American-Eurasian J. Agric. & Environ. Sci., 22 (3): 119-125, 2022
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2022.119.125

Analytical Study of the Components of Watermelon Rind and Evaluation of its Use as a Substitute for Flour

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Abstract: Watermelon rind is treated as agricultural waste and commonly discarded, causing environmental pollution. This study was done to identify components profiles of watermelon rind to utilize of this by-product and convert into useful products. The present results confirmed that watermelon rind is a good source of the dietary fiber (~ 16%), nutrition minerals (especially potassium which was more than 4%) and antioxidants compounds (phenols was 1415 ppm & flavonoids was 732 ppm). Watermelon rind powder was used partially substituted for wheat flour in produced cookies at different levels (5, 10 and 20 %). Sensory evaluation has been done for the produced cookies, which confirmed the overall acceptability of the product. Then, this study approved the watermelon rind powder could be used for bakery manufacturers as a cheap source for substitute for wheat flour to produce baked food products that contain many ingredients that have beneficial effects on human health and at low costs.

Key words: Watermelon rind · Nutritional components · Substitution · Evaluation

INTRODUCTION

Agro-waste is the large volumes of solids waste, resulting from the production, preparation and consumption of fruit and vegetable. These wastes pose potential disposal and pollution problems along with loss of valuable biomass and nutrients. There are many sources of fruit wastes but there is lake of information about their content and activity of antioxidant compounds. There is a potential for conversion of agro-wastes into useful products or even as raw material for other industries [1].

The peel of fruits and vegetables are generally higher in antioxidants, fiber, vitamins and minerals than the flesh. The antioxidant levels in the peel of fruits could be up to 328 times higher than those found in the flesh [2]. Watermelon (*Citrullus lantus*), a tropical fruit, belongs to the family *Cucurbitaceae* and grows in almost all parts of Africa and South East Asia [3]. Watermelon fruit is generally eaten raw; however, most times only the fleshy pulp of the fruit is consumed leaving the seeds and rind.

Watermelon rind is treated as agricultural waste and commonly discarded, causing environmental issues and biomass loss. The edible rind makes up approximately 40% of the total watermelon mass yet is often discarded as waste [4]. Watermelon rinds are edible, being rich in many nutrients, but because of their unappealing flavor, most people avoid eating those [5]. It would be favorable to take advantage of the nutritional potential of rind and create commercial value, rather than limiting it to agricultural waste.

Whereas, watermelon rind is a rich source of dietary fiber, also serves as a good source of phyto-chemicals and bioactive compounds; hence it could be used in the development of functional foods.

This study was aimed to identify the nutritional quality of watermelon rind with regards to its content of antioxidants compounds, fiber, protein, fat, carbohydrate and nutrition minerals. Besides to doing food safety analyzes. In addition to Feasibility study of using watermelon rind as a substitute for flour in making some baked products.

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MATERIALS AND METHODS

This study was carried out in the Regional center for Food and Feed (RCFF), Agricultural Research center (ARC), Giza, Egypt.

Preparation of Watermelon Samples: Three watermelon peels samples were extracted from three different parts of the fruit. Each sample was collected from 3 fruits, mixed together, then cut into small pieces and air dried at 50°C for 48 h using oven, the dried samples were ground to a fine powder and stored at 4°C for further analysis.

Chemical Analysis

Antioxidants Determination: Total antioxidant activity was measured according to the procedure described by AOAC [6], total phenols was determined by Singleton *et al*. [7] method and total flavonoids was determined according to Arvouet-Grand *et al*. [8] method.

Screening of Phytochemical Compounds: Determination of phytochemicals compounds were performed according to the method described by Santana *et al.* [9] using GC/MS/MS technique. The analysis was carried out using a GC (Agilent Technology 7890A) coupled with a mass-selective detector (MSD, Agilent 7000 Triple Quad).

