International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 8, 2025
https://theaspd.com/index.php

Optimization Of Watermelon Rind For The Nutritional Enrichment In Wheat Based Cookies

Arshida Noushad Shameena[1], Dr Anju M Neeliyara[2*], Jiby Abraham[3], Akshara S[4]
[1]Department of Clinical Nutrition and Dietetics, Sivagiri Sree Narayana Medical Mission, Thiruvananthapuram, Kerala, India, 695145
[2*] Department of Home Science St. Joseph's College for Women, Alappuzha, Kerala, India,688001
[3]Department of Home Science St. Joseph's College for Women, Alappuzha, Kerala, India,688001
[4]Department of Clinical Nutrition, Amrita Institute of Medical Sciences, Kochi, Kerala, India,682041

Abstract
Watermelon is a widely consumed fruit with lots of therapeutic significance, but people consume only the flesh part of the fruit and its remaining by-products mainly its rind part is often underutilized. Despite being loaded with several nutritional and health potential; they are largely discarded. Hence, present study was undertaken to optimize watermelon rind through their incorporation in convenience food. The core material watermelon rind was processed into rind flour by freeze drying method. Cookies were developed by incorporating this in 3 variations (10%, 20% and 30%). Organoleptic evaluation of these three samples and consumer acceptability of the best accepted sample was obtained. Total antioxidant activity of the product was estimated through DPPH assay. Popularization of the developed product was executed through an awareness talk followed by distribution of leaflet. Organoleptic evaluation and consumer acceptability scores of products revealed that cookie with 10% rind flour incorporation scored highest mean score with good overall acceptability. From DPPH assay of cookie, low IC50 value of 118.38 µg/ml indicates high antioxidant property of the cookie. The nutrient composition of best accepted sample was13.85g of protein, 124.5g of carbohydrate, 36.2g fat, 4.31 g of crude fibre, 112.01 mg of calcium, 5.12 mg of iron and 179.29 mg of magnesium. Hence, it can be concluded that underutilized watermelon rind bio waste can be effectively reutilized by developing nutritional, antioxidant and fibre rich cookie, which in turn increase the demand and optimization of such part. This offers variety and sustainability.
Keywords: *Antioxidant activity, DPPH assay, Sensory evaluation, Underutilized biowaste Watermelon rind*

INTRODUCTION

Watermelon (*Citrullus lanatus*) is a tropical fruit and is widely distributed in tropics and subtropical region. It is a functional food and has been reported to have therapeutic and pharmacological significance. [1].Watermelon flesh forms around sixty percentage of the total watermelon [2].Several studies have pointed out that only half of watermelon is utilized and remaining half goes as biowaste. Watermelon rinds is rich in several significant minerals and vitamins and are considered highly nutritious as they are also rich in specific amino acid like arginine, citrulline and healthy fatty acids like linoleic acid and oleic acid. They have antioxidant lycopene that help in reversing early skin aging and several degenerative diseases. An analytical study of rind reported that it contains good amount of moisture, protein, ash, carbohydrate, fat and provided about thirty percentage of the total weight. The major fibre which is present in watermelon rind is insoluble fibre and its presence has been related to several medical advantages including a decreased susceptibility of cardiovascular conditions and prevent excess gain in weight and reduce the incidence of diabetes, certain types of cancer and hypertension [3].

Processed fruits and vegetables produce a bulk of waste, which creates waste disposal and environmental problems. Worldwide usage of watermelon in 2018 was estimated around 166 million tons [4]. Large amount of biowaste which forms the massive volume of solid waste, ensuing from the production, preparation and consumption of watermelon could create disposal issues beside valuable biomass and nutrient loss. By raising dietary optimization of by-products, solid bio-waste associated environmental hazards and public health issues can be effectively managed [5]. Schieber et al has pointed that optimization and reutilization of bio wastes from processed vegetables and fruits as a source of ingredient that are functional is a very promising field.

