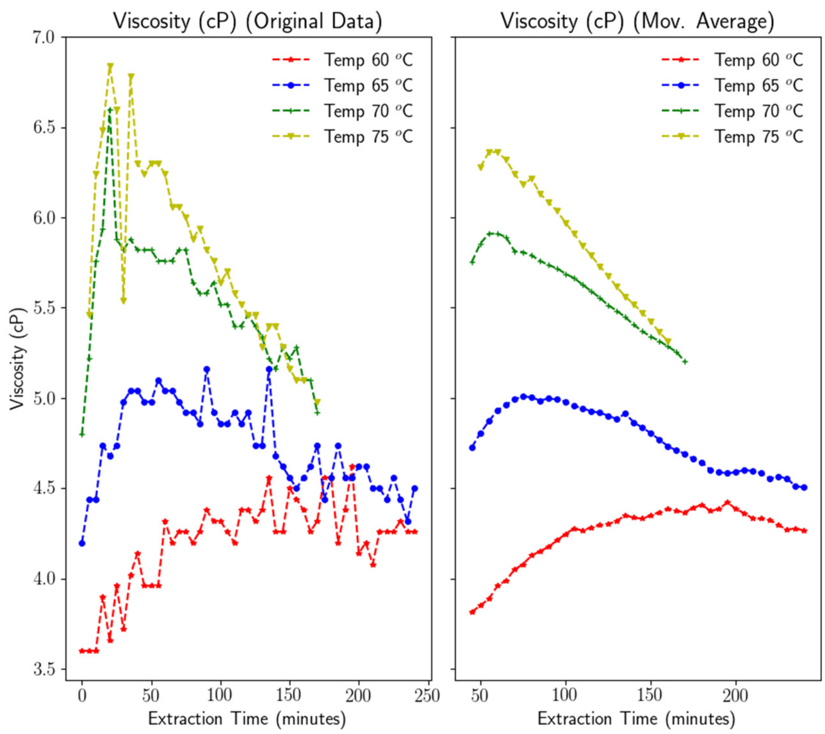

Figure 7. Viscosity cP with different extraction times and at different temperatures.

3.1.5. Color

The value of L (lightness) is higher at 60 °C than at 65 °C. However, the value of L is even higher at 70 and 75 °C (Figure 8). Similarly, the value of a at the end of the extraction time is higher at 60 °C than at 65 °C. The value of a also increases with extraction time at 70 and 75 °C, potentially exceeding the a value at 60 °C (Figure 9).

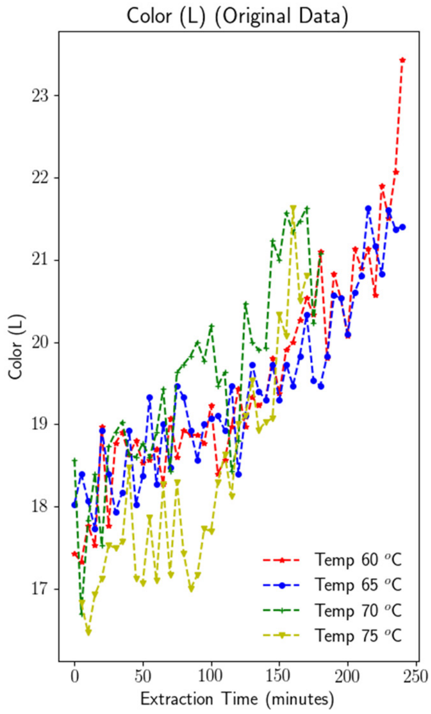

Figure 8. Color (L) with different extraction times and at different temperatures.

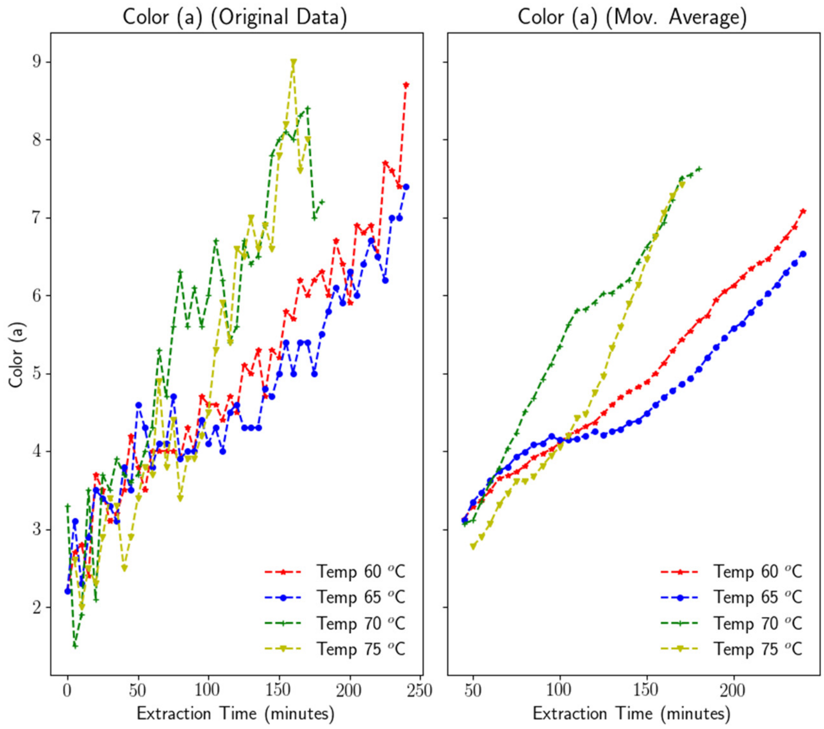

Figure 9. Color (a) with different extraction times and at different temperatures.

3.2. Training of the Machine Learning Model

The ANN model used three layers (one input layer, one hidden layer, and one output layer) to maintain simplicity. The hidden layer consists of six nodes. Training for all quality parameter data was performed using 5000 iterations. Experiments with more than 5000 iterations showed similar convergence results. The correlation between the ANN model's output (prediction) and the data is shown in Figure 10. As can be seen, viscosity and color are the parameters with the largest correlation values. The value of pH varied in the ANN output, while the actual data showed only small variations.

