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ANTIOXIDANT ACTIVITY OF LEMON, LIME, MANDARIN AND KIWI FRUIT PEELS

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Annotation

The article presents the results of studies conducted to evaluate the antioxidant activity of the peel of local lemon variety "Meyer", Iranian lime, Turkish and Chinese mandarins varieties "Nova" and "Mini", as well as Iranian kiwi variety "Hajian". The antioxidant activity of aqueous extracts of dried at room temperature and crushed fruit peels was measured in vitro using a method based on the inhibition of the reaction of adrenaline autoxidation. All the studied fruit peels showed high antioxidant activity, and it was found that the peel of lime and kiwi exhibited the highest antioxidant activity.

How to Cite

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Introduction. Citrus fruits are fruits of the genus *Citrus L. of the Rutaceae* family. These are fruits are very well accepted by consumers due to their attractive color, pleasant taste, aroma and healing properties. Citrus fruits are one of the most widely grown fruits in the world. In recent years, the average annual production of these fruits in the world has been about 150 million tons [1]. Spain, Mexico, China, India, Brazil and the United States are the countries that grow the most citrus fruits, such as lemons, limes, tangerines, kiwis, oranges, grapefruits.

Fruit peels, which are a waste product of consumption and processing of these fruits, are a unique source of biologically active substances with strong antibacterial and antioxidant properties, such as flavonoids, phenolic acids and essential oils. As an example, Table 1 The relative concentrations of phytochemicals in the peel and pulp of mandarin fruits are compared [5, 6, 4].

Table 1. Concentration of biologically active substances in the peel and pulp of citrus fruits .

Biologically active substance	Citrus zest	Citrus pulp	Source
Hesperidin	111 mg/100 g wet weight	17 mg/100 g wet weight	[7]
Limonene	up to 70% essential oils	Low concentration	[8]
Vitamin C	53 mg/100 g wet weight	70 mg/100 g wet weight	[9]
Beta-carotene	0.08 mg/100 g wet weight	0.11 mg/100 g wet weight	[10]
Fiber	15.2 %	7.8 %	[11]
Total phenolic acids	70 mg/100 g wet weight	24 mg/100 g wet weight	[12]

This table shows that the pulp contains more vitamin C and carotenoids, while the peel contains more other components with antioxidant properties, including flavonoids and essential oils. Therefore, in most cases, the peel of citrus fruits has higher antioxidant properties than their pulp. These natural organic substances not only prevent the formation of dangerous microbes, but also protect the body from oxidative stress, which is the cause of a number of chronic diseases [2, 3, 4].

Free radicals cause severe destructive damage to DNA, proteins and cells, being highly reactive particles due to their unpaired electron. Antioxidants are protective agents that neutralize free radicals and therefore protect the body. from oxidative stress [13, 14, 15].

This article presents the results of studies conducted to assess the antioxidant activity (AOA) of lemon, lime, mandarin and kiwi peels.

Materials and methods. The peel of local lemon of the Meyer variety, Iranian lime, Turkish and Chinese mandarin oranges of the Nova and Mini varieties, as well as peels of Iranian kiwi fruits of the Hadjyan variety. The antioxidant activity of the samples was assessed *in vitro.* by a method based on the inhibition of the reaction of adrenaline autoxidation under conditions [16, 17, 18].

Sample preparation: The peel was separated from the fruit and dried at room temperature in a cool place in the air until constant weight. The dried bark was crushed into small pieces and ground in a mill.

Sample extraction: 0.75 g of crushed fruit peel sample was boiled in 50 ml of water for 10 min, the extract was passed through a 0.45 μm syringe filter and used for AOA measurement.

Measurement of antioxidant activity of the extract. For this purpose, 3 ml of 0.2 M carbonate buffer solution are quickly mixed in a 10 mm thick cuvette (Na_2CO_3-$NaHCO_3$, pH = 10.65) and 0.15 ml of 0.18% adrenaline tartrate solution and measure the optical density of the resulting solution on a K7000 spectrophotometer (YOKE, China). D_1 at a wavelength of 347 nm every 30 seconds for 10 minutes. Then the cuvette is washed, dried and 3 ml of 0.2 M carbonate buffer solution are quickly mixed in it in the same way. (Na_2CO_3-$NaHCO_3$, pH = 10.65) and 0.15 ml of 0.18% adrenaline tartrate solution, additionally add 0.045 ml of filtered extract of the test sample and at the same wavelength, in exactly the same way, measure the optical density D_2 (Table 2).