In today's scenario, convenience food industry is adapting to Indian demands and is growing at a rapid pace in India [6].Cookies are mostly preferred all around the globe irrespective of age due to their good nutritional, taste variations, affordable and ready-to-eat nature and longer expiry date. It is also widely consumed and popular snack item which can be easily enriched with by-products that are rich with

bioactive components [7].In addition to this, use of cookie as a substitute to bread and such confectionaries also adds to the demand cookie production [8].

Modification and conversion of underutilized biowaste of watermelon such as rind into convenient product like cookies help to reduce mass of food waste accumulated, through reuse method with the aim to valorize and increase economic value thereby promoting sustainability of food. Furthermore, these biowaste that aren't being utilized might pollute the environment. Hence efficiently utilizing these food waste could be an effective means to promote sustainability of food in accordance to Sustainable Development Goal (SDG) by United Nation for ensuring sustainable eating and patterns of production [9].

Value added practices are considered as a major key to the future of sustainable farming. It can be achieved by processing fruits and its biowaste into various forms [10]. Despite its nutritional, economic and medicinal significance, watermelon rind still remains underexplored due to lack of awareness. By analysing the significant potentials of this underutilized part of watermelon, it necessitated to determine the method of utilizing watermelon rind, which are discarded and considered as biowaste, for preparing convenient food such as cookie. Convenient products developed by utilizing/incorporating watermelon rind flour is less available and purchased in markets, even though they are rich in lots of micro and macronutrients. All the factors mentioned above makes the study more significant. Hence the study entitled "Optimization of Watermelon Rind for the Nutritional Enrichment in Wheat Based Cookies" was undertaken emphasizing food sustainability through bio-waste reutilization. The following objectives were identified for carrying out the present study:To formulate and standardize cookies incorporated with processed watermelon rind, To evaluate organoleptic attributes and consumer acceptability of developed product**,** To analyze the antioxidant activity of developed cookies **,** To find the nutritional composition with regard to functional nutrients in the developed productand Popularization of developed product and imparting awareness regarding nutritional significance of watermelon rind, and its relevance in food sustainability.

MATERIALS AND METHODS

a) Processing of Watermelon rind into rind flour

High quality and fresh watermelon were bought from the local stores in Alappuzha district. Processing of watermelon began with removal of dust particles and other unnecessary items followed by cleaning the watermelon rind in running water.

Watermelon rind and pulp were properly separated. The sliced rinds were kept for pre freezing for 2 days and then freeze dried/lyophilized at -50^{0}C for 3 days. As this is a low temperature and complete dehydration processing method, they prevent microbiological activities thereby ensuring good quality final product. The dehydrated watermelon rind was then ground into rind flour and sieved to obtain fine flour. This rind flour was incorporated in the cookies. It was stored in zipper bag for subsequent treatments.