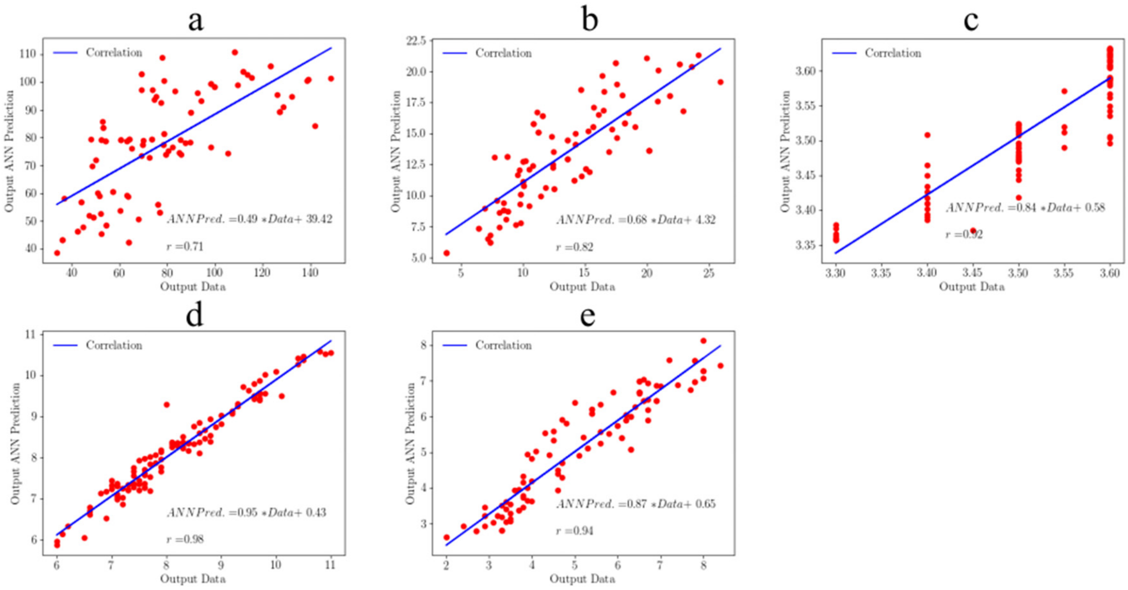

Figure 10. Correlation between output ANN prediction and output data for the training dataset (**a**) Phenols, (**b**) Flavonoids, (**c**) pH, (**d**) Viscosity, (**e**) Color.

Phenols and flavonoids, as the main quality parameters, show relatively lower (but still strong) correlations ($0.5 \leq |r| < 1$), of 0.71 and 0.82, respectively. Non-linearity with phenols is clearly seen compared to flavonoids. Figures 4 and 5 confirm this fact. Both flavonoid and phenol contents increase with an increase in extraction temperature and extraction time, while phenol shows an unclear pattern with changes in temperature and extraction time.

3.3. Testing of the Machine Learning Model

The generalization of the model was conducted using the testing dataset. The purpose of the model is to predict the kecombrang plant processing extraction process. Thus, underfitting and overfitting must be avoided. The temperature and the extraction time should help accurately predict the phenol and flavonoid contents so precise decisions can be made regarding the extraction process control system.

The prediction of quality parameters using the testing dataset and the model obtained from training results shows a good correlation (Figure 11). Of all the parameters, the correlation value of phenol is still the lowest (but still strong), at 0.71. The correlation values obtained from the training data and testing data are not significantly different from each other, so it can be concluded that this model is accurate and feasible for use in control systems.

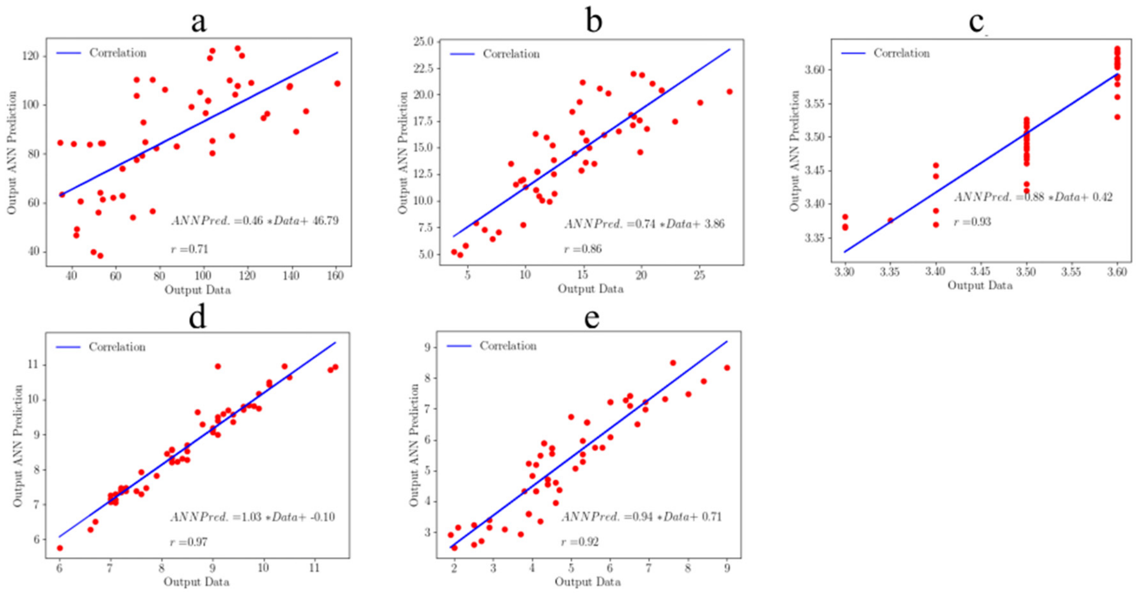

Figure 11. Correlation between output ANN prediction and output data for the testing dataset (**a**) Phenols, (**b**) Flavonoids, (**c**) pH, (**d**) Viscosity, (**e**) Color.

3.4. Concept of Applying the Model into the Control System

Applying the ANN model in a control system of the extraction process is useful for improving the performance of the control system. The ANN model can measure ongoing extraction process data for the self-learning process. The ANN has a good ability to adjust control parameters as variations occur in the system [31]. The ANN model can be applied to the control system structure to improve the quality parameters of the extraction results. As a functional food product, the purpose of the control system is to control the quality of antioxidants, namely phenols and flavonoids. Other quality parameters (pH, viscosity, and color) are relatively tolerable if phenols and flavonoids are at the highest levels possible.

There are two control strategies for the extraction process. The first involves directly using the temperature and the extraction time as a set-point (Figure 12a). The extraction operation time is set, while the operating temperature becomes the set-point that is input as the control variable. In this way, the ANN model can be used to determine the values of phenols and flavonoids and to compare them to the output of the control system [32,33]. A comparison of the output of the control system and the ANN model can also be a strategy for model improvement. This method can be classified as indirect neuro-control [32]. The new data obtained in the extraction process are used as additional training data so that the ANN model and the observation data (data measured from the extraction process) have similar values. The controller must maintain the temperature at the set-point value. This is a commonly used method.

