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Review Article

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From Waste to Wellness: Exploring the Nutritional Composition, Health Benefits and Utilization of Watermelon Rind

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Abstract

Watermelon (*Citrullus lanatus*) is a renowned and commonly consumed fruit for its sweet, juicy, and refreshing pulp. However, its rind which carries almost 40% of total fruit weight is often discarded due to its unappealing taste which contributes to agricultural waste. Watermelon rind (WMR) possesses a wide range of nutritional components and bioactive compounds such as dietary fiber, polyphenols, carotenoids, saponins, etc. Owing to its rich nutritional profile, it exhibits several therapeutic properties such as antioxidant, anti-diabetic, anti-tumour, cardioprotective, and hepatoprotective. To reduce this agricultural waste as well as keeping in view the health and well-being of consumers, it is important to utilize WMR in various industries like food, pharmaceuticals, and cosmetics. Therefore, to address this issue of agricultural waste and promote consumer well-being, harnessing the potential of WMR in various industries is crucial. This review article aims to delve into scientific studies outlining the nutritional composition and therapeutic properties of WMR. By shedding light on its importance, the review seeks to raise awareness among customers. Additionally, it will outline the objectives of the review, emphasizing the transition from waste reduction to enhancing wellness further extending to the diverse food applications of WMR, from traditional to culinary food practices such as pickles, chutney, smoothies, cakes, and functional foods. Through this exploration, the review aspires to encourage the utilization of WMR across food, pharmaceutical, and cosmetic industries, transforming it from a byproduct into a valuable resource for both health and sustainability.

Keywords

Watermelon rind, Health implications, Agricultural waste, Byproduct, Nutritional composition

Introduction

In an era marked by heightened awareness of sustainability and a growing appreciation for holistic health, the exploration of unconventional sources of nutrition and therapeutic benefits has gained paramount significance. Among the myriad of natural treasures, the watermelon (*C. lanatus*) stands out as a quintessential summertime delight, celebrated for its succulent and sweet flesh. Watermelon is a tropical plant that belongs to the Cucurbitaceae family. Tarbooz, Tarbuj, Kaduvrindavana, Eriputccha, Kallangadiballi, Tormuj and Indrak are some of the commonly used names for watermelon in Hindi or Urdu, Manipuri, Marathi, Telugu, Kannada, Bengali and Gujrati, respectively [1, 2]. It is the most cultivated fruit with approximately 102 million tons of production worldwide in 2021. Its biomass mainly consists of three major parts viz: rind, flesh, and seeds [3]. The flesh is usually dark red in color and accounts for 40-50% of total fruit weight [4].

It is the most consumed part of the fruit due to its nutritional composition and sweet juicy taste.

The fruit *C. lanatus* flesh is 91% water, 6% sugar and very little fat. It is also a good source of micronutrients such as vitamins A, B, and C and minerals like potassium, magnesium, iron, and calcium [1, 5]. The rind is the white or light green color layer of the fruit that accounts for almost 40% of the total weight. Still, due to a lack of awareness about its nutritional composition and unappealing taste, it is mostly discarded as a by-product or is used as animal feed [3]. It has been estimated that the total amount of food wasted is one-third of the edible portion of the food produced for human consumption amounting to 1.3 billion tons globally. In developing countries, out of the total food waste 400-500 calories per person per day are wasted, while in developed countries wastes 1500 calories per person per day [6]. Traditionally relegated to the compost heap or discarded altogether, WMR emerges as a focal point in the pursuit of sustainable practices and a holistic approach to nutrition (Figure 1). This oversight, however, belies the hidden potential within the WMR, an overlooked resource of diverse nutritional components and bioactive compounds. Agricultural and industrial residues are a natural powerhouse of nutrition that offers various therapeutic properties like anti-diabetic, antioxidant, anti-hypertensive, anti-ulcer, anti-tumour, and hypocholesterolemic effects [7].

Therefore, this study aims to explore the nutritional composition of WMR, uncover its untapped potential, and highlight its potential health benefits. In addition to its intrinsic nutritional value, innovative applications of WMR for culinary and wellness purposes can lead to novel recipes, reduced food waste, and improved dietary diversity. These innovative approaches to utilizing waste resources can lead to remarkable outcomes and provide a unique opportunity to move towards a more sustainable and healthier lifestyle (Table 1).

Table 1: Nutritional composition of WMR.