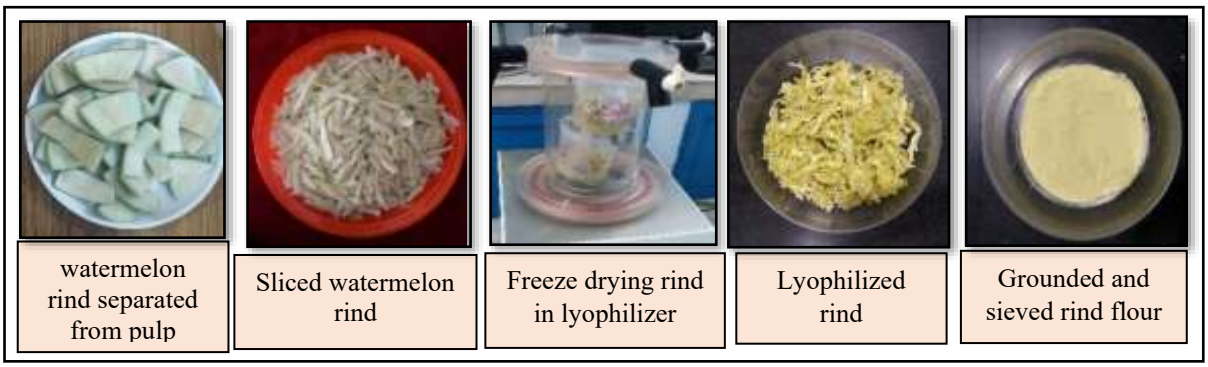

Figure 1. Processing of fresh watermelon rind to rind flour

b) Development and standardization of watermelon rind incorporated cookie

Preparation of cookies was carried out in the Food and Nutrition Laboratory, Department of Home science, St Joseph's College for Women, Alappuzha. Watermelon rind flour was the core ingredient and other ingredients such as sugar, wheat flour, butter, salt, vanilla essence, cardamom, baking powder; corn

flour and flax seed were purchased from local wholesale and retail outlets in Alappuzha. A recipe of cookie incorporated with watermelon rind flour was formulated and further subjected to standardization.
Three variations were developed through trial-and-error method by adding watermelon rind flour into wheat flour at three different proportion (10%, 20%, and 30%).In MRC 1 variation, 10g of watermelon rind flour was incorporated in 90g of wheat flour. In MRC 2 variation, 20g of watermelon rind flour was incorporated in 80g wheat flour and in MRC 3 variation, 30g of rind flour was incorporated in 70g of wheat flour. Other ingredients such as brown sugar (50g), butter (40g), baking powder (3g), vanilla essence (1 teaspoon), cardamom (2g), and flaxseed powder (5g) were added at same quantity to all the three variation samples.
After preparing the cookie, its sensory features such as colour, flavour, taste, texture, overall appearance and acceptability were assessed. Finally, the best accepted among all the three variations was selected and subjected to consumer acceptability and further analysis.

Method of preparation

Butter and sugar were thoroughly mixed well. Vanilla essence was added to this creamed mixture. All the dry ingredients were weighed and mixed together (Wheat flour, baking powder, flax seed flour, salt). To this dry mixture, watermelon rind flour was added. This sieved dry mix was then combined with wet ingredients and mixed to form dough. It was then flattened and cut into desirable shape using cookie cutter. They were loaded in tray placed with butter paper. Cookies were then baked for 160^0 C for 30 minutes. After baking, they were allowed to cool to room temperature. After cooling, they were packed and stored in polythene zipper bags for further analysis. Table 1 shows the composition of ingredients which are added for making cookies

Table1. Composition of ingredients of Melon rind cookies (MRC) variations

	VARIATIONS		
Ingredients	**MRC 1 (90:10)**	**MRC 2 (80:20)**	**MRC 3 (70:30)**
Wheat flour	90g	80g	70g
Melon rind powder	10g	20g	30g
Vanilla essence	1 tsp	1 tsp	1 tsp
Corn flour	5g	5g	5g
Sugar	50g	50g	50g
Salt	1g	1g	1g
Cardamom powder	1g	1g	1g
Butter	40g	40g	40g
Baking powder	3g	3g	3g
Flaxseed flour	5g	5g	5g
Milk	10 ml	10ml	10ml
Total no of cookies	12 cookies		

***Wheat flour: Watermelon rind flour**

c) Organoleptic Evaluation

Organoleptic attributes of the product were evaluated by 5 trained panellists amongst the faculty members of St Joseph's College for Women, Alappuzha. A panellist were selected on the basis of their willingness to participate and has knowledge on sensory evaluation of products. Evaluation with regard to attributes of product such as colour, appearance, taste, texture, flavour, and overall acceptability of product was carried out using 5-point hedonic rating scale (5 = excellent, 1= poor), Which is depicted in **Table 2**. Overall acceptability of cookies was also assessed by each member of the panel.