Table 2. Values of the optical density of the adrenaline solution in carbonate buffer without and with the addition of the extract of the test sample, measured over time.

Time is sec.	Optical density					
	Adrenalin D_1	Iranian kiwi variety "Hajjan" D_2	Turkish mandarin variety “Nova” D_2	Local lemon variety 'Meyer'. D_2	Iranian lime D_2	Chinese Mandarin Orange "Mini" D_2
0	0.052	0.04	0.042	0.039	0.042	0.044
30	0.088	0.073	0,077	0,071	0.073	0.081

60	0.129	0.103	0,111	0.102	0.104	0.116
90	0.168	0.133	0.145	0.135	0.134	0.151
120	0.207	0.163	0.178	0.167	0.164	0.185
150	0.244	0.192	0.21	0.198	0.193	0.217
180	0.282	0.221	0.241	0.227	0.22	0.249
210	0.319	0.249	0.271	0.256	0.247	0.279
240	0.352	0.275	0.299	0.285	0.272	0.308
270	0.387	0.3	0.325	0.312	0.296	0.334
300	0.417	0.325	0.351	0.337	0.319	0.359
330	0.445	0.348	0.374	0.362	0.339	0.383
360	0.471	0.37	0.395	0.384	0.359	0.405
390	0.496	0.391	0.416	0.405	0.377	0.426
420	0.52	0.41	0.434	0.425	0.394	0.446
450	0.542	0.428	0.451	0.443	0.41	0.463
480	0.561	0.444	0.467	0.459	0.425	0.479
510	0.578	0.46	0.48	0.474	0.437	0.493
540	0.596	0.474	0.493	0.49	0.449	0.505
570	0.612	0.487	0.505	0.501	0.461	0.517
600	0.624	0.498	0.515	0.513	0.471	0.528

A graphical representation of the results presented in Table 2 is illustrated in Figure 1. It can be seen from the figure that the curves of the time dependence of the optical density of solutions containing adrenaline with the addition of aqueous extracts of the peels of all the fruits studied, lie below that of such a curve for only the adrenaline-containing buffer solution. This indicates that the studied citrus peels have positive antioxidant activity.