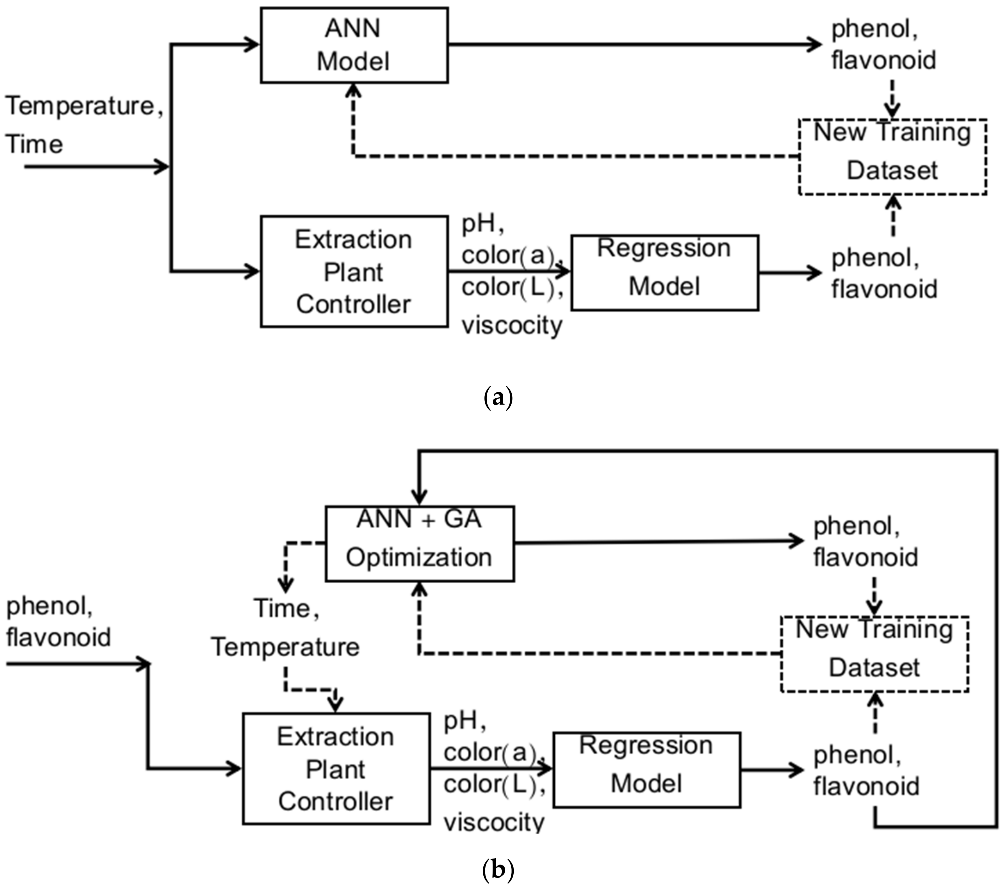

Figure 12. Indirect (**a**) and direct (**b**) neuro-control design.

The second method involves using the levels of phenols and flavonoids as a set-point (Figure 12b). The extraction operation time and temperature become a new set-point variable that varies according to the values of phenols and flavonoids obtained from the control system. This method can be classified as direct neuro-control [34]. In this direct-neuro controller control method, the set-point, in the form of the phenol and flavonoid parameters, is optimized using the ANN model and a genetic algorithm [31,35,36] to obtain new extraction temperature and time. The input in the form of temperature and extraction time is the new set-point that must be maintained by the extractor. Thus, the target values of phenols and flavonoids will be achieved. In this method, phenols and flavonoids in the extractor are approached by measuring the values of color, pH, and viscosity as an approximation model. The close relationship between the estimators (color, pH, and viscosity) and the predicted parameters (phenols–flavonoids) can be seen in the correlation matrix (Figure 13).

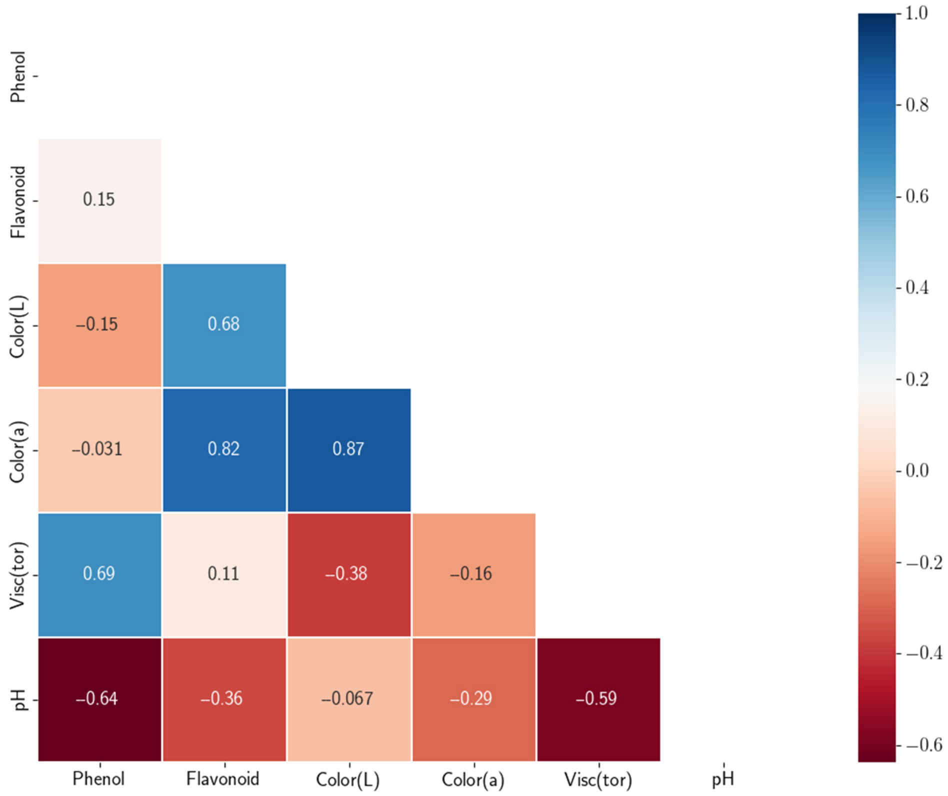

Figure 13. Parameter pair correlations.

The correlation shows how strongly one dataset is related to the other dataset. Although it does not show a cause-and-effect relationship, the correlation is a useful indicator for making linear prediction models [37,38]. The correlation matrix shows that for phenol, a strong correlation value ($0.5 \le |r| < 1$) is given by pH and viscosity, which are −0.64 and 0.69, respectively. In flavonoids, color (a) and color (L), also have strong correlations, of 0.82 and 0.68, respectively. Phenol and flavonoid levels can be approximated (predicted) from the parameters that have a strong correlation with them. Multilinear regression is used for this. The equations obtained from the respective regressions are:

$$\text{Phenol} = 402.48 + 11.20 \cdot \text{Visc(tor)} - 118 \cdot \text{pH} \quad (1)$$

$$\text{Flavonoid} = 11.20 - 0.66 \cdot \text{Color (L)} + 3.26 \cdot \text{Color (a)} \quad (2)$$

In the implementation of the two control strategies, pH, color (a), color (L), and viscosity data are needed as inputs for Equations (1) and (2). Sampling or sensing using sensors for pH, color (a), color (L), and viscosity is required during the extraction process.

During the experimental operation of the extraction at various temperatures and extraction times, data on the quality parameters of the extraction results were obtained. When applied to a production plant, the extraction process may differ due to scaling from the experiment. Neuro-control design allows for the updating of the training data from the experimental data to the production data. ANN model training with updated data can be conducted periodically. There is a possibility that there is a change in the temperature value and the optimum extraction time so that optimization continues to be carried out periodically with additional data.

4. Conclusions

To obtain kecombrang extracts with maximum phenol and flavonoid contents, the extraction process in an industrial plant needs to be controlled. The measurement of extract samples must always be carried out in an effort to maintain quality. It is necessary to apply an adaptive control system to monitor changes in extract quality. An ANN model can subsequently be used in the extraction process control strategy, with both indirect and direct neuro-control schemes.

From this research, it can be concluded that backpropagation ANN can well model the extraction process for kecombrang flowers. This can be seen from the correlation value between the observation data and the prediction model, in terms of both the training data and the testing data. The ANN model predicts phenols, flavonoids, pH, viscosity, and color using time and temperature as inputs. The ANN model can further be used as a tool for optimization. The combination of both inputs to produce the desired levels of phenols and flavonoids can be determined using a direct neuro-control strategy.

Furthermore, from the correlation parameter pairs, it can be seen that phenols and flavonoids, as the main quality parameters, can be approximated by regression equations from other quality parameters. These parameters are pH, viscosity, and color. This finding is useful for predicting phenol and flavonoid levels in real time inside the control system. Phenol and flavonoid values can be directly fed back to the ANN model.