Table 2. 5 point hedonic rating scale for Organoleptic Evaluation of MRC

EXPRESSION	SCORE
Like Extremely	5
Like Moderately	4
Neither Like nor Dislike	3
Dislike Moderately	2
Dislike Extremely	1

d) Consumer Acceptability

40 consumers from two selected SHG units in Thiruvananthapuram district were selected as the consumer panellist for the study. Consumer acceptability score cards were distributed among the members. They evaluated the product and scored on attributes of the product such as appearance, texture, taste, aroma and overall acceptability etc using 5-point hedonic rating scale (5 denotes "Like extremely" and 1 denotes "dislike extremely"), which is shown in **Table 3.**

EXPRESSION	SCORE
Excellent	5
Very Good	4
Good	3
Fair	2
Poor	1

Table 3 : 5-point hedonic rating scale for consumer acceptability of product

e) Analysis of Antioxidant activity of best accepted product

Antioxidant activity was estimated through DPPH free radical scavenging assay. The principle behind the DPPH assay was to obtain the antioxidants scavenging potential. The percentage inhibition of already generated free radicals by antioxidants was typically used to classify the DPPH scavenging activity. Parameter used to represent the antioxidant capacity was the IC50 value. It was acquired through the interpolation of results from linear regression analysis. The following formula was used to determine the amount of radical scavenging activity:

Inhibition (%) = $[(A_0 - A_t)/A0] \times 100$ (A_0 represents absorbance control and A_t is for absorbance sample respectively

f) Nutritional composition with regard to functional nutrients in the developed product

The nutritive values of the most acceptable variation of the cookies were calculated using C Gopalan's book of "Nutritive value of Indian Foods (2010). The nutrients taken into consideration were protein, fat, carbohydrate, fibre, calcium, magnesium and iron. A value of watermelon rind was computed using the established values from care listed journal articles.

g) Statistical Analysis of data

All the data were expressed as Mean ± SD, plotted graphs and formed regression equations using Microsoft Excel. The evaluation scores by panellists were gathered and statistically compared by plotting tables using simple statistical tools.

h) Product popularization and preparation of visual aid

In the present study, popularization of Melon Rind Cookie (MRC) developed by incorporating watermelon rind flour was implemented in 2 steps. Primarily, consumers were given a short awareness talk to get familiarized regarding the relevance in reutilizing the underutilized parts of watermelon and their social and economic importance. This was followed by the introduction of developed product and distribution of leaflet.

RESULTS AND DISCUSSION

Organoleptic evaluation

Organoleptic evaluation of the three variations of watermelon rind cookies were rated using 5-point scale hedonic score system (5 = excellent, 1= poor) by trained sensory panels. Results of the organoleptic evaluation showed that MRC 1 cookies incorporated with 10 percent rind flour was preferred best among all the variations and had the highest mean scores for all the attributes such as appearance, colour, texture, flavour and aroma. Overall acceptability of MRC 1 was higher when compared to other two variations. It can be observed from **Fig.1** that the overall acceptability of the cookies reduced with increased watermelon rind flour addition.