Nutrients	Amount	Ref.
Energy (Kcal/100 g)	129.99	[8]
Moisture (%)	91.22 - 94.62	[8-11]
Ash (%)	0.41 - 3.84	
Proteins (%)	0.15 - 2.15	
Fats (%)	0.08 - 0.69	
Carbohydrates (%)	4.2 - 29.65	
Dietary fiber (%)	0.3	[8]
Total sugar (%)	5.39	[10]
β-carotene (%)	96.44	[12, 13]
Vitamins		
Vitamin A (mg/100 g)	52.13	[12-14]
Vitamin B1 (mg/100 g)	1.23	
Vitamin B2 (mg/100 g)	2.71	
Vitamin B3 (mg/100 g)	4.25	
Vitamin B6 (mg/100 g)	5.34	
Vitamin C (mg/100 g)	8.46	
Minerals		
Iron (mg/100 g)	1.29	[12-14]
Manganese (mg/100 g)	1.42	
Phosphorous (mg/100 g)	135.24	
Calcium (mg/100 g)	29.15	
Sodium (mg/100 g)	12.65	
Copper (mg/100 g)	0.45	
Zinc (mg/100 g)	1.29	
Magnesium (mg/100 g)	1.48	
Potassium (mg/100 g)	1.37	
Antioxidant activity (%)	39.7	[13]
Anti-nutritional factors		
Saponins (%)	0.34	[11]
Tannins (%)	0.12	
Alkaloids (%)	0.62	

Nutritional Composition of WMR

WMR is a nutritional by-product of watermelon. Based upon the research studies, it has been reported that WMR provides 129.9 kcal/100 g energy and 0.30% dietary fiber. It possesses 91.22-94.62% moisture content and 0.15-2.15 g/100 g of protein. It is also an excellent source of various vitamins including vitamin A, vitamin B1, vitamin B2, vitamin B3, vitamin B6 and vitamin C. In addition to this, it also contains several minerals such as iron, manganese, phosphorus, calcium, sodium, copper, zinc, magnesium, and potassium. It also holds water absorption capacity and oil absorption capacity.

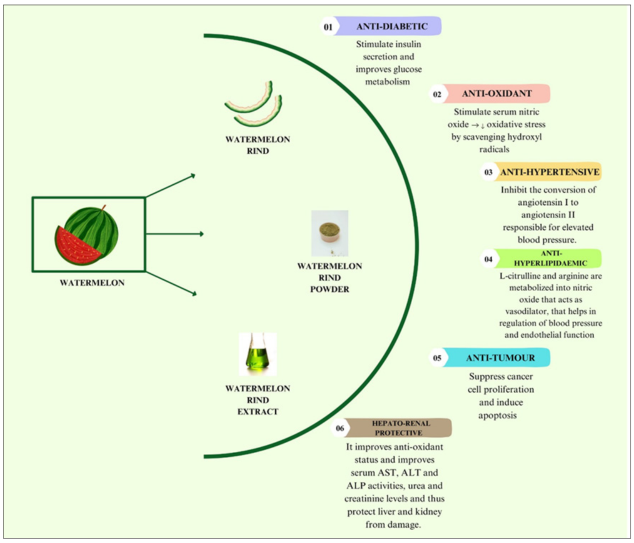

Figure 1: Pharmacological properties of WMR and its associated health benefits.

Health Implications of WMR

Antidiabetic effect of WMR

Type II diabetes mellitus is a multi-factorial metabolic disease characterized not only by β-cell failure of the pancreas but also by chronic insulin resistance in target organs. Several studies in animals and humans have reported the anti-diabetic effect of WMR by stimulating insulin levels and improving glucose metabolism. Sorour et al. [15] reported the ameliorating effect of WMR juice intake on female albino rats that resulted in improving the structural changes in the pancreas and significantly decreasing the blood glucose levels. The potential mechanism of WMR might be due to the enhancement of blood glucose uptake into the tissues by stimulating the insulin secretion by β-cells of the pancreas and inhibiting the carbohydrate-digesting enzymes viz. α-amylase and glycosylation of haemoglobin. Another study conducted by Azizi et al. [16] revealed the potential effect of WMR extract on metabolic and inflammatory parameters in diabetes mellitus. The results observed in both cases are attributed to the inherent presence of the amino acid citrulline, which is naturally found in the WMR. Citrulline, a precursor of arginine and nitric oxide is present in abundant amounts in WMR. Citrulline and WMR extract collectively increase the synthesis and bioavailability of nitric oxide and reduce insulin resistance, improve the glycemic index and glucose metabolism and decrease the inflammatory biomarkers [7].