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Machine Learning Model for Quality Parameters Prediction and Control System Design in the Kecombrang Flower (Etlingera elatior) Extraction Process

by Ardiansyah Ardiansyah

processes

Article

Machine Learning Model for Quality Parameters Prediction and Control System Design in the Kecombrang Flower (*Etlingera elatior*) Extraction Process

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Abstract: Kecombrang flowers have bioactive components that can be used as food additives. The development of the kecombrang functional food industry for the production of food additives requires information on production parameters. The extraction process for kecombrang to obtain bioactive components, especially phenols and flavonoids, requires maximum temperature treatment and extraction time. This study aims to determine the standard for the kecombrang flower extraction process, create a machine learning model to estimate the quality parameters of the extraction results (phenol, flavonoid, pH, color, and viscosity), and design a strategy for controlling the extraction machine work to maintain the quality of the extraction, especially of phenols and flavonoids. This research was conducted at extraction temperatures of 60 °C, 65 °C, 70 °C, and 75 °C. During the extraction process, the quality of the material was checked by measuring phenol and flavonoid contents, as well as color, pH, and viscosity. Sampling was carried out at 5 min intervals. The data on the quality parameters during the extraction process were analyzed for trends. A machine learning model, which is an artificial neural network, was developed using a 2–6–1 architecture for each quality parameter. The two inputs of ANN were temperature of extraction and extraction time (duration). The output was the quality parameters of the products (phenols, flavonoids, pH, viscosity, and color), which were evaluated separately. The results show a good correlation between the model and the experimental data, with both the training dataset and the testing dataset. These results were then used to formulate a strategy for controlling the extraction process. A neuro-control system was used as a strategy. This control system was adaptive to changes that occurred during the extraction process so that phenols and flavonoids could be maintained.

Keywords: kecombrang flower; extraction process; quality parameters; machine learning model; neuro-control system

1. Introduction

Plant-based bioactive compounds have attracted great interest as viable alternatives to synthetic materials due to their antibacterial, anti-inflammatory, and antioxidant properties. The extraction and processing of several parts of kecombrang, or torch ginger (*Etlingera elatior*), such as the leaves, torches, stems, flowers, and rhizomes, have also been the subject of extensive investigation. The earliest stages of the study focused on identifying the bioactive components found in the kecombrang plant and defining the function and application of each discovered compound [1–4]. Kecombrang is a plant that is native to Indonesia and Malaysia and is widespread in Southeast Asia. For generations, local people have used and exploited the plant for food, condiments, medicine, and food flavoring [5].

The active chemicals in the kecombrang plant are considered to be less effective and to have a shorter shelf life when the plant parts are used fresh. Thus, the contents of kecombrang plants need to be extracted, dried, modified, and further processed to preserve their bioactive components [6]. While drying kecombrang powder increases its durability by reducing its water content, it also damages the bioactive components found in fresh kecombrang flowers [7]. As a result, the ideal drying temperature and duration for powdering kecombrang must be determined to avoid the degradation of some of its bioactive components, such as phenols, flavonoids, and vitamin C, which results in a loss of its antioxidant action.

Extraction is critical for obtaining a desired bioactive component from kecombrang, as the chemicals are present in trace amounts in plants. According to [8], there are two primary approaches for extracting bioactive compounds from plants: traditional methods and nonconventional methods. Hydrodistillation [2], column chromatography [9], Soxhlet extraction, and maceration are all examples of classical extraction methods. Conventional methods have disadvantages in terms of increased reliance on high-purity organic solvents, increased cost, decreased extraction efficiency, prolonged processing time, and increased temperature [10]. To address these issues, non-traditional technologies, such as microwave-assisted extraction and supercritical carbon dioxide (SC-CO_2), are used [11]. According to [2], the leaves contain more volatile components (essential oils) than the stems, flowers, and rhizomes. The antioxidant component extracts from kecombrang flowers range from 61.61 to 83.17 percent, those from the stems range from 57.42 to 84.65 percent, those from the leaves range from 40.64 to 60.40 percent, and those from the rhizomes range from 58.40 to 69.66 percent [12]. This shows that the flowers and stems contain a greater concentration of bioactive chemicals with antioxidant activity than the leaves and rhizomes.

Of the various extraction methods, conventional or traditional methods are still attractive for use in the industry. The industry and researchers still rely on traditional or solvent extraction techniques to generate high quantities of chemicals with relatively simple and inexpensive equipment [13]. For example, maceration, percolation, and reflux extraction do not require expensive solvents and can be conducted at atmospheric pressure. When it comes to solvent extraction, the choice of solvent is critical. When choosing a solvent, selectivity, solubility, cost, and safety should be taken into account [14].

The extraction will be more efficient if the diffusivity and solubility of the solute is increased. Important factors that can influence the extraction are particle size, type of solvent, ratio of solvent to solid, temperature, and extraction time (duration) [15–17].

Several studies on natural product extraction suggest temperatures ranging from 40 °C to 100 °C and extraction times ranging between 10 min and more than 2 h [16,18,19]. These two factors can be controlled by applying automatic control to the extraction machine. Automatic control with electronic principles for processing machines is easy to implement practically [20–22].

On an industrial scale, this powdered form typically preserves the natural flavor of the raw material, making it impractical. However, few studies have been conducted to standardize the manufacturing process, which is a vital stage in the production of kecombrang powder or extract. Numerous studies have indicated that there is currently no way to standardize the manufacturing process, which is a vital stage in processing kecombrang plants. Before the powder enters the industrial process, a method of process control is required to produce kecombrang powder with the highest standardized bioactive component. However, research on the quality parameter related to processing each kecombrang plant component is lacking, even in Indonesia.. Therefore, this study was conducted with the objective of standardizing process quality in kecombrang powder in order to achieve high-quality bioactive components.

To date, there has been no standardization of the kecombrang plant's processing to manufacture phenol and flavonoid components on an industrial scale. Because the flavonoid and phenol concentrations vary throughout processing, we applied a machine learning technique to model the temperature and time processing to standardize the procedure of the extraction process. Artificial neural networks (ANNs) were used to obtain the optimal value by inputting previous research data in the learning process (training).

Currently, the use of ANNs in food science as well as their practical application in food processing is common [23–26]. The objective of this study was to standardize the quality of the kecombrang flower extraction process before the extract enters industrial processes. Specifically, the purpose of this study was to determine the effect of temperature and extraction process time on the quality parameters of kecombrang flower extract preparations using an artificial neural network (ANN). Time and temperature were used as inputs for the ANN. The output to be produced was the quality parameters, namely the levels of phenols and flavonoids. This ANN modeling process is important for designing control systems. The temperature and the extraction time can be used directly as set-points for designing the control system, which is common. Moreover, to directly use phenol and flavonoid levels as set-points, we need a control algorithm that includes machine learning. The work in this paper involves two stages. First, we create a machine learning model using an artificial neural network to estimate the quality parameters of the extraction process of kecombrang flowers. Second, the ANN model is used to formulate a strategy for controlling the extraction process to produce the best-quality kecombrang extract.

2. Materials and Methods

The overall process in a kecombrang processing plant is shown in Figure 1. The process of extraction occurs after the milling of dried samples (appears in the dashed red line box). The maceration method is used for extraction. It involves water, a temperature range of 60–75 °C, and mixing for 4 h (240 min).

