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Some Current Utilization Aspects of Rambutan Waste: A Brief Overview

Vanya Zhivkova
University of Economics – Varna, blvd "Kniaz Boris I" 77, 9002 Varna, Bulgaria

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ABSTRACT
The aim of this paper was to provide a brief overview of some current aspects concerning the possibilities for the utilization of rambutan waste. The preparation of the present mini-review was based on the descriptive approach, and a search was carried out using the keywords "rambutan waste" among literature sources indexed in authoritative world-leading scientific databases. A limitation in the writing of this overview was that it did not aim to compile all existing information available in scientific databases related to the indicated subject. In summary, many and varied studies are being conducted and various methods are being applied to utilize waste rambutan seeds and peels.
Keywords: rambutan waste; utilization; highlights; descriptive approach.

I. INTRODUCTION

Rambutan is an important tropical commercial fruit in southeast Asia (Jahurul et al., 2020). According to Hernández-Hernández et al. (2019), rambutan contained phytochemical compounds with different bioactivities, among them antioxidant. As Bhattacharjee et al. (2022) point out in their review, apart from the properties possessed by rambutan peels and the possibilities for industrial use of rambutan seeds, rambutan is among the minor fruits worldwide, but "its increasing popularity and acceptance would make it an important commercial fruit crop in near future". In the mini-review by Mahmood et al. (2018), it is stated that rambutan seeds and peels, which are separated as waste by-products during its processing, make up about 50% of the weight of the whole fruit. Rambutan seed and peel waste can be considered as a potential natural source of phenolic compounds (Rakariyatham et al., 2020). According to Jahurul et al. (2020), rambutan seed is a source of food ingredients. In the review article by Cheok et al. (2018), it was noted that rambutan peels were utilized at a higher rate than rambutan seeds (57% vs. 43%, respectively).
The aim of the present overview is to summarize some current aspects of rambutan waste utilization.

II. MATERIALS AND METHODS

For the writing of this mini-review, based on a descriptive approach, a literature survey was conducted in the scientific databases Scopus, Web of Science, Google Scholar, PubMed. The main keywords used to search in the resources of these databases were "rambutan waste". As a limitation, it should be pointed out that the scope of the present work does not include the collection of all the scientific output that has come out to date and available in the databases mentioned above, as well as book chapters were not considered at all.

III. RESULTS AND DISCUSSION

In Table 1, the scientific publications cited in the present overview were systematized by some main words contained in the title and their percentage share.

Main words in the title of the article	Share, %	Reference
"waste/wastes"	2,41%	Benjamas, 2020; Perera et al., 2020
"peel/peels"	39,76%	Ahmad & Alrozi, 2011a; Ahmad & Alrozi, 2011b; Amalia et al., 2019; Arie et al., 2021; Boyano-Orozco et al., 2020; Castro et al., 2020; Cerda-Cejudo et al., 2022; Chollakup et al., 2020; Estrada-Gil et al., 2022; Herdianty et al., 2022; Hernández-Hernández et al., 2020; Jantapaso &

International Journal of Pharmaceutical Research and Applications
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		Mittraparp-arthorn, 2022; Kamaludin et al., 2016; Kumar et al., 2015; Kumar et al., 2021; Lee & Ong, 2017; Mistriyani et al., 2018; Mistriyani et al., 2021; Njoku et al., 2014; Nurhuda et al., 2013; Oliveira et al., 2016; Oliveira et al., 2022; Permatasari & Rohman, 2016; Prakash Maran & Priya, 2014; Ragunath et al., 2021; Rubcumintara et al., 2012; Sukatta et al., 2021; Suresh et al., 2022; Torgbo et al., 2022; Wong et al., 2020; Yuvakkumar et al., 2014a; Yuvakkumar et al., 2014b; Yuvakkumar et al., 2015
"seed/seeds"	27,71%	Ahmad et al., 2017; Aziz et al., 2022; Azzatul et al., 2020; Camongol et al., 2017; Chai et al., 2018a; Chai et al., 2019; Febrianto et al., 2016; Fitriyanti et al., 2022; Ghobakhlou et al., 2019; Hamid et al., 2022; Harahap et al., 2012; Issara et al., 2014; Jahurul et al., 2019; Jahurul et al., 2020; Khairy et al., 2015; Khairy et al., 2017; Khairy et al., 2018; Minh, 2021; Osman et al., 2020; Siol et al., 2022; Solís-Fuentes et al., 2010; Wahini et al., 2018; Yoswathana, 2013
"kernel"	2,41%	Sirisompong et al., 2011; Witayaudom & Klinkesorn, 2017
"peel/peels" and "waste/wastes"	2,41%	Adinaveen et al., 2019; Batool et al., 2022
"rind/rinds" and "waste/wastes"	3,61%	Fakhlaei et al., 2015; Palanisamy et al., 2011; Perera et al., 2012
"skin" and "waste/wastes"	2,41%	Ooi et al., 2012a; Ooi et al., 2012b
"seed/seeds" and "waste/wastes"	1,20%	Karawake et al., 2014
"waste/wastes" and "utilization"	1,20%	Cheok et al., 2018
"seed/seeds" and "rind/rinds"	1,20%	Fila et al., 2012
"peel/peels" and "valorization"	1,20%	Kumar et al., 2016
"peel/peels", "waste/wastes" and "utilization"	1,20%	Kusumayanti et al., 2020
"seed/seeds", "peel/peels" and "by-product/by-products"	1,20%	Rakariyatham et al., 2020
"by-product/by-products" and "valorization"	1,20%	Mahmood et al., 2018