Antioxidant effect of WMR

As per the findings, WMR is a rich source of various antioxidants and bioactive compounds such as β-carotene, saponins, flavonoids, phenols, L-citrulline, fiber, protein, carbohydrates, and fats that help in stimulating the serum nitric oxide and provides resilience to oxidative stress by scavenging the hydroxyl radicals [17-18]. Romdhane et al. [19] conducted a study on the structural attributes, functional properties and biological activities of polysaccharides extracted from WMR while optimizing the hot water extraction which displayed antihypertensive, and antioxidant properties along with a protective effect against hydroxyl radical-induced DNA damage.

Antihypertensive effect of WMR

Hypertension is a metabolic disease that largely contributes to the pathogenesis of cardiovascular diseases. WMR has been found to have an antihypertensive effect which means it helps in lowering blood pressure. A study by Romdhane et al. [19] identified the presence of various polysaccharides, including galactose, arabinose, glucose, galacturonic acid, rhamnose, mannose, xylose, and traces of glucuronic acid in the WMR extract. This extract was found to exhibit an inhibitory effect on angiotensin I-converting enzymes which regulate the renin-angiotensin system and play a pivotal role in the conversion of angiotensin I to angiotensin II. Angiotensin II is a potent vasoconstrictive peptide that contributes to elevated blood pressure, thereby increasing the risk of cardiovascular diseases. The findings suggest that WMR extract could be a potential natural remedy for hypertension, and further research in this area could provide valuable insight into the development of new treatments for cardiovascular diseases [19, 20].

Antihyperlipidaemic/cardioprotective/hypocholesterolemic effect of WMR

Abu-Hiamed [21] conducted a research study to determine the hypocholesterolemic effect of WMR. The study was conducted by dividing the rats in 6 groups and fed different diets containing normal control diet (Group-1), 1% cholesterol (Group-2), control + 5% WMR (Group-3), control + 5% WMR + 1% cholesterol (Group-4), control + 10% WMR (Group-5) and control + 10% WMR + 1% cholesterol (Group-6). The group that was fed a normal control diet with 1% cholesterol showed a significant increase in serum levels of TC, TG, LDL-C and VLDL-C (187.2, 266.2, 159.5 and 37.4 mg/dl, respectively) compared to the normal control group (141.2, 195.1, 58.3 and 28.2 mg/dl, respectively). Whereas groups 3 and 5 had no significant effect on serum TG, TC or lipoprotein levels compared to the normal control group. However, compared to group 2, group 6 observed significantly decreased levels of serum TC, TG, LDL-C and VLDL-C (160.1, 222.7, 94.4 and 32.0 mg/dl, respectively) and increased levels of HDL-C (96.36 mg/dl). The observed effects may be due to the presence of natural constituents including polyphenols, flavonoids, alkaloids, phytosterols, dietary fibres and several other medicinal compounds in WMR [21]. The presence of citrulline in WMR that is metabolized to arginine is also vital for cardiovascular health [22].

Antitumor and anticancer effect of WMR

Dammak et al. [23], revealed that polysaccharide extracted from WMR had a cytotoxic effect on human laryngeal carcinoma Human epithelial type-2 (Hep-2) cells in a time and dose-dependent manner. The results proved that WMR substantially inhibited the proliferation of Hep-2 cells by increasing the sample concentration from 2.5 to 10 g/ml with an inhibition rate of 25.93% and 65.02% respectively [16, 23]. El Gizawy et al. [24] study provided insight into the phytochemical profiling of WMR and its associated cytotoxic effect. Results revealed that the aqueous extract of the rind displayed anticancer activity against seven different cancer cell lines. The extract was found to inhibit cell migration, trigger apoptosis, drive the accumulation of cells in the S phase, and elevate the activity of caspase-3 and the BAX/BCL-2 ratio in plate_number_1 and Hep-2 cells. These findings suggest that the complete phytochemical and cytotoxic investigation of the WMR extract has identified its potential potency as an anticancer agent. It may also be beneficial as a nutraceutical or food supplement.