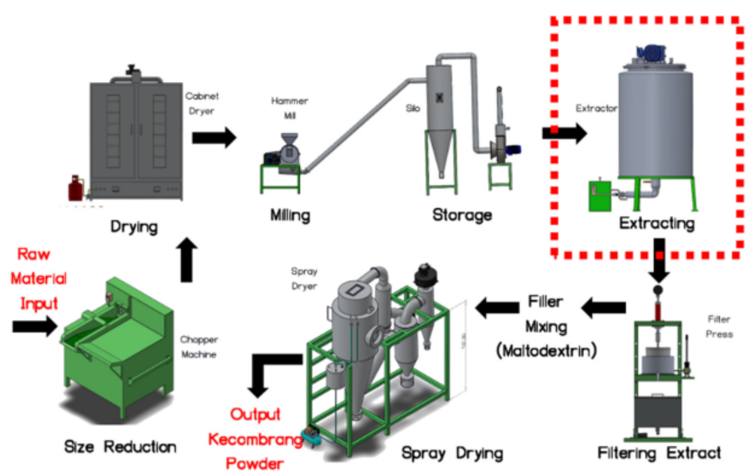


Figure 1. Design of the kecombrang processing plant.

Kecombrang flower extraction machines that are applied in industrial plants are batch extraction machines. Figure 2 shows the scheme of a conventional extraction machine modified from [27], which is the machine used in this study. This extraction does not require cooling in the same way as a common distillation process. Output substances are further processed via filtering without cooling.

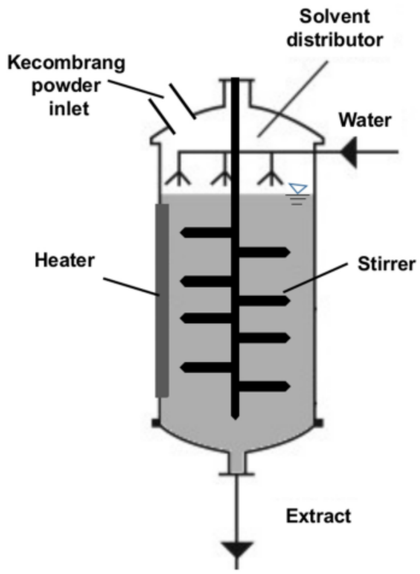


Figure 2. Industrial extraction machine.

Making a kecombrang flower extract requires kecombrang flowers that have been dried and ground into powder. Kecombrang flower powder is placed in the extractor with water at a ratio of 1:14. In the extractor machine, the water is heated to a temperature above 50 °C. Extraction is carried out in the machine for 3 h or more.

Extraction using four different temperatures was conducted in order gather data. The temperature treatments included 60 °C, 65 °C, 70 °C, and 75 °C. Four quality parameters, namely color, viscosity, and phenol and flavonoid contents, were measured every 5 min during extraction as a time series. Phenol and flavonoid contents were determined by laboratory measurement of the sample. Color was measured using Color Reader C10 from Minolta, and viscosity was measured using Brookfield's Viscometer.

Color reader outputs used the CIE L*a*b system. In the measuring unit, the higher the value of L, the greater the lightness of a color and vice versa. Color measurements took only L and *a* parameters. The higher the value of a, the higher the redness of the color. Conversely, the lower it is, the higher the greenness of the color. [28]. Viscosity data were presented in the form of cP and tor.

Machine Learning Model and Control System Design

The machine learning model was developed using an artificial neural network [29] . The model used the backpropagation method for data learning. A network structure of 2–6–1 (2 nodes in input layer, 6 nodes in hidden layer, and 1 node in output layer) was chosen. This structure was chosen after experiments using more complex structures did not show different result. A structure that uses 1 hidden layer only is good for simplicity (Figure 3). The data were split into two sets: a training dataset and a testing dataset. The 70–30 rule of training–testing was applied. Each quality parameter dataset was trained separately. The performance of the ANN model was evaluated for each quality parameter using correlations between observed and ANN model outputs. If the correlation between the training dataset and the testing dataset was medium or strong, then the model was used as a predictor for the quality parameter of kecombrang extraction. Furthermore, if the correlation between the training dataset and the testing dataset was weak, a new ANN architecture was used by adding nodes to the hidden layer or by increasing the number of hidden layers.

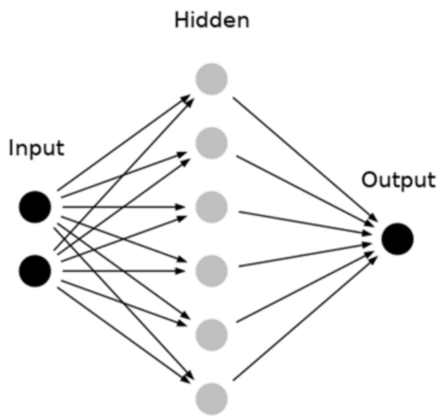


Figure 3. The structure of the 2 (inputs)–6 (hidden layer nodes)–1 (output) ANN.

The ANN model produced in the previous step was used to design the adaptive control system of the extraction machine [30].

3. Results and Discussion

3.1. Quality Parameters

The quality parameters that are discussed in this paper are flavonoid content, phenol content, color, viscosity, and pH. Antioxidants are the main focus in the content, as they are important components of functional ingredients. For the production of functional ingredients, the process must be able to maintain consistent maximal levels of phenols and flavonoids. The process settings that can be set on the extraction machine are time and temperature. However, time and temperature may also change other quality parameters, such as viscosity, color, and pH. Viscosity, color, and pH are parameters that are related to human preferences.

Data on the dynamics of phenol, flavonoid, pH, viscosity, and color at various temperatures (60 °C, 65 °C, 70 °C, and 75 °C) during the extraction process are described below.

3.1.1. Phenols

From Figure 4, we can see that both the extraction time and the extraction temperature influenced the phenol content. The extraction time shows a rising trend after 100 min for all temperatures except 75 °C. An increase in temperature also increased the phenol content. The optimum operation for obtaining the highest phenol content involved using a temperature of 70 °C and an extraction time of 163 min (125 mg TAE/100 g).

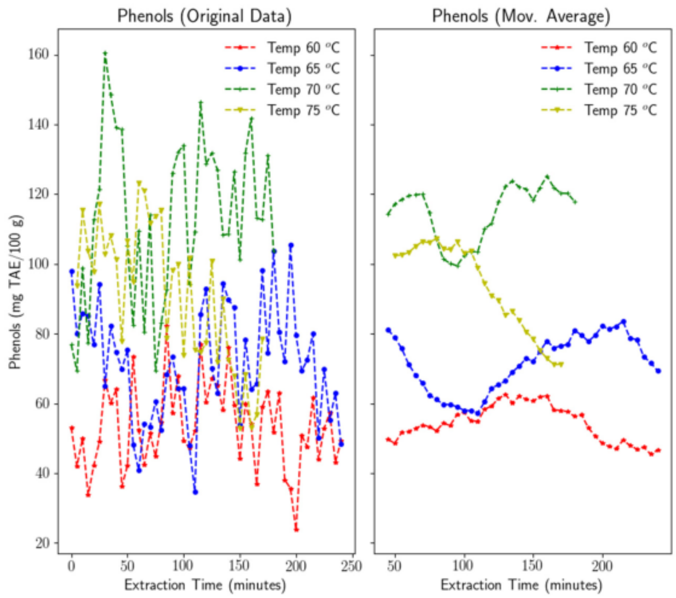


Figure 4. Phenol content with different extraction times and at different temperatures.