The identification of components was based on a comparison of their mass spectra with the authentic compounds and by computer matching with NIST library as well as by comparison of the fragmentation pattern of the mass spectral data with those registered in the literature

Proximate Analysis: Total protein, fat, crude fiber, moisture and ash content were analyzed according to standard methods of Association of Official Analytical Chemists Total carbohydrate was determined by subtracting [10].

Determination of Minerals Concentration: The analytical determination of the minerals, Calcium (Ca), magnesium (Mg), Iron (Fe), Copper (Cu), Zinc (Zn), sodium (Na) and potassium (K), was carried out by inductively coupled plasma-mass spectrophotometer (ICP/MS/MS Agilent 8800) according to the AOAC [11].

Detection of Bacterial Strains: Total *Faecal Coliform* count was done according to Nmkl [12]; enumeration of *Bacillus Cereus* count according to Nmkl [13]; enumeration of *Staphylococcus* count according to Nmkl [14]; enumeration of *Salmonella* count according to Gantois *et al*. [15]; enumeration of total bacterial count according to Nmkl [16] while enumeration of total fungal count done according to Nmkl [17].

Storage experiments were done and samples were analyzed every month for a period of three months. These experiments have been done at two temperatures for storage, one below zero (-20 ± 2°) in polyethylene packages and the other at room temperature (25 ± 2°) in burlap bags.

Making of Cookies: According to recipes described by Adebowale *et al*. [18], cookies dough was prepared except Watermelon rind powder was used partially substituted for wheat flour in produced cookies at levels (5, 10 and 20 %).

Sensory Analysis: Sensory evaluation of baked cookies was conducted according to the method of Johnson *et al*. [19]. The characteristic of biscuits include odor, texture, taste and color. Samples were evaluated after few hours of preparation by trained judges. Score were collated and analyzed statistically. The data were statistically analyzed by analysis of variance using completely randomized design and least significant difference (L.S.D.) at 0.05 level according to the method described by Snedecor and Cochran [20].

RESULTS AND DISCUSSION

From results shown in Table (1) turn out that watermelon rind is a rich source of antioxidant compounds such as phenols and flavonoids as explained by Feizy *et al*. [21] and Zain *et al*. [22]. It is also a source of phytochemicals. Whereas, Fig 1. show the obtained chromatograph of watermelon sample by GC/MS and results from Table (2) show that there were more than (17) flavonoid compounds as tetramethoxyflavanone and tetramethoxyflavone that besides to about (15) phenols as 2-hydroxy-4-methoxyacetophenone and 2, 6-Dihydroxybenzoic acid in watermelon extract. These obtained results agree with Du and Ramirez [23] who identified volatile profiles of watermelon rind using GC-MS and found, the little but dominated nine-carbon volatiles in the rind associated with fresh, green and melon-like aroma have potential to make positive contributions to the food products. Which make the properties of watermelon rind are ideal for using as a food ingredient in different food products.

Table 1: Anti-oxidants, phenols and flavonoids results.

Sample	Total anti-oxidant activity (ppm)	Total phenols (ppm)	Total flavonoids (ppm)
Watermelon rind	10344.7	1414.8	731.9