Hepato-renal protective effect of WMR

In a study conducted by Michael et al. [18], male Wistar rats were administered lead acetate followed by oral administration of WMR ethanol extract. The study examined the impact of the extract on serum levels of kidney markers, including total protein, uric acid, urea, creatinine, and liver function enzymes viz. alanine transaminase aspartate aminotransferase and alkaline phosphatase. The results showed a significant decrease in these levels following the administration of WMR ethanol extract in comparison to the lead acetate-exposed rats. Therefore, the WMR extract has the potential to reduce serum levels of liver enzymes and protect the liver and kidney from stress and damage.

Anti-nutritional compounds

Anti-nutrients are the naturally occurring compounds in foods that can interfere with the absorption or utilization of nutrients in the body. While WMR does contain some compounds that could be considered anti-nutrients such as alkaloids, saponins and tannins, their impact is generally negligible.

Table 2: Value-added products.

Value-added product	Key findings	Ref.
WMR fruit butter	WMR fruit butter was formulated in four different ratios: 100:0, 75:25, 50:50, 25:75 and 0:100 (Apple: WMR) with 300 gm of sugar, 400 gm of WMR pulp, spice mixture (nutmeg, cinnamon, and clove) and citric acid.	[3]
	Sample 4 formulated with a 0:100 ratio was deemed acceptable after organoleptic evaluation.	
WMR incorporated toast bread	Formulated with 9.06% of WMR and baked at 206.66 °C for 20 min.	[24]
WMR muffins	For the formulation of WMR muffins, rice was substituted with various percentages (7%, 14%, 21%, and 28%) of WMR.	[25]
	It was observed that muffins with 14% WMR enhances fiber and minerals content in muffins.	
WMR dehydrated candy	For the preparation of WMR-incorporated candy, different pretreatments were given and the best one was used for candy with sugar in different ratios: S1 (100%), S2 (75:25), and S3 (50:50 Sucrose: Honey).	[26]
	After evaluating the sensory score, S2 was found to be the best among all.	
WMR fat reduced mayonnaise	The study used a randomised design with 1 control group (full-fat mayonnaise with 70% oil), 3 treatment groups (RF2 with 2% WMR flour and 50% oil, RF4 with 4% WMR flour, RF6 with 6% WMR flour) and 4 replicates were formulated.	[27]
	RF6 reduced fat showed a significant increase in antioxidant capacity and achieved the viscosity of full-fat mayonnaise.	
WMR cookies	Wheat flour was replaced with different levels of WMR powder (10-30%) where the use of up to 20% of WMR increased the total phenolic content, DPPH and FRAP and lowered the glycaemic index.	[28]
WMR cake	WMR powder was used as a partial substitute for wheat flour in varying amounts (5%, 10%, and 15%).	[2]
	After sensory evaluation, samples containing 5% and 10% powder were found to be more acceptable compared to 100% wheat flour.	
WMR noodles	WMR noodles were made by incorporating different varieties of rind viz: dark green, yellow, and pale green rind.	[29]
	Wheat flour was partially substituted by varying percentages of 0%, 10%, 15% and 20%.	
	Based on sensory evaluation, control sample was the most preferred and noodles with 10% WMR powder were moderately acceptable.	

Incorporation of WMR in Preparation of Value-added Products

Table 2 represents the various WMR-based value-added products along with its significant findings. WMR contains the main molecular families of bioactive compounds including phytochemicals, and polysaccharides like pectin and fiber which have a positive influence on health and so can contribute to commercial use, instead of just being agricultural waste [30]. Several products that have been formulated using WMR include butter, toast bread, muffins, dehydrated candies, fat-reduced mayonnaise, cookies, cake, and noodles.

Conclusion

WMR is a valuable resource that has been ignored due to its unappealing taste and lack of awareness about its nutritional composition. However, it serves as an inspiring example of how agricultural waste can be an integral component of a healthy and eco-friendly diet. Its diverse nutritional components and bioactive compounds exhibit several therapeutic properties including antioxidant, anti-diabetic, anti-tumour, antihypertensive, anti-hyperlipidaemic, and hepato-renal protective effects. As a result, it has the potential to be further applied in various industries like food, pharmaceuticals, and cosmetics.

This review paper has highlighted the overlooked nutrients present in this, from its fiber-rich content to certain vitamins, minerals, and phytochemicals. Moreover, this review has also explored the scientific studies outlining the nutritional composition and therapeutic properties of WMR. It has also highlighted the diverse food applications of WMR, from traditional to culinary food practices such as pickles, chutneys, smoothies, cakes, and functional foods. By reducing agricultural waste and promoting consumer well-being, harnessing the potential of WMR is crucial. It is hoped that this study will raise awareness among customers, researchers, and industries about the untapped potential of WMR and encourage the development of innovative and sustainable approaches to utilizing waste resources wellness.