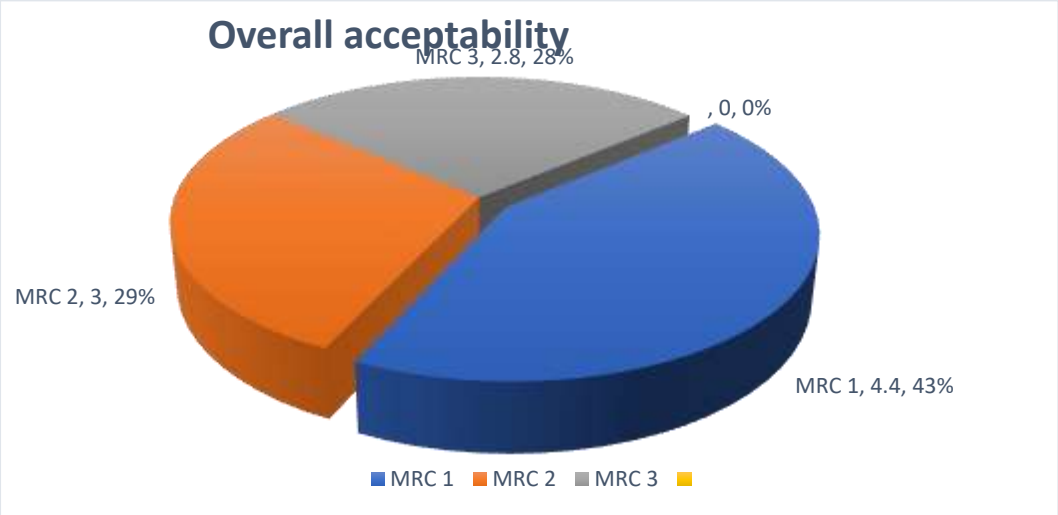

Figure 2. Overall acceptability of cookies variations

Table 4 presents the mean organoleptic scores of melon rind cookies. It can be the result of decreased impression of sensory attributes. With increasing watermelon rind flour content in the cookies, presence of unappealing flavour and darkening of cookie colour was observed. Increment in watermelon rind flour caused a decrease in texture attributes of the cookies as well. This may be due to change in gluten composition. Increased addition of fiber rich gluten free ingredient interferes the formation of gluten and affects the texture. Also, the moisture content of watermelon rind flour might also be a reason for the softness of the cookie. In terms of aroma, much significant variation was not observed among the three samples.

Table 4. Mean organoleptic scores of Melon Rind Cookies variations (MRC)

***Wheat flour: Watermelon rind flour**

Attributes	Samples		
	MRC 1 (90:10)	MRC 2 (80:20)	MRC 3 (70:30)
	Mean ± Standard deviation		
Appearance	3.8 ± 0.447	3.2 ± 0.477	3 ± 0.00
Colour	3.6 ± 0.547	3 ± 0.707	2.8 ± 0.447
Texture	4.0 ± 0	3.2 ± 0.447	2.6 ± 0.547
Flavour	3.8 ± 0.447	2.8 ± 0.447	2.6 ± 0.547
Aroma	4 ± 0	3.8 ± 0.447	3.8 ± 0.447
Acceptability	4.4 ± 0.547	3 ± 0	2.8 ± 0.447

Consumer acceptability

Consumer acceptability was conducted for the best accepted variation of watermelon rind flour incorporated MRC sample. 40 consumers were randomly selected from two different SHG units in

Thiruvananthapuram district, Kerala. Acceptability was tested using5-point hedonic scale. Results were presented as Mean ± SD.
Mean scores of attributes such as appearance, colour, texture, flavour and aroma of the product evaluated by the consumers are presented in **Table.5.** Appearance scored a mean score of 4.2 ± 0.406. Texture wise it was acceptable by the consumers with a mean score of 4± 0.262. Aroma of the cookie had the highest mean score of 4.26 ±0.583 among the attributes. The consumers opined that the aroma of the developed product was pleasing. Taste of the product was also suggested acceptable.

Table 5. Mean consumer acceptability scores of Melon Rind Cookies variations

Attributes	Mean ± SD
Appearance	4.2 ± 0.406
Texture	4 ± 0.262
Taste	4.03 ± 0.319
Aroma	4.26 ± 0.583
Acceptability	4.23 ± 0.626

By analysing the overall acceptability mean score presented in **Fig.2**, it can be clearly understood that the best accepted sample MRC 1 has high acceptability among the consumer with a mean score of 4.23 ± 0.626. Sample MRC 1 was rated highly acceptable and liked by the consumers.