3.1.2. Flavonoids

Figure 5 shows that the flavonoid content increases with the extraction time. Each temperature treatment shows the same trend. However, at 240 min, when the extraction ended, higher flavonoid levels were obtained at the lowest temperature (60 °C). At 110 min, higher temperatures (70 and 75 °C) resulted in higher flavonoid levels. This creates a dilemma whereby the best results are obtained with low temperature–long time (LT–LT) or high temperature–short time (HT–ST) processes. The process that results in the highest flavonoid content should be considered as the operating standard for extraction.

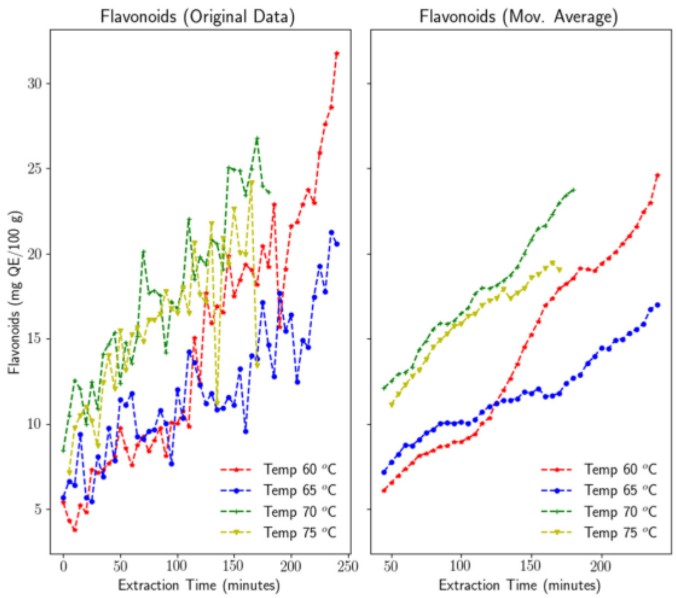


Figure 5. Flavonoid content with different extraction times and at different temperatures.

3.1.3. pH

There was no remarkable change in pH at different extraction temperatures or with different extraction times. The values ranged between 3.3 and 3.6, with both representing low pH values (acidic conditions) (Figure 6). A constant pH level was observed at an extraction temperature of 60 °C. An increase in pH was observed over time at 65 °C until it was close to that of 60 °C. At 70 and 75 °C, the pH decreased as the extraction time increased. Thus, we conclude that temperature treatment and extraction time do not have much of an effect on pH. However, extraction results with a pH close to neutral are preferred.

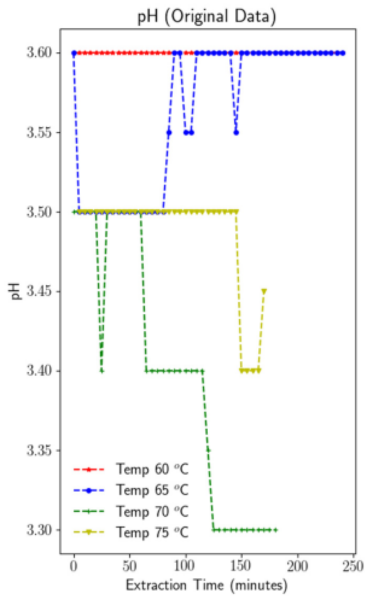


Figure 6. pH with different extraction times and at different temperatures.

3.1.4. Viscosity

Viscosity showed a trend of decreasing as the extraction time increased (Figure 7). The steepest decrease occurred at 75 °C, the highest temperature. The value ranged from 3.5 to 7.0 cP.

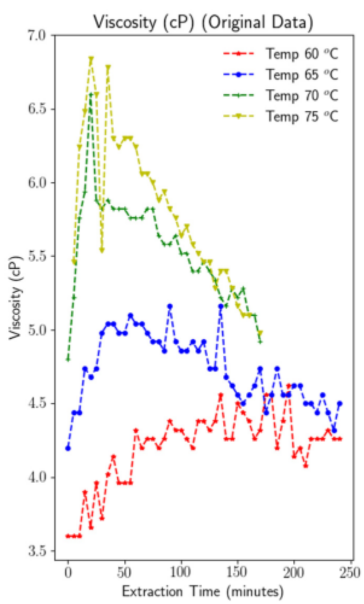


Figure 7. Viscosity cP with different extraction times and at different temperatures.

3.1.5. Color

The value of L (lightness) is higher at 60 °C than at 65 °C. However, the value of L is even higher at 70 and 75 °C (Figure 8). Similarly, the value of a at the end of the extraction time is higher at 60 °C than at 65 °C. The value of a also increases with extraction time at 70 and 75 °C, potentially exceeding the a value at 60 °C (Figure 9).

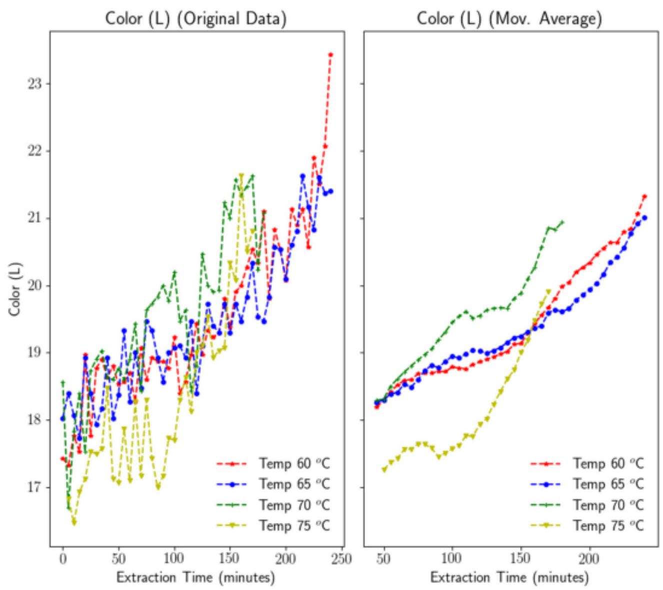


Figure 8. Color (L) with different extraction times and at different temperatures.

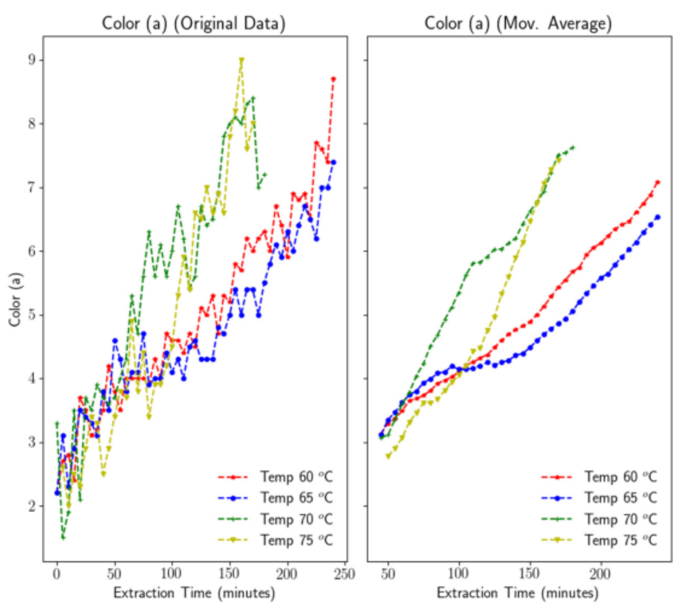


Figure 9. Color (a) with different extraction times and at different temperatures.