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Table 1. Systematization of the scientific publications cited in this paper by main words contained in the title and their percentage share

Table 1 showed that the most common words in the titles of the articles included here were "peel/peels" (presented in almost 40% of the titles used) followed by "seed/seeds" (just over a quarter). Also present in the titles are "rind/rinds" and "waste/wastes" (3,61%); "waste/wastes" (2,41%); "kernel" (2,41%); "peel/peels" and "waste/wastes" (2,41%); "skin" and "waste/wastes" (2,41%); as well as with 1,20% each of the word combinations: "seed/seeds" and "waste/wastes"; "waste/wastes" and "utilization"; "seed/seeds" and "rind/rinds"; "waste/wastes" and "utilization"; "seed/seeds" and "rind/rinds"; "peel/peels" and "valorization"; "peel/peels", "waste/wastes" and "utilization"; "seed/seeds", "peel/peels" and "by-product/by-products"; "by-product/by-products" and "valorization". In just over 20% of the publications cited in the current mini-review, the number of authors was six or more.

The articles used in this overview paper were systematized by utilization aspects and present some main highlights from them in Table 2.

Utilization aspects	Field of application	Waste material	Reference
Synthesis	Zinc oxide nanocrystals	Rambutan peel waste	Yuvakkumar et al., 2014a
	Zinc oxide nanochains	Rambutan peel waste	Yuvakkumar et al., 2015
	Nickel oxide nanocrystals	Rambutan peel waste	Yuvakkumar et al., 2014b
	Nickel oxide nanoparticles with photocatalytic activity for rhodamin B degradation under UV light	Rambutan peel	Adinaveen et al., 2019
	Copper oxide nanoparticles	Rambutan peel	Ragunath et al., 2021
	Copper oxide nanocrystals with antibacterial activity	Rambutan peel wastes	Suresh et al., 2022
	Porous carbons to encapsulate sulfur cathodes for Li – S batteries	Waste rambutan peels	Arie et al., 2021
	Bioadsorbent for gold recovery	Rambutan peel	Rubcumintara et al., 2012
	Silver nanoplates	Rambutan peel	Kumar et al., 2015
	Spherical silver nanoparticles	Rambutan peel and seed	Perera et al., 2020
	Silver-doped titanium dioxide nanoparticles	Rambutan peel	Kumar et al., 2016
	Gold nanoflowers	Rambutan peel	Kumar et al., 2021
	Adsorbent for basic fuchsin dye	Rambutan peel	Lee & Ong, 2017
	Nanostructured lipid carrier from kernel fat	Rambutan kernel	Witayaudom & Klinkesorn, 2017
Compounds and bioactivity characterization	Fatty acid content	Rambutan seed	Camongol et al., 2017
	Ellagic acid	Rambutan peel	Cerda-Cejudo et al., 2022
	Ellagitannins	Rambutan peel	Estrada-Gil et al., 2022
	Fat, saponin and tannin	Rambutan seed	Chai et al., 2018a
	Anti-nutrient contents	Rambutan seed and rind	Fila et al., 2012