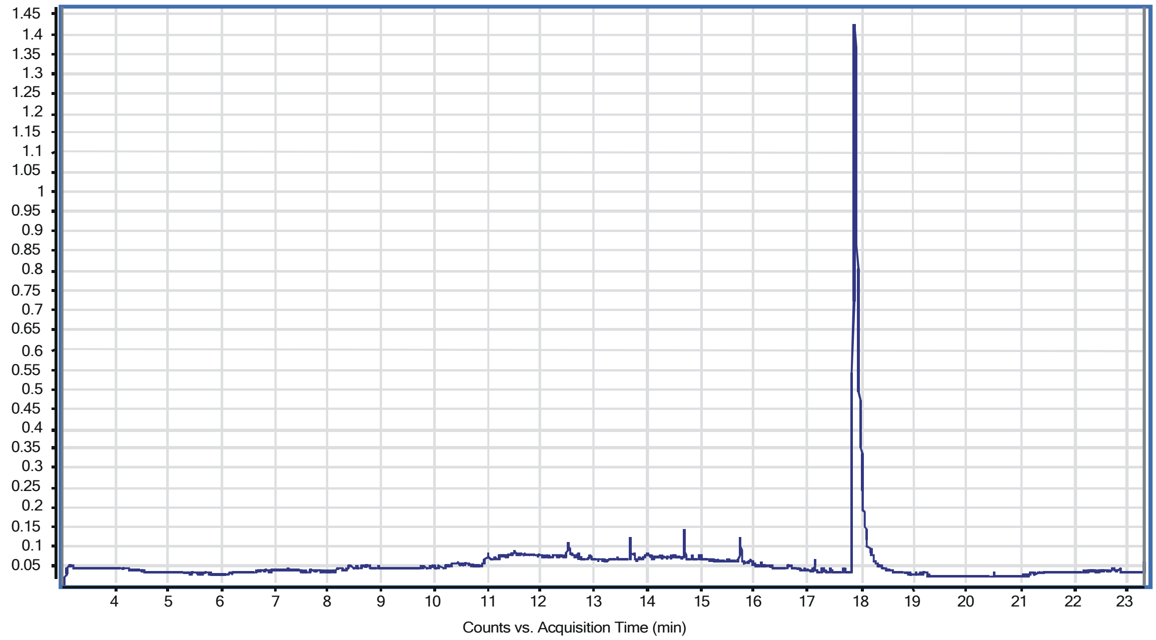

Fig. 1: Chromatograph of watermelon Sample by GC/MS

Table (3) exposure the proximate composition of watermelon rind which emphasizes the beneficial effect on human health as confirmed by Abu-Hiamed [24] and Al-Sayed and Ahmed 2013 [25] who found that watermelon rinds had moisture, ash, fat, protein and carbohydrates 10.61%, 13.09%, 2.44%, 11.17% and 56.00%, respectively. And this can be used as dietary materials.

Table (4) reflects that watermelon rind is also serving as a good source of nutrition minerals. This agrees with Gladvin *et al*. [26] in declaring that

The preponderance of these nutrients in the rind samples, are nutritional importance warranting further studies to increase the dietary use of these food wastes and reduce the attendant burden in the environment.

And before using these peels as dietary materials, it was necessary to ensure their nutritional safety. Food Safety tests results are shown in Table (5). And according to these results it could be said that watermelon peels are safe and can be used in food products.

From Tables (6) & (7) it was clear that antioxidant activity, total phenols and flavonoids were decreased with the passage of time and at both temperatures under study and the concentrations at room temperature were lower than those at the freezing point. This is consistent with what Moldovan *et al*. [27] found in his study on Effects of storage temperature on the total phenolic content of Cherry. He found that the content and stability of phenolic compounds decreases with increasing of storage temperature. Also, Sánchez *et al*. [28] cleared that stability in phenolic content and antioxidant activity when stored some parts of plant during 60 days at 25°C less than stability when stored at -20°C.

Proximate analysis results in Tables (8), (9) It showed that the protein analysis only changed slightly compared to the rest of the analysis, which was not affected by a noticeable effect at both temperatures with the passage of the storage period. The results of the analyses of the elements from Tables (10), (11) also did not witness a noticeable effect on storage or when changing the degree of storage.

Food safety analyzes - Tables (12), (13) - showed an increase in the values of some bacteria after storage, especially at room temperature, where they were greater than those when kept at freezing. The values were the largest after 3 months. It was noted that salmonella bacteria did not appear in any sample and under any storage conditions.

