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Investigation of The Effects of The Different Extraction Conditions on Phenolic Compounds Extraction from Onion Skin

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ABSTRACT: Onion skin, which is a waste from the onion cultivation and processing industry, is one of the richest natural sources of phenolic compounds. In this study, the onion skin was extracted using different solvents and extraction times at various solid:solvent ratios to optimize the total phenolic compounds (TPC) and total flavonoid compounds (TFC) of the onion skin extract. The greatest content of TPC (61.29 mg GAE/g) and TFC (56.83 mg QE/g) of the extracts were obtained with 50% ethanol (ethanol/water; v/v) in 0.2 g/10 mL solid:solvent ratio. The highest TPC value was detected at the end of 90 minutes for 0.2 g/5 mL (55.25 mg GAE/g) and at the end of 120 minutes for 0.2 g/10 mL (60.14 mg GAE/g), while the highest TFC (51.06; 56.55 mg QE/g) value for both solid:solvent ratios were detected at the end of 120 minutes. It was found that the TPC and TFC of the onion skin were strongly influenced by the extraction condition. The findings of this study show that onion skin extract is a good source of phenolic compounds and emphasize that the extraction parameters used in obtaining onion skin extract are important.

Keywords *– Bioactive compound, extraction, onion skin, quercetin, waste*

Soğan Kabuğundan Fenolik Bileşik Ekstraksiyonu Üzerine Farklı Ekstraksiyon Koşullarının Etkisinin Araştırılması

ÖZET: Soğan yetiştirme ve işleme endüstrisinin atıklarından biri olan soğan kabuğu, fenolik bileşiklerin en zengin doğal kaynaklarından biridir. Bu çalışmada, soğan kabuğu ekstraktındaki toplam fenolik madde (TFM) ve toplam flavonoid (TFL) değerlerini optimize etmek için soğan kabuğu farklı katı:çözücü oranlarında çeşitli çözücüler ve ekstraksiyon süreleri kullanılarak ekstrakte edilmiştir. En yüksek TFM (61.29 mg GAE/g) ve TFL (56.83 mg KE/g) içeriği 0.2 g/10 mL katı:çözücü oranında %50 etanol (etanol/su; h/h) kullanılarak elde edilen ekstraktta tespit edilmiştir. En yüksek TFM değeri 0.2 g/5 mL için (55.25 mg GAE/g) 90 dakika sonunda ve 0.2 g/10 mL için (60.14 mg GAE/g) 120 dakika sonunda belirlenirken, her iki katı:sıvı oranı için en yüksek TFL (51.06; 56.55 mg KE/g) değeri 120 dakika sonunda saptanmıştır. Soğan kabuğundan elde edilen ekstraktın TFM ve TFL değerlerinin ekstraksiyon koşullarından önemli düzeyde etkilendiği tespit edilmiştir. Bu çalışmanın bulguları, soğan kabuğu ekstraktının iyi bir fenolik bileşik kaynağı olduğunu göstermekte ve bu ekstraktın eldesinde kullanılan ekstraksiyon parametrelerinin önemli olduğunu vurgulamaktadır.

Anahtar Kelimeler *– Biyoaktif bileşik, ekstraksiyon, soğan kabuğu, kuersetin, atık*

1. Introduction

Onion (*Allium cepa* L.) is one of the most important horticultural plants and has been cultivated worldwide since ancient times (Sagar et al., 2020). The production of onion is increasing due to its nutritional and medicinal values (Kim et al., 2019). The onion industry produces each year more than 500 000 tons of onion wastes including unconsumed skins, roots and bulbs in the worldwide (Benito-Roman et al., 2020). According to the data of

Food and Agriculture Organization (FAO) for 2022, Türkiye has an important region for dry onion production in the world both in terms of area harvested (57 630 hectar alan) and production quantity (2 350 000 tons) (Anonymous, 2022). Many studies conducted in recent years showed that onion skin is a rich source of dietary fiber, fructooligosaccharides, polyphenols and organosulfur compounds (Sagar et al., 2020). Several health advantages of these compounds, including antioxidant, antimicrobial, antiobesity, antidiabetic, anticancer, antiinflammatory, cardiovascular diseases protection have been determined (Stoica et al., 2023). Onion skin contains significantly higher amount of flavonoids as compared to the edible part of the onion (Škerget et al., 2009). Flavonoids are polyphenol compounds known for their hydrogen-donating antioxidant activities (Martino and Guyer, 2004). The main flavonoid found in the highest amount in onion skin is quercetin (Jang et al., 2013; Sagar et al., 2020). It was determined that the amount of quercetin in onion skin is 77 times more than the edible part of onion (Kim et al., 2019). Recently, the quercetin has attracted attention due to its beneficial effects on human health (Jin et al., 2011). Moreover, quercetin can be used as a natural colorant, it can also be used as a natural antioxidant due to its antioxidant activity. It also has the potential to gain an important position in the cosmetics, chemical and pharmaceutical industries (Jang et al., 2013). The high content of quercetin of onion skin makes important the extraction of phenolic compounds from onion skin (Jang et al., 2013).