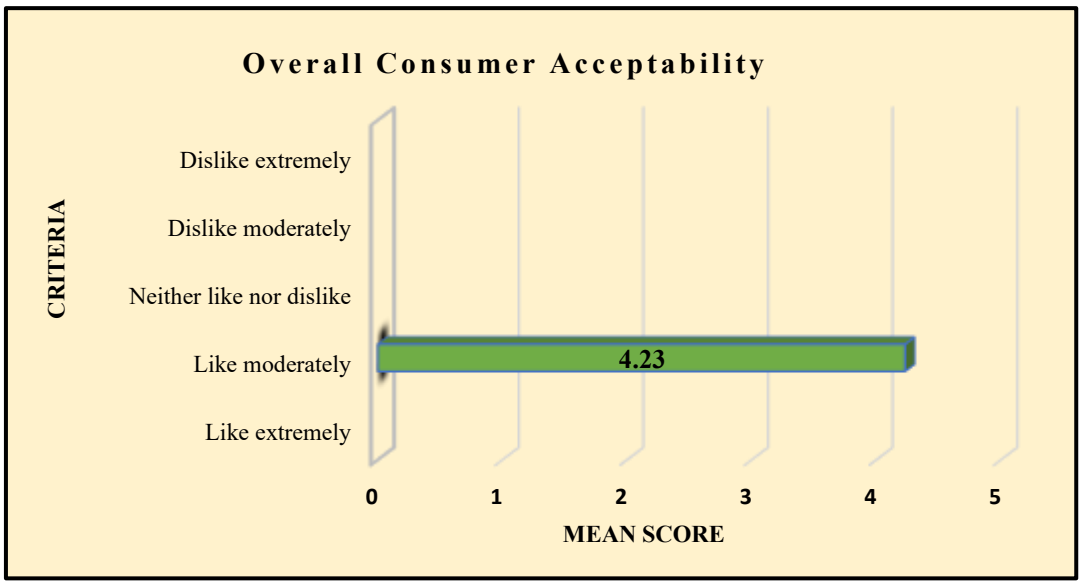

Figure 3. Overall consumer acceptability of best accepted cookie

Nutritional composition of best accepted product
Table 6 shows the nutrient composition of the best accepted cookie. From nutrient analysis, it was clear that MRC cookie has good amount of nutrients. Nutritional composition of12 developed MRC cookies 13.85g of protein, 124.5g of carbohydrate, 36.2g fat, 4.31 g of fibre, 112.01 mg of calcium, 5.12 mg of iron and 179.29 mg of magnesium.

Generally, fibre composition in wheat flour is reduced due to its bran removal during milling process. Watermelon rind is an abundant source of fibre which when incorporated with wheat flour enrich the food product with appreciable fibre and enhance the overall health and value of the developed product. Presence of insoluble fibre in watermelon rind flour has been related to several health advantages. [3]. Watermelon rind flour also enhanced overall magnesium and calcium content. The use of brown sugar instead of white sugar also contributed in increased mineral level such as calcium, iron, magnesium etc. due to its molasses content. Overall rind flour supplementation enhanced the overall nutritional content of the wheat-based cookie.

Table 6. Nutritional composition of the best accepted cookie

Ingredients	Amount (g)	Protein (g)	Carbohydrate (g)	Fat (g)	Fiber (g)	Calcium (mg)	Iron (mg)	Magnesium (mg)
Wheat flour	90 g	10.89	62.46	1.53	1.71	43.2	4.41	118.8
Melon rind flour	10 g	1.12	5.602	0.23	1.72	2.91	0.12	34.66
Corn flour	5g	0.01	4.56	-	0.04	-	-	-
Brown sugar	50g	0.2	48	-	-	41.5	0.35	4.5
Cardamom powder	1g	0.3	1.26	0.06	0.6	3.9	0.12	1.73
Butter	40g	-	-	32.4	-	-	-	-
Baking powder	3g	0.003	0.75	-	-	-	-	-
Flaxseed flour	5g	1.01	1.44	1.8	0.24	8.5	0.1	19.6
Milk	10ml	0.32	0.44	0.20	-	12	0.02	-
TOTAL		**13.85g**	**124.5g**	**36.2g**	**4.31g**	**112.01 mg**	**5.12mg**	**179.29 mg**