3.2. Training of the Machine Learning Model

The ANN model used three layers (one input layer, one hidden layer, and one output layer) to maintain simplicity. The hidden layer consists of six nodes. Training for all quality parameter data was performed using 5000 iterations. Experiments with more than 5000 iterations showed similar convergence results. The correlation between the ANN model's output (prediction) and the data is shown in Figure 10. As can be seen, viscosity and color are the parameters with the largest correlation values. The value of pH varied in the ANN output, while the actual data showed only small variations.

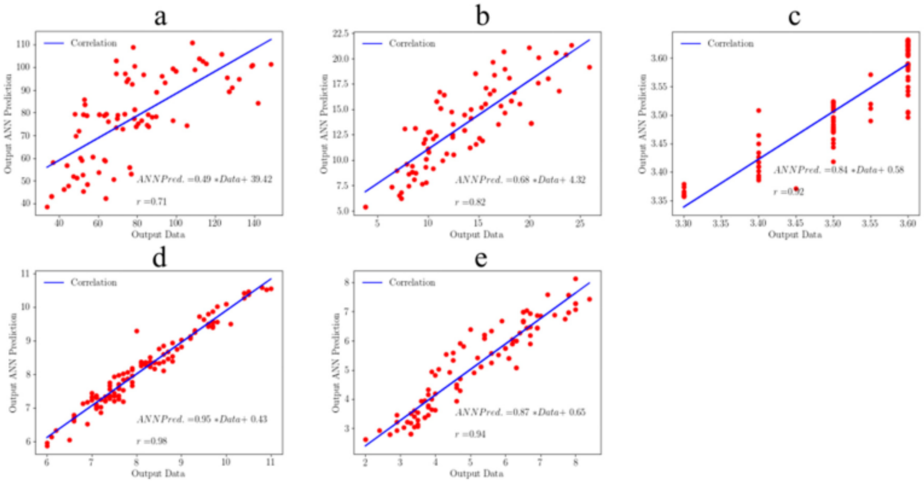


Figure 10. Correlation between output ANN prediction and output data for the training dataset (**a**) Phenols, (**b**) Flavonoids, (**c**) pH, (**d**) Viscosity, (**e**) Color.

Phenols and flavonoids, as the main quality parameters, show relatively lower (but still strong) correlations (0.5 ≤ |r|< 1), of 0.71 and 0.82, respectively. Non-linearity with phenols is clearly seen compared to flavonoids. Figures 4 and 5 confirm this fact. Both flavonoid and phenol contents increase with an increase in extraction temperature and extraction time, while phenol shows an unclear pattern with changes in temperature and extraction time.

3.3. Testing of the Machine Learning Model

The generalization of the model was conducted using the testing dataset. The purpose of the model is to predict the kecombrang plant processing extraction process. Thus, underfitting and overfitting must be avoided. The temperature and the extraction time should help accurately predict the phenol and flavonoid contents so precise decisions can be made regarding the extraction process control system.

The prediction of quality parameters using the testing dataset and the model obtained from training results shows a good correlation (Figure 11). Of all the parameters, the correlation value of phenol is still the lowest (but still strong), at 0.71. The correlation values obtained from the training data and testing data are not significantly different from each other, so it can be concluded that this model is accurate and feasible for use in control systems.

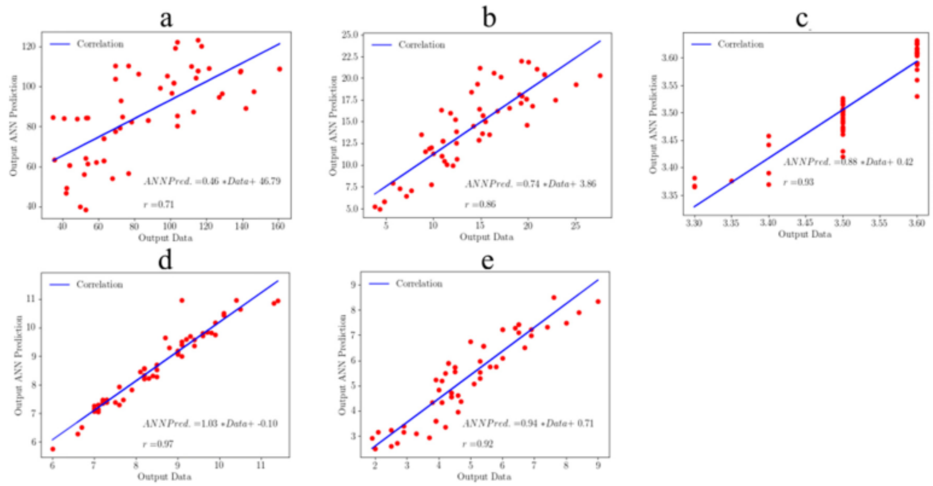
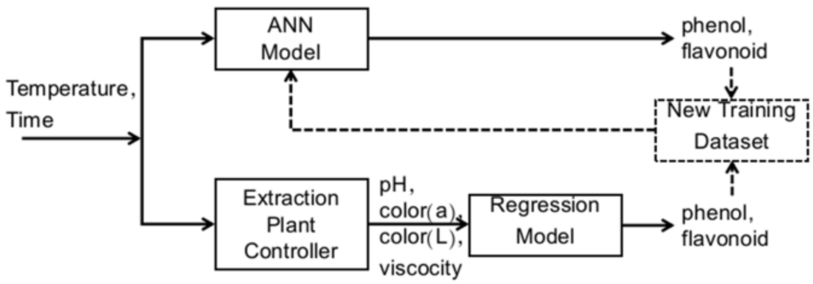


Figure 11. Correlation between output ANN prediction and output data for the testing dataset (**a**) Phenols, (**b**) Flavonoids, (**c**) pH, (**d**) Viscosity, (**e**) Color.

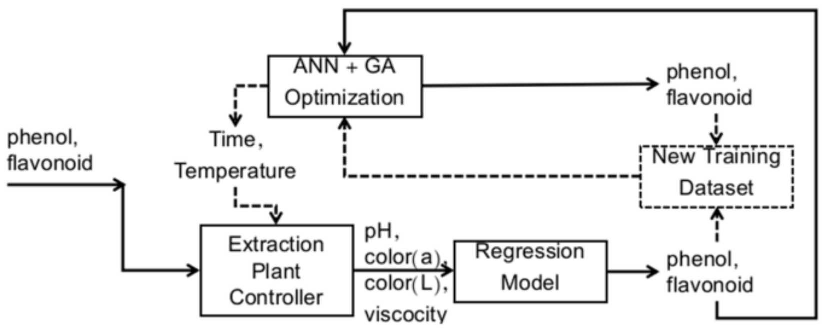
3.4. Concept of Applying the Model into the Control System

Applying the ANN model in a control system of the extraction process is useful for improving the performance of the control system. The ANN model can measure ongoing extraction process data for the self-learning process. The ANN has a good ability to adjust control parameters as variations occur in the system [31]. The ANN model can be applied to the control system structure to improve the quality parameters of the extraction results. As a functional food product, the purpose of the control system is to control the quality of antioxidants, namely phenols and flavonoids. Other quality parameters (pH, viscosity, and color) are relatively tolerable if phenols and flavonoids are at the highest levels possible.