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None.

Conflict of Interest

None.

References

1. Alka G, Anamika S, Ranu P. 2018. A review on watermelon (*Citrullus lanatus*) medicinal seeds. *J Pharmacogn Phytochem* 7(3): 2222-2225.
2. Dubey S, Rajput H, Batta K. 2022. Utilization of watermelon rind (*Citrullus lanatus*) in various food preparations: a review. *Chem Sci Rev Lett* 11 (41): 77-82.
3. Du X, Ramirez J. 2022. Watermelon rind and flesh volatile profiles and cultivar difference. *Horticulturae* 8(2): 99. https://doi.org/10.3390/horticulturae8020099
4. Gu I, Balogun O, Brownmiller C, Kang HW, Lee SO. 2023. Bioavailability of citrulline in watermelon flesh, rind, and skin using a human

intestinal epithelial Caco-2 cell model. *Appl Sci* 13(8): 4882. https://doi.org/10.3390/app13084882

5. Yadav V, Prasad VM, Singh D, Singh YK. 2022. Study on preparation of squash by blending of watermelon and sugar beet pulp and its storage for quality product. *Pharma Innov J* 11(10S): 185-191.
6. Joy GFF, Jeff-Agboola YA, Sunday OZ, Remilekun A, Olusegun AD. 2022. Waste-to-wealth; nutritional potential of five selected fruit peels and their health benefits: a review. *Afr J Food Sci* 16(7): 172-183. https://doi.org/10.5897/AJFS2021.2138
7. Zia S, Khan MR, Shabbir MA, Aadil RM. 2021. An update on functional, nutraceutical and industrial applications of watermelon by-products: a comprehensive review. *Trends Food Sci Technol* 114: 275-291. https://doi.org/10.1016/j.tifs.2021.05.039
8. Fila WA, Itam EH, Johnson JT, Odey MO, Effiong EE, et al. 2013. Comparative proximate compositions of watermelon *Citrullus lanatus*, squash *Cucurbita pepo'l* and rambutan *Nephelium lappaceum. Int J Sci Technol Res* 2(1): 81-88.
9. Erukainure OL, Oke OV, Daramola AO, Adenekan SO, Umanhonlen EE. 2010. Improvement of the biochemical properties of watermelon rinds subjected to *Saccharomyces cerevisae* solid media fermentation. *Pak J Nutr* 9(8): 806-809. https://doi.org/10.3923/pjn.2010.806.809
10. Hoque MM, Iqbal A. 2015. Drying of watermelon rind and development of cakes from rind powder. *Int J Novel Res Life Sci* 2(1): 14-21.
11. Mohan A, Shanmugam S, Nithyalakshmi V. 2016. Comparison of the nutritional, physico-chemical and anti-nutrient properties of freeze and hot air dried watermelon (*Citrullus lanatus*) rind. *Biosci Biotech Res Asia* 13(2): 1113-1119.
12. Nadeem M, Navida M, Ameer K, Iqbal A, Malik F, et al. 2022. A comprehensive review on the watermelon phytochemical profile and their bioactive and therapeutic effects. *Korean J Food Preserv* 29(4): 546-576. https://doi.org/10.11002/kjfp.2022.29.4.546
13. Al-Sayed HM, Ahmed AR. 2013. Utilization of watermelon rinds and sharlyn melon peels as a natural source of dietary fiber and antioxidants in cake. *Ann Agric Sci* 58(1): 83-95. https://doi.org/10.1016/j.aoas.2013.01.012
14. Gladvin G, Sudhaakr G, Swathi V, Santhisri KV. 2017. Mineral and vitamin compositions contents in watermelon peel (rind). *Int J Curr Microbiol App Sci* 5(5): 129-133.
15. Sorour H, Selim M, Almoselhy L, Gouda S. 2019. Ameliorative effect of watermelon rind ingestion on the pancreas of diabetic female albino rat (histological, immunohistochemical and morphometric study). *Egypt J Histol* 42(1): 10-22. https://doi.org/10.21608/ejh.2018.4243.1018
16. Azizi S, Mahdavi R, Vaghef-Mehrabany E, Maleki V, Karamzad N, et al. 2020. Potential roles of citrulline and watermelon extract on metabolic and inflammatory variables in diabetes mellitus, current evidence and future directions: a systematic review. *Clin Exp Pharmacol Physiol* 47(2): 187-198. https://doi.org/10.1111/1440-1681.13190