Antioxidant activity of best accepted cookie

Figure 3 depicted the antioxidant activity of accepted product. Antioxidant capacity of the best accepted cookie sample was evaluated through DPPH method. The IC50 value obtained for the ethanolic extract of the sample was 118.38 µg/ml. The result revealed that percentage inhibition increased and absorbance decreased as sample concentration increased which indicates that the developed rind flour incorporated cookie MRC exhibited high antioxidant property. In a research work evaluating chemical features of

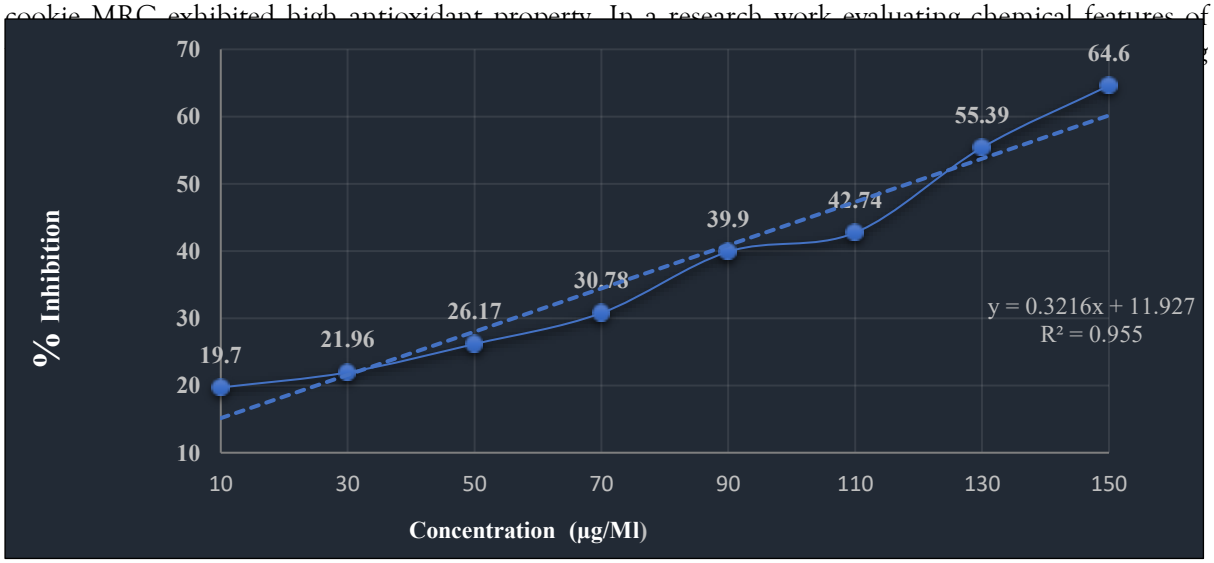

Figure 4.DPPH assay of MRC-ethanolic extract

Product popularization

Popularization of cookies developed by incorporating the watermelon rind was carried out through a short awareness talk followed by the distribution of leaflet. The main objectives of the awareness talk were to familiarize the concept of food sustainability and relevance in reutilization of functional bio waste among the people, simultaneously introducing the developed product. The selected population were not familiar with the concept of food sustainability and its influence in environmental integrity. So, it was briefly explained to them. Main topics that were highlighted in leaflet was nutritional and therapeutic potentials of watermelon rind along with the recipe of developed product. The matters presented in the leaflets were kept in simple and easily understandable form.

CONCLUSION

From the study it can be concluded that watermelon rind when supplemented in convenient product like cookie enhanced the overall nutritional composition and antioxidant activity of the cookie. The developed product was liked and rated acceptable by the consumers. All the concerns and doubts regarding the consumption of rinds were successfully discussed and convinced through awareness talk that was implemented as part of product popularization. Addressing the great challenges of minimizing waste arising from food processing and utilizing them for the production of nutritionally enriched products supports the goal of sustainable production. The watermelon rind flour's high total dietary fibre content suggests that it could be used as an enrichment ingredient in food products to create high-fibre, nutritious foods with added value. Large amount of waste produced by its consumption, mainly when only the pulp of the watermelon fruit is consumed and the remaining rind is discarded can be thus utilized successfully in food application, thereby solving the issue of food loss and disposal concerns.