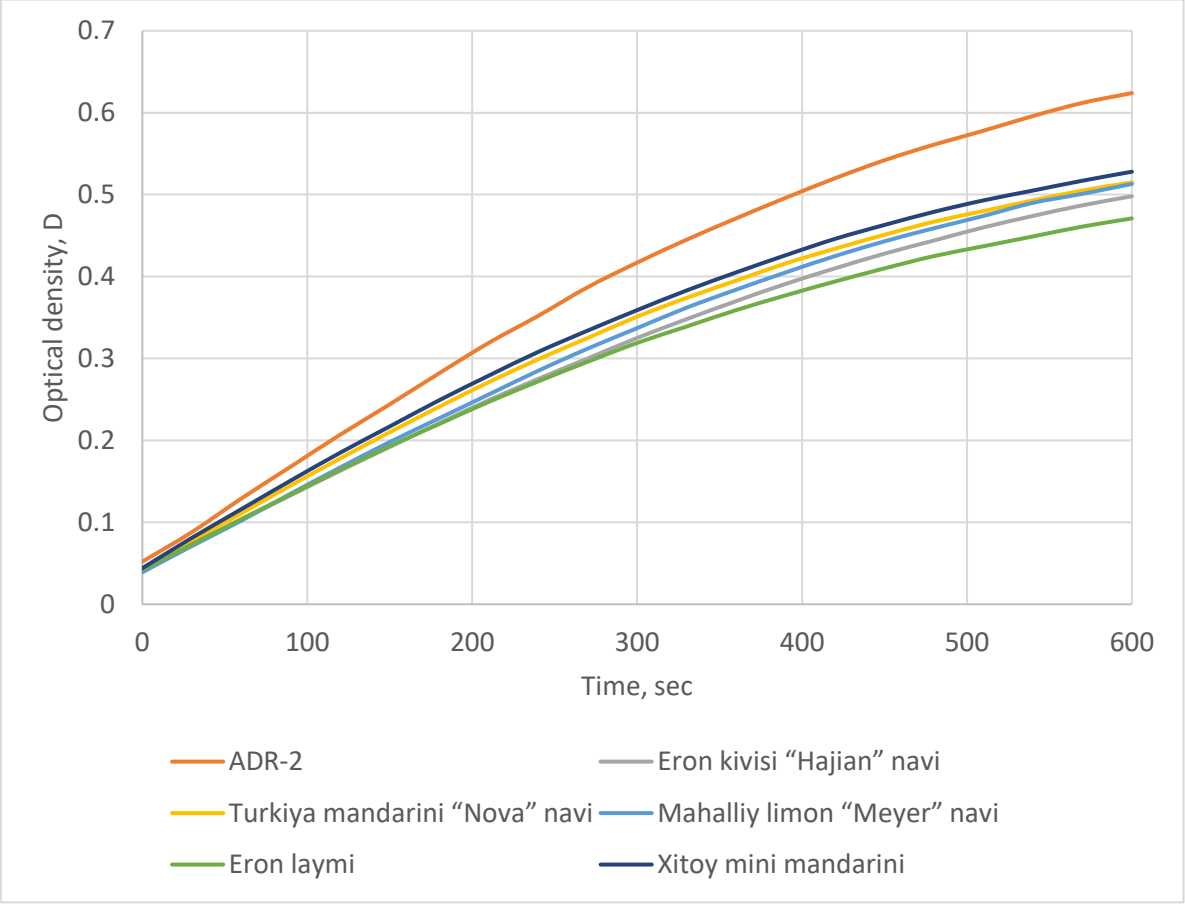


Figure 1. Time dependences of the optical densities of an adrenaline solution in a carbonate buffer without and with the addition of an extract of the test sample at a wavelength of 347 nm.

The antioxidant activity (AOA, %) of the fruit peel was calculated using the formula [16, 17, 18] using the measured optical densities given in Table 1:

$$AOA, \% = \frac{(D_1 - D_2) \cdot 100}{D_1}$$

and is reduced to Table 2. Here D_1 is the optical density of the adrenaline tartrate solution in carbonate buffer without the addition of the test sample, D_2 is the optical density of the same solution with the addition of the test sample.

Table 2. Changes in antioxidant activity (AOA, %) of aqueous extracts of the studied citrus peels over time and their average values.

Measurement time, min	AOA, %				
	Iranian kiwi variety "Hajjan".	Turkish mandarin "Nova" variety.	Local lemon variety “Meyer”.	Iranian lime	Chinese mini mandarin.
1	20.2	14.0	20.9	19.4	10.1
3	21.6	14.5	19.5	22.0	11.7
5	22.1	15.8	19.2	23.5	13.9
10	20.2	17.5	17.8	24.5	15.4
Average	**21.0**	**15.5**	**19.4**	**22.4**	**12.8**

The analysis of the results presented in Table 2 shows that the AOA index of Iranian kiwi and local lemon peel does not change over time (change by 1-1.5%), while the antioxidant capacity of Turkish and Chinese tangerines and Iranian lime peel increases slightly (by 4-5%). All the fruit peels studied exhibit fairly high antioxidant activity. The peel of the Chinese mandarin has an average AOF of 12.8 % , while the Iranian lime and kiwi show almost twice as high an AOF.

Conclusion. Based on the evaluation of the antioxidant activity of aqueous extracts of the peel of local lemon varieties "Meyer", Iranian lime, Turkish and Chinese mandarins of the varieties "Nova" and "Mini" and Iranian kiwi "Hajjan" under *in vitro conditions* using a method based on the inhibition of the reaction of adrenaline autoxidation, it was established that all the tested citrus peels exhibit high antioxidant activity. Among them the peels of lime and kiwi fruits have the greatest activity. The results obtained serve as a basis for the development of new medicinal food supplements from the peels of these fruits.

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