17. Rahman H, Manjula K, Anoosha T, Nagaveni K, Eswaraiah MC, et al. 2013. *In-vitro* antioxidant activity of *Citrullus lanatus* seed extracts. *Asian J Pharm Clin Res* 6(3): 152-157.
18. Michael OS, Bamidele O, Ogheneovo P, Ariyo TA, Adedayo LD, et al. 2021. Watermelon rind ethanol extract exhibits hepato-renal protection against lead induced-impaired antioxidant defenses in male Wistar rats. *Curr Res Physiol* 4: 252-259. https://doi.org/10.1016/j.crphys.2021.11.002
19. Romdhane MB, Haddar A, Ghazala I, Jeddou KB, Helbert CB, et al. 2017. Optimization of polysaccharides extraction from watermelon rinds: structure, functional and biological activities. *Food Chem* 216: 355-364. https://doi.org/10.1016/j.foodchem.2016.08.056
20. Nurhidayati E, Putri SM, Muizzuddin M, Hasyatiningsih G, Pratiwi SZ, et al. 2015. Watermelon rind meatball, functional food to normalize blood pressure for people with hypertension. In 3rd ASEAN/Asian Academic Society International Conference Proceeding, Indonesia.
21. Abu-Hiamed H. 2018. Hypocholesterolemic effects of watermelon fruit rind on rats. *Nutr Food Sci* 48(5): 836-845. https://doi.org/10.1108/NFS-02-2018-0038
22. Fan J, Park E, Zhang L, Edirisinghe I, Burton-Freeman B, et al. 2020. Pharmacokinetic parameters of watermelon (rind, flesh, and seeds) bioactive components in human plasma: a pilot study to investigate the relationship to endothelial function. *J Agric Food Chem* 68(28): 7393-7403. https://doi.org/10.1021/acs.jafc.0c02756
23. Dammak MI, Salem YB, Belaid A, Mansour HB, Hammami S, et al. 2019. Partial characterization and antitumor activity of a polysaccharide isolated from watermelon rinds. *Int J Biol Macromol* 136: 632-641. https://doi.org/10.1016/j.ijbiomac.2019.06.110
24. El Gizawy HA, El-Haddad AE, Attia YM, Fahim SA, Zafer MM, et al. 2020. *In vitro* cytotoxic activity and phytochemical characterization (UPLC/T-TOF-MS/MS) of the watermelon (*Citrullus lanatus*) rind extract. *Molecules* 27(8): 2480. https://doi.org/10.3390/molecules27082480
25. Shivapour M, Yousefi S, Ardabili SM, Weisany W. 2020. Optimization and quality attributes of novel toast breads developed based on the antistaling watermelon rind powder. *J Agric Food Res* 2: 100073. https://doi.org/10.1016/j.jafr.2020.100073
26. Çelik C, Isik F. 2023. Quality characteristics of gluten-free muffins fortified with watermelon rind powder. *Food Sci Technol* 43. https://doi.org/10.1590/fst.113822
27. Dhakal D, Pradhananga ML. 2017. Utilization of watermelon rind (by-product) in preparation of candy and its quality evaluation. *Int J Multidiscip Res* 2(1): 1-6.
28. Evanuarini H, Amertaningtyas D, Utama DT. 2021. Viscosity, fat content, total acidity, and antioxidant capacity of reduced-fat mayonnaise made with watermelon (*Citrullus lanatus*) rind flour as stabilizer. *IOP Conf Ser Earth Environ Sci* 788: 012100. https://doi.org/10.1088/1755-1315/788/1/012100
29. Naknaen P, Itthisoponkul T, Sondee A, Angsombat N. 2016. Utilization of watermelon rind waste as a potential source of dietary fiber to improve health promoting properties and reduce glycemic index for cookie making. *Food Sci Biotechnol* 25(2): 415-424. https://doi.org/10.1007/s10068-016-0057-z
30. Chakrabarty N, Mourin MM, Islam N, Haque AR, Akter S, et al. 2020. Assessment of the potential of watermelon rind powder for the value addition of noodles. *J Biosyst Eng* 45: 223-231. https://doi.org/10.1007/s42853-020-00061-y