There is a need for various studies on the extraction of valuable bioactive compounds from the raw materials in which they are found (Jin et al., 2011; Soquetta et al., 2018; Ghenabzia et al., 2023). In the extraction of phenolic compounds, the type of solvent, solid:solvent ratio, contact surface of solid and solvent (Şahin, 2011), the degree of polymerization of phenolic compounds, interaction with other components, extraction time and temperature are of great importance (Çoklar and Akbulut, 2016). The type and amount of secondary metabolites that are recovered from plant material are largely dependent on the choice of suitable solvents during the extraction process (Ghaffar and Perveen, 2024). The solubility of the compounds in the extraction solvent affects the yield of recovered phytochemicals (Almeida et al., 2019). In a study using solvents with different polarities, it was determined that solvent polarity has a significant effect on extraction efficiency and that extraction efficiency increases as the polarity of the solvent increases (Ghaffar and Perveen, 2024). Methanol, ethanol, water, propanol, acetone, ethyl acetate and their combinations are frequently used in the extraction of phenolic compounds from plant materials (Garcia-Salas et al., 2010). Methanol and ethanol from these solvents were classified as Generally-Recognized-As-Safe (GRASS) solvents (Kim et al., 2019). According to the Turkish Food Codex Communiqué on Extraction Solvents Used in the Production of Foodstuffs and Food Components, the maximum residue limit of methanol in the extracted foodstuff or component is 10 mg/kg (Anonymous, 2013). The use of appropriate solvent system is of great importance for the effective extraction of phenolic compounds from plant material. In addition to the total amount of phenolic compounds, the solvent system to be used in the extraction stage also affects the profile of phenolic compounds extracted from plant material (Türkyılmaz et al., 2017).

In this research, it was aimed to investigate the effect of different solvents in the extraction process using different solid:solvent ratios from onion skin in the first stage. Subsequently, the effect of extraction time was researched in the second stage of this study.

2. Material and Methods

2.1. Material

2.1.1. Plant Material

In the study, onion skin (*Allium cepa* L.) for the extraction of phenolic compounds was obtained as waste from the Tokat 48th Infantry Training Regiment Command Cafeteria (Tokat, Türkiye) in August 2021 and brought to Tokat Gaziosmanpaşa University Food Engineering laboratories. The brown part of the onion skins was separated from the other onion waste parts. Onion skins were not subjected to any washing process before drying. The amount of onion waste and onion skin released in a cafeteria was determined. According to this, it was determined that 27.36±1.70 kg of waste was released from 100 kg of onions. 10.52±1.11 kg is the brown onion skin of 100 kg of onion waste. In other words, 2.88 kg of brown onion skin is released as waste from 100 kg of onions. Brown onion skins were dried at room conditions (25±2 °C) and stored in polypropylene bags under laboratory conditions until to the grinding process. Dried onion skins were grinded and sieved. (The sieve pore area is 0.45 mm^2). Afterward, it was dried at drying-oven up to 2.87% ± 0.10 humidity value.