Table 2: Organic compounds content obtained by GC/MS instrument

NO.	RT.	Compound Name	Area sum%
1	8.709	7,3',4',5'-Tetramethoxyflavanone	4.06
2	9.783	6,7,3',4'-Tetramethoxyflavone	2.39
3	10.443	Gardenin	1.76
4	10.981	Syringic acid	1.08
5	11.264	2,6-Dihydroxybenzoic acid	1.41
6	11.546	Propyl gallate	1.12
7	12.506	Phloroglucinol	0.79
8	12.604	Flavone, 3,5,7-trimethoxy-	1
9	12.904	3-(3,4-Dimethoxyphenyl)-4-methylcoumarin	0.66
10	13.47	3,6,2',3'-Tetramethoxyflavone	0.73
11	13.675	5,7,2'-Trimethoxyflavone	1.26
12	13.749	3-Hydroxy-7,8,2'-trimethoxyflavone	0.77
13	14.003	2'-Hydroxy-3,4,5-trimethoxychalcone	0.75
14	14.491	3,4'-Dimethoxy-2'-hydroxychalcone	0.72
15	14.684	Baicalein trimethyl ether	1.29
16	14.856	3,2',4',5',6-Pentamethoxyflavone	0.64
17	14.856	Nobiletin	1.03
18	15.512	3,2',4',5'-Tetramethoxyflavone	0.87
19	15.742	7-Hydroxy-8-methylisoflavone	1.59
20	15.902	3-(3,4-Dimethoxyphenyl)-6-methyl-4-phenylcoumarin	0.75
21	16.144	3-Hydroxy-6,3',4'-trimethoxyflavone	0.7
22	16.652	Apigenin 8-C-β-D-glucoside	0.88
23	16.812	3,6'-Dimethoxy-2'-hydroxychalcone	1.05
24	17.14	2'-Hydroxy-2,4,4'-trimethoxychalcone	1.12
25	17.296	Benzoic acid	0.83
26	17.444	3,4-Dihydrocoumarin	0.92
27	17.686	3-(3,4-Dimethoxyphenyl)-7-methoxy-4-phenylcoumarin	1.07
28	17.895	2'-Hydroxy-4'-methoxyacetophenone	63.55
29	19.21	7-Diethylamino-3-(3,4-dimethoxyphenyl)coumarin	1.25
30	19.207	Gentisic acid	0.69
31	20.482	Salicylic acid β-D-O-glucuronide	1
32	21.2	Dimethylfraxetin	0.73
33	22.766	3,7,8,2'-Tetramethoxyflavone	0.8
34	22.853	Flavone, 5-hydroxy-3,3',4',6,7-pentamethoxy-	0.77

Table 3: Proximate analysis results

Sample	Protein	Moisture	Fat	Ash	Fiber	Carbohydrate
Watermelon rind	16.8	7.3	1.8	7.8	15.8	50.5

Table 4: Macro and micro elements contents results

Sample	Na(%)	Mg(%)	K(%)	Ca(%)	P(%)	Fe(ppm)	Mn(ppm)	Cu(ppm)	Zn(ppm)
Watermelon rind	1.02	0.87	4.13	0.38	1.62	671	286	11.5	52.9

Table 5: Food safety analysis results

Sample	FCC	BCC	SCC	SC	TBC	TFC
Watermelon rind	ND	ND	ND	ND	$< 10^3$	ND

FCC: Faecal Coliform count in cfu/g unit

BCC: Bacillus Cereus count in cfu/g unit

SCC: Staphylococcus count in cfu/g unit

SC: Salmonella count in cfu/g unit

TBC: Total bacterial count in cfu/g unit

TFC: Total fungal count in cfu/g unit

ND: not detected

Table 6: Anti-oxidant, phenols and flavonoids results after storage at freezing degree

Period	Total anti-oxidant activity (ppm)	Total phenols (ppm)	Total flavonoids (ppm)
After 1 month	8870	1110	418
After 2 months	4887	788	232.5
After 3 months	3245.4	469.8	193.6

Table 7: Anti-oxidant, phenols and flavonoids after storage at room temperature

Period	Total anti-oxidant activity (ppm)	Total phenols (ppm)	Total flavonoids (ppm)
After 1 month	6877.5	1050	431
After 2 months	3988	780	221
After 3 months	2592	458.1	131.8