Acknowledgement

We extend our sincere gratitude to Dr. Rita Latha D'Couto, Principal, and the management of St. Joseph's College for Women, Alappuzha, for providing the opportunity to carry out this research in their esteemed institution and for their valuable cooperation throughout the study

Funding: The authors gratefully Acknowledge the financial assistance offered by ASPIRE Scholarship, Directorate of collegiate education, Government of Kerala for the successful completion of the project.

Conflict of interest: The authors declare no conflict of interest.

Data Availability Statement: The data used and/or analysed during the current study are available from the corresponding author upon reasonable request

Ethics Statement: This research did not involve human participants, animal subjects, or any material that requires ethical approval

Clinical Trial Registration: This research does not involve any clinical trials

Authors' Contributions

Arshida Noushad was developed the product. Dr Anju M Neeliyara and Jiby Abraham guided the original research and also done the sensory evaluation of the product. Akshara S has helped in preparation of this manuscript.

REFERENCES

1. Maoto MM, Beswa D, Jideani AIO. Watermelon as a potential fruit snack. *https://doi.org/101080/1094291220191584212*. 2019;22(1):355-370. doi:10.1080/10942912.2019.1584212
2. Rico X, Gullón B, Alonso JL, Yáñez R. Recovery of high value-added compounds from pineapple, melon, watermelon and pumpkin processing by-products: An overview. *Food Research International*. 2020;132:1-21. doi:10.1016/J.FOODRES.2020.109086
3. Fradinho P, Nunes MC, Raymundo A. Developing consumer acceptable biscuits enriched with Psyllium fibre. *J Food Sci Technol*. 2015;52(8):4830-4840. doi:10.1007/S13197-014-1549-6
4. FAO. Statistical data base. Food and Agriculture Organization of the United Nations. 2020. Accessed June 3, 2022. http://faostat3.fao.org/home/E
5. Egbuonu ACC. Comparative assessment of some mineral, amino acid and vitamin compositions of watermelon (Citrullus lanatus) rind and seed. *Asian Journal of Biochemistry*. 2015;10(5):230-236. doi:10.3923/AJB.2015.230.236
6. Raj S, Suvadarshini A, Mishra BB. Role, Relevance and Significance of Convenience Food -A Literature Review Approach. *Global Media Journal*. 2021;19(41):253.
7. Veronika Kuchtová, Zlatica Kohajdová, Jolana Karovičová, Michaela Lauková. Physical, Textural and Sensory Properties of Cookies Incorporated with Grape Skin and Seed Preparations. *Pol J Food Nutr Sci,*. 2018;68(4):309-317.
8. Apeda agri exchange. Market Intelligence Report for Biscuits. 2020. Accessed June 2, 2022. https://agriexchange.apeda.gov.in/Weekly_eReport/Biscuit_ Report.pdf

9. Lau KQ, Sabran MR, Shafie SR. Utilization of Vegetable and Fruit By-products as Functional Ingredient and Food. *Front Nutr*. 2021;8:261. doi:10.3389/FNUT.2021.661693
10. Dalal N, raj N, Bisht V. Value Added Products from Ber. *Int J Curr Microbiol Appl Sci*. 2019;8(01):1603-1615. doi:10.20546/IJCMAS.2019.801.169
11. Hanan S, Ahmed AR. Utilization of watermelon rinds and sharlyn melon peels as a natural source of dietary fiber and antioxidants in cake. *Annals of Agricultural Sciences*. 2013;58(1):83-95. doi:10.1016/J.AOAS.2013.01.012