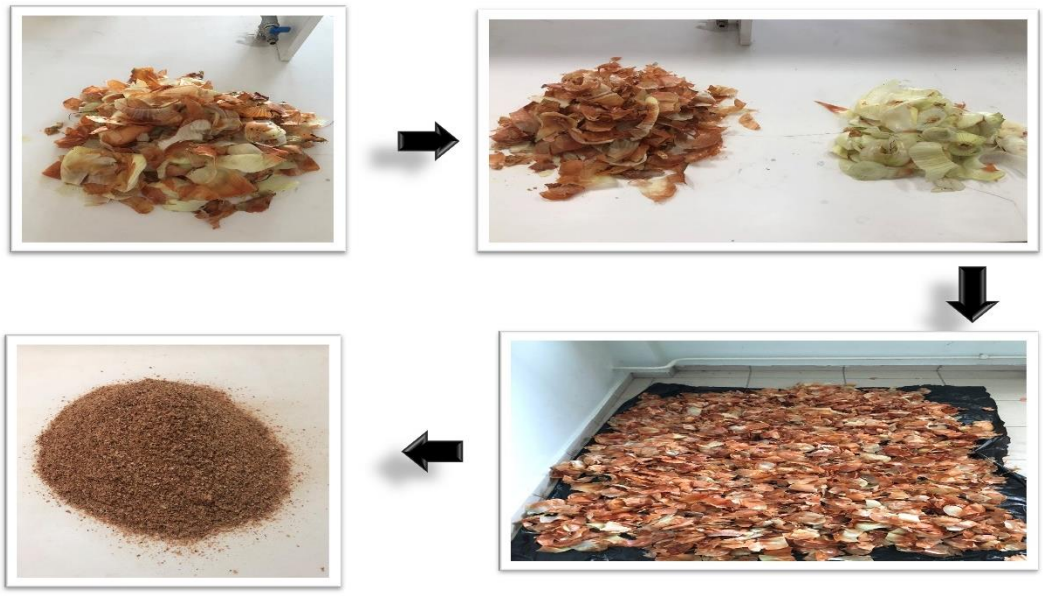

Figure 1. Steps of converting onion wastes into onion skin powder

2.1.2. Chemical materials and equipment

Ethanol (Tekkim, Bursa), methanol (Isolab, Ankara), gallic acid (Sigma-Aldrich, Germany), quercetin (Sigma-Aldrich, Germany), aluminium chloride ($AlCI_3$) (Merck, Germany), sodium hydroxide (NaOH) (Merck, Germany), sodium nitrite ($NaNO_2$) (Merck, Germany), sodium carbonate (Na_2CO_3) (Isolab, Germany), Folin-Ciocalteu (FC) reagent (Carlo Erba, France) were used at the analyses.

Precise balance (Radwag, AS 220 R2, Poland), grinder (Sinbo SHB 3020, Turkey), UV-VIS spectrofometer (PG Instrument, T80+, England), vortex (Velp Scientifica, Italy) and incubator (Memmert, Germany) were used at different stages during the research.

2.2. Methods

2.2.1. Extraction of the Phenolic Compounds from Onion Skin

In the first stage, the effect of solid:solvent ratio and extraction solvent were investigated on the extraction of phenolic compounds from onion skin. For this purpose, onion skin powder was weighed into the tubes and its solvents [ethanol (EtOH), methanol (MeOH), distilled water, 50% EtOH, 50% MeOH, 40% EtOH, 40% MeOH, 30% EtOH, 30% MeOH, 20% EtOH and 20% MeOH)] were added. Different concentrations of EtOH and MeOH were prepared by mixing with distilled water. Trials were created for all solvents with a solid:solvent ratio of 0.2g/5 mL (1:25) and 0.2g/10 mL (1:50). The tubes were subjected to extraction for 2 hours in a shaking water bath with a temperature set at 50 °C. The extraction time and temperature were chosen in the literature datas. Then, the obtained extracts were filtered with coarse filter paper and centrifuged at 6000 rpm for 5 minutes. The supernatant parts on the tube were separated for analysis and the pellet parts were removed.

In the second stage, the effect of solid:solvent ratio and extraction time on phenolic compound extraction was investigated by using the solvent in which the highest phenolic compound was obtained in the first stage. For this purpose, onion skin powder was weighed into the tubes and 50% EtOH was added. Trials were created for all solvents with a solid:solvent ratio of 0.2g/5 mL (1:25) and 0.2g/10 mL (1:50). The tubes were subjected to extraction for 10, 30, 60, 90, 120, 150, 180, 210, 240, 270 and 300 minutes in a shaking water bath at 50 °C. Then, the obtained extracts were filtered with coarse filter paper and centrifuged at 6000 rpm for 5 minutes. The supernatant parts on the tube were separated for analysis and the pellet parts were removed.

2.2.2. Total phenolic compound

In the first stage for total phenolic compounds (TPC) analyses, FC reagent (200 µL) and distilled water (2 mL) were added to the diluted extract (100 µL). This mixture was maintained at room temperature (3 minute). 20% Na_2CO_3 solution (1 mL) was added to this mixture and stirred. Then the mixture was left to incubate (1 hour) at room conditions. After incubation, the absorbance of the mixture was measured with a UV/VIS spectrophotometer at 765 nm. TPC results of onion skin extracts were expressed as mg gallic acid equivalent (GAE)/g dry weight (DW) (Singleton and Rossi, 1965).