Table 8: Proximate analysis results after storage at freezing degree

Period	Protein	Moisture	Fat	Ash	Fiber	Carbohydrate
After 1 month	15.7	7.7	1.8	7.8	16.1	50.9
After 2 months	14.8	8.2	2	8	15.6	51.4
After 3 months	13.9	8.8	2.1	8.7	15.6	50.9

Table 9: Proximate analysis results after storage at room temperature

Period	Protein	Moisture	Fat	Ash	Fiber	Carbohydrate
After 1 month	12.4	8.9	1.7	7.4	11.4	58.2
After 2 months	11.8	9.3	1.6	7.6	10.6	59.1
After 3 months	10.9	9.8	1.6	7.7	9.8	60.2

Table 10: Macro and micro elements contents results after storage at freezing degree

Period	Na (%)	Mg (%)	K (%)	Ca (%)	P (%)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
After 1 month	1	0.87	4.11	0.40	1.6	677	279	11	51
After 2 months	0.99	0.88	4.09	0.41	1.58	680	273	10.9	49
After 3 months	0.99	0.88	4.08	0.42	1.57	683	269	10.7	48

Table 11: Macro and micro elements contents results after storage at room temperature

Period	Na (%)	Mg (%)	K (%)	Ca (%)	P (%)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
After 1 month	12.4	8.9	1.7	7.4	11.4	58.2	12.4	8.9	1.7
After 2 months	11.8	9.3	1.6	7.6	10.6	59.1	11.8	9.3	1.6
After 3 months	10.9	9.8	1.6	7.7	9.8	60.2	10.9	9.8	1.6

Table 12: Food safety analysis results after storage at freezing degree

Period	FCC	BCC	SCC	SC	TBC	TFC
After 1 month	$< 10^2$	10	$< 10^3$	ND	$< 10^3$	ND
After 2 months	10^2	3 x10	$<10^3$	ND	$< 10^4$	ND
After 3 months	$<10^3$	5x 10	$<10^4$	ND	$11x\ 10^4$	ND

Table 13: Food safety analysis results at after storage room temperature.

Period	FCC	BCC	SCC	SC	TBC	TFC
After 1 month	$< 10^3$	5x10	10^3	ND	$23x\ 10^3$	ND
After 2 months	$15x10^3$	$<10^2$	$<10^4$	10	$55x\ 10^4$	ND
After 3 months	$9x10^4$	10^2	$<10^5$	10	$21x\ 10^5$	ND

Table 14: Sensory evaluation bakery product of watermelon peel.

Sensory characters	Color	Taste	Texture	Odor
T_5	8.55^a	8.5^{ab}	8.5^a	8^a
T_{10}	8.65^a	8.9^a	8.75^a	8.75^a
T_{20}	8.25^a	8.2^b	8.45^a	7.85^a
LSD	0.78	0.64	0.69	0.85

Scale represent 9-points score system where 1=dislike extremely, 2= dislike very much, 3= dislike moderately, 4= dislike slightly, 5= neither liked or dislike, 6= like slightly, 7= liked moderately, 8= liked very much and 9= liked extremely

LSD = Least significant differences

Table (14) shows sensory evaluation of the prepared cookies. The cookies produced from all substitution level were found to have good quality grade for all the evaluated sensory quality. So, it can be recommended to use the watermelon rind powder for bakery makers as a cheap source for substitute for wheat flour to produce baked food products.

CONCLUSION

The obtained results showed that watermelon rinds are valuable by-products due to their content of many nutrients and antioxidants; Thus, these rinds can be used in the manufacture of products as nutritional supplements. It is preferable to use fresh vegetable peels, not stored and in the case of storage, they are stored in polyethylene bags and at -20°C. It can also be recommended to use the watermelon rind dry powder for bakery manufacturers as a cheap source for substitute for wheat flour to produce baked food products that contain many ingredients that have beneficial effects on human health and at low costs. Finally, the utilization of wastes of fruit and vegetable processing as a source of functional ingredients is a promising field.

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