There are two control strategies for the extraction process. The first involves directly using the temperature and the extraction time as a set-point (Figure 12a). The extraction operation time is set, while the operating temperature becomes the set-point that is input as the control variable. In this way, the ANN model can be used to determine the values of phenols and flavonoids and to compare them to the output of the control system [32,33]. A comparison of the output of the control system and the ANN model can also be a strategy for model improvement. This method can be classified as indirect neuro-control [32]. The new data obtained in the extraction process are used as additional training data so that the ANN model and the observation data (data measured from the extraction process) have similar values. The controller must maintain the temperature at the set-point value. This is a commonly used method.



(a)



(b)

Figure 12. Indirect (**a**) and direct (**b**) neuro-control design.

The second method involves using the levels of phenols and flavonoids as a set-point (Figure 12b). The extraction operation time and temperature become a new set-point variable that varies according to the values of phenols and flavonoids obtained from the control system. This method can be classified as direct neuro-control [34]. In this direct-neuro controller control method, the set-point, in the form of the phenol and flavonoid parameters, is optimized using the ANN model and a genetic algorithm [31,35,36] to obtain new extraction temperature and time. The input in the form of temperature and extraction time is the new set-point that must be maintained by the extractor. Thus, the target values of phenols and flavonoids will be achieved. In this method, phenols and flavonoids in the extractor are approached by measuring the values of color, pH, and viscosity as an approximation model. The close relationship between the estimators (color, pH, and viscosity) and the predicted parameters (phenols–flavonoids) can be seen in the correlation matrix (Figure 13).

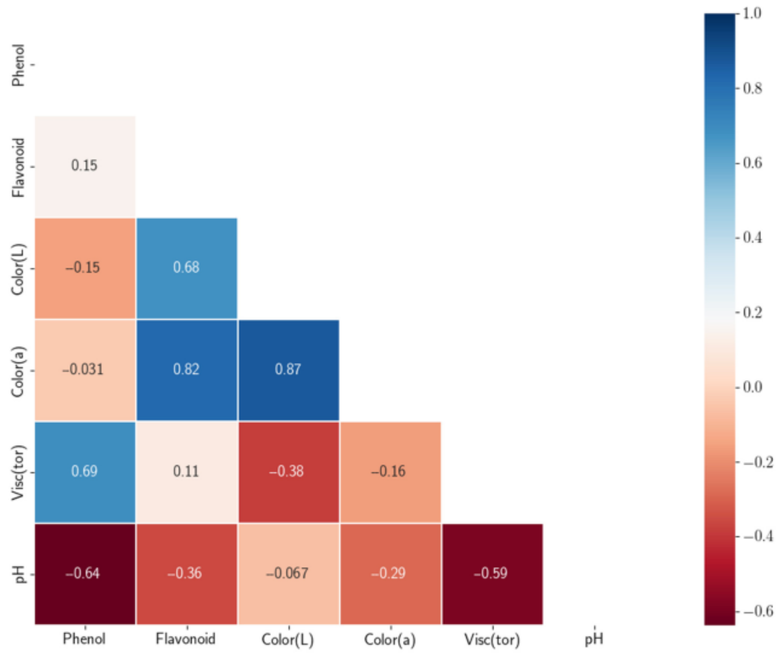


Figure 13. Parameter pair correlations.

The correlation shows how strongly one dataset is related to the other dataset. Although it does not show a cause-and-effect relationship, the correlation is a useful indicator for making linear prediction models [37,38]. The correlation matrix shows that for phenol, a strong correlation value ($0.5 \leq |r| < 1$) is given by pH and viscosity, which are −0.64 and 0.69, respectively. In flavonoids, color (a) and color (L), also have strong correlations, of 0.82 and 0.68, respectively. Phenol and flavonoid levels can be approximated (predicted) from the parameters that have a strong correlation with them. Multilinear regression is used for this. The equations obtained from the respective regressions are:

$$\text{Phenol} = 402.48 + 11.20 \cdot \text{Visc(tor)} - 118 \cdot \text{pH} \quad (1)$$

$$\text{Flavonoid} = 11.20 - 0.66 \cdot \text{Color (L)} + 3.26 \cdot \text{Color (a)} \quad (2)$$

In the implementation of the two control strategies, pH, color (a), color (L), and viscosity data are needed as inputs for Equations (1) and (2). Sampling or sensing using sensors for pH, color (a), color (L), and viscosity is required during the extraction process.

During the experimental operation of the extraction at various temperatures and extraction times, data on the quality parameters of the extraction results were obtained. When applied to a production plant, the extraction process may differ due to scaling from the experiment. Neuro-control design allows for the updating of the training data from the experimental data to the production data. ANN model training with updated data can be conducted periodically. There is a possibility that there is a change in the temperature value and the optimum extraction time so that optimization continues to be carried out periodically with additional data.

4. Conclusions

To obtain kecombrang extracts with maximum phenol and flavonoid contents, the extraction process in an industrial plant needs to be controlled. The measurement of extract samples must always be carried out in an effort to maintain quality. It is necessary to apply an adaptive control system to monitor changes in extract quality. An ANN model can subsequently be used in the extraction process control strategy, with both indirect and direct neuro-control schemes.

From this research, it can be concluded that backpropagation ANN can well model the extraction process for kecombrang flowers. This can be seen from the correlation value between the observation data and the prediction model, in terms of both the training data and the testing data. The ANN model predicts phenols, flavonoids, pH, viscosity, and color using time and temperature as inputs. The ANN model can further be used as a tool for optimization. The combination of both inputs to produce the desired levels of phenols and flavonoids can be determined using a direct neuro-control strategy.

Furthermore, from the correlation parameter pairs, it can be seen that phenols and flavonoids, as the main quality parameters, can be approximated by regression equations from other quality parameters. These parameters are pH, viscosity, and color. This finding is useful for predicting phenol and flavonoid levels in real time inside the control system. Phenol and flavonoid values can be directly fed back to the ANN model.

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to me, Ardiansyah, Rifda, Poppy, Nurul, Rumpoko, Muhammad, Condro, Sugeng, Processes

Dear Dr. Ardiansyah,

Thank you again for your manuscript submission:

Manuscript ID: processes-1781718
Type of manuscript: Article
Title: Machine Learning Model for Quality Parameters Prediction and Control System Design in Kecombrang Flower (Etlingera elatior) Extraction Process
Authors: Ardiansyah Ardiansyah *, Rifda Naufalin, Poppy Arsil, Nurul Latifasari, Rumpoko Wicaksono, Muhammad Syaiful Aliim, Condro Kartiko, Sugeng Waluyo
Received: 6 June 2022
E-mails: ard@unsoed.ac.id, rifda.naufalin@unsoed.ac.id, poppy.arsil@unsoed.ac.id, nurul@ittelkom-pwt.ac.id, rumpoko.wicaksono@unsoed.ac.id, muhammad.syaiful.aliim@unsoed.ac.id, condro.kartiko@ittelkom-pwt.ac.id, sugeng.waluyo@unsoed.ac.id

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Thank you very much for providing the revised version of your paper:

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Authors: Ardiansyah Ardiansyah *, Rifda Naufalin, Poppy Arsil, Nurul Latifasari, Rumpoko Wicaksono, Muhammad Syaiful Aliim, Condro Kartiko, Sugeng Waluyo
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Kind regards,
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Dear Dr. Ardiansyah,

Congratulations on the acceptance of your manuscript, and thank you for submitting your work to Processes:

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