2.2.3. Total flavonoid compound

Total flavonoid compounds (TFC) of the onion skin extracts were determined with the partial modification of the method applied by Gaafar and Salama (2013). Distilled water (2 mL) and 5% $NaNO_2$ (150 µL) were added to the extract (500 µL) and the mixture was kept at room temperature (5 minute). 10% $AlCl_3$ (150 µL) solution was added to the mixture. This blend was maintained at room conditions (5 minute) and 1 M NaOH solution (1 mL) was added and stirred with vortex. Then the mixture was made up to 5 mL with distilled water (1.2 mL). The absorbance of the mixture was measured with a UV/VIS spectrophotometer at 510 nm. TFC of samples were calculated by the calibration curve of

quercetin standards. TFC results of onion skin extracts were expressed as mg quercetin equivalent (QE)/g DW.

2.2.4. Statistical analyses

The statistical analysis of research results was done by using Duncan test with the help of Statistical Package for the Social Sciences (SPSS) 22.0 (IBM, ABD) statistical package program.

3. Results and Discussion

3.1. Effect of Different Solvent Concentrations on Amount of Total Phenolic and Total Flavonoid Compounds

Phenolic compounds are a group of seconder metabolites found in different plant species. Phenolics are seen to be present in all types of plant origin such as fruits, vegetables, cereals, roots, and leaves. Phenolic compounds include phenolic acids, flavonoids, lignans, tannins and coumarins (Luna-Guevara et al., 2018). Onion skin is a by-product obtained from onion harvesting and processing that contains plenteous phenolic compounds (Kumar et al., 2022). In the first stage, the solid:solvent ratio was determined. A sufficient amount of supernatant could not be obtained from the mixtures prepared at 0.2 g/1 mL, 0.2 g/2 mL and 0.2 g/3 mL levels. After, preliminary trials were carried out for 0.2 g/5 mL and 0.2 g/10 mL, and these solid:solvent ratios were used later extraction stages. Subsequently, the effects of different solvents (EtOH, MeOH, distilled water, 50% EtOH, 50% MeOH, 40% EtOH, 40% MeOH, 30% EtOH, 30% MeOH, 20% EtOH and 20% MeOH) on the extraction process prepared in both 0.2 g/5 mL and 0.2 g/10 mL ratios were investigated. The effects of different solvent types and different solid:solvent ratios on TPC are presented in Table1.

Table 1. Effect of different solvents and different solid:solvent ratios on total phenolic compounds

Solvents	TPC (mg GAE/g DW)	
	0.2 g/5 mL	**0.2 g/10 mL**
EtOH	$13.72\pm0.49^{g*}$	10.24 ± 0.99^{j}
MeOH	26.17 ± 0.14^{f}	25.09 ± 0.78^{h}
Distilled water	14.65 ± 0.32^{g}	16.04 ± 1.27^{ı}
50% EtOH	55.45 ± 0.11^{a}	61.29 ± 0.64^{a}
50% MeOH	43.77 ± 0.00^{c}	49.89 ± 1.48^{c}
40% EtOH	47.92 ± 0.92^{b}	56.74 ± 1.27^{b}
40% MeOH	44.27 ± 1.84^{c}	47.24 ± 0.42^{d}
30% EtOH	44.85 ± 0.53^{c}	51.94 ± 1.13^{c}
30% MeOH	42.07 ± 0.28^{d}	43.49 ± 0.35^{e}
20% EtOH	28.92 ± 0.21^{e}	37.24 ± 1.13^{f}
20% MeOH	26.02 ± 0.57^{f}	30.09 ± 0.35^{g}

Results are given as mean ± standard deviation.

* Small letters in the same column indicate statistical difference between extraction solvents ($p<0.05$)

In terms of TPC values for 0.2 g/5 mL, the difference between EtOH and distilled water was statistically insignificant ($p>0.05$), while the difference of EtOH and distilled water

from MeOH was statistically significant ($p<0.05$). For 0.2 g/10 mL, the difference between EtOH, MeOH and distilled water was statistically significant ($p<0.05$).

It was determined that TPC values varied between 13.72-55.45 mg GAE/g DW for different solvents used at 0.2 g/5 mL solid:solvent ratio, and between 10.24-61.29 mg GAE/g DW for different solvents used at 0.2 g/10 mL solid:solvent ratio. For both samples, the lowest TPC values were detected in the EtOH extract, while the highest TPC value was detected in the 50% EtOH extract. Additionally, a decrease in TPC values was detected as the EtOH concentration decreased from 50% EtOH to 20% EtOH. In a study, it was investigated effect on TPC value of grape stem of EtOH concentration (0%, 25%, 50%, 75%, and 100%, v/v), solid/solvent ratio (1:50 and 1:100, w/v) and extraction temperature (25 °C and 40 °C). The highest content of total phenolic compounds the extracts were obtained with 50% EtOH and at 40 