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	Fat properties, saponins and total phenolic contents	Fermented rambutan seeds	Hamid et al., 2022
	Fat	Rambutan seed	Solís-Fuentes et al., 2010
	Kernel fat	Rambutan kernels	Sirisompong et al., 2011
	Composition of seed and seed oil	Rambutan seed	Harahap et al., 2012
	Geraniin	Rambutan rind	Palanisamy et al., 2011
	Geraniin	Rambutan rind waste	Perera et al., 2012
	Geraniin	Rambutan peel	Hernández-Hernández et al., 2020
	Lignocellulosic material	Rambutan peel	Oliveira et al., 2016
	Soda lignin	Rambutan peel	Oliveira et al., 2022
	Polysaccharide	Rambutan peel	Prakash Maran & Priya, 2014
	Phytochemical composition and bioactivities	Rambutan peels	Jantapaso & Mittraparp-arthorn, 2022
	Physicochemical properties	Rambutan sweatings	Chai et al., 2018b
	Physicochemical properties of seed oil	Rambutan seed	Ghobakhlou et al., 2019
	Nutritional value	Rambutan seed	Wahini et al., 2018
	Antioxidant activity	Rambutan peel	Kamaludin et al., 2016
	Antioxidant activity	Rambutan peel	Mistriyani et al., 2018
	Antioxidant properties	Rambutan rind	Fakhlaei et al., 2015
	Antioxidant activities and identification of 3,4-dihydroxybenzoic acid	Rambutan peel	Mistriyani et al., 2021
	Effect of blanchings on browning enzymes and antioxidant activities	Rambutan peel	Nurhuda et al., 2013
	DPPH radical scavenging activity	Rambutan peel	Permatasari & Rohman, 2016
	Antimicrobial and antioxidant properties	Rambutan peel	Sukatta et al., 2021
	Antioxidant and antibacterial activities	Rambutan peels and seeds	Thitilertdecha et al., 2008
	Phenolic compounds with antioxidant activity	Rambutan peel	Thitilertdecha et al., 2010
	Bioactive metabolites and antioxidant capacity	Rambutan peels and seeds	Valdez López et al., 2020
Activated carbon	Removal of remazol brilliant blue R dye	Rambutan peel	Ahmad & Alrozi, 2011a
	Adsorption of malachite green dye	Rambutan peel	Ahmad & Alrozi, 2011b
	Adsorption of acid yellow 17 dye	Rambutan peel	Njoku et al., 2014
Foods	Cocoa butter alternative substitute	Rambutan seed	Issara et al., 2014
			Khairy et al., 2015
			Febrianto et al., 2016

International Journal of Pharmaceutical Research and Applications
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			Khairy et al., 2017
			Khairy et al., 2018
			Chai et al., 2019
			Osman et al., 2020
			Azzatul et al., 2020
	Phenolic compounds as ingredient in white bread preparation	Rambutan peel	Torgbo et al., 2022
Some other utilization aspects	Drying methods	Rambutan seed	Ahmad et al., 2017
			Jahurul et al., 2019
			Siol et al., 2022
		Rambutan peel	Boyano-Orozco et al., 2020
	Coagulant	Rambutan seeds	Aziz et al., 2022
	Natural dye	Rambutan peel	Amalia et al., 2019
			Kusumayanti et al., 2020
	Biochar	Rambutan peel	Wong et al., 2020
	Biochar nanocomposite	Rambutan peel waste	Batool et al., 2022
	Alcohol production	Low quality rambutan	Benjamas, 2020
	Bioethanol production	Rotten rambutan	Hadeel et al., 2011
	Biodiesel raw material	Rambutan seeds	Fitriyanti et al., 2022
	Biodiesel production	Rambutan seed	Nguyen et al., 2016
	Chemical pretreatment	Rambutan peels	Castro et al., 2020
	Component in cassava starch and whey protein blend films	Rambutan peels	Chollakup et al., 2020
	Liquid soap preparation and antibacterial properties	Rambutan peel	Herdianty et al., 2022
	Sunscreen	Rambutan peel	Mota et al., 2020
	Vegetable growth enhancement by extracted gibberellic compounds	Rambutan seed	Karawake et al., 2014
	Parameters affecting seed oil extraction	Rambutan seed	Minh, 2021
	Optimization of supercritical CO_2 extraction of oil	Rambutan seeds	Yoswathana, 2013
	Properties of polyvinyl alcohol/rambutan skin waste flour crosslinked films	Rambutan skin waste	Ooi et al., 2012a
			Ooi et al., 2012b

Table 2. Summarizing of the scientific publications cited in the present overview by utilization aspects and field of application

As can be seen from the summary data in Table 2, there are many and varied research directions for the utilization of rambutan waste. If we trace the development of the valorization aspects regarding the rambutan waste utilization in chronological order, it can be concluded that at the beginning researches carried out was related to the characterization of various properties of rambutan

seeds and peels, the study of rambutan seed oil, the extraction of various compounds and determination of their biological activity, the production of bioethanol, the synthesis of nanoparticles, the preparation of activated carbon and its use for the adsorption of various contaminants in aqueous solutions. In recent years, the main trends and research aspects established in the earlier period related to the search for opportunities and ways to utilize rambutan waste have been preserved, further developed and deepened. Researches were intensified and expanded regarding the disclosure of the challenges of incorporating individual components of rambutan waste into various final products, suggestions and recommendations were made for the continuation and deepening of investigations, especially those affecting environmental protection and consumer safety.

IV. CONCLUSIONS

As a result of this overview, it can be concluded that the possible ways to utilize rambutan waste are the subject of intensive and varied research. The perspectives and challenges related to the application and possible future industrial implementation of the proposed methods in the various developments are carefully considered and discussed, with priority being given to the protection of the environment and the safety of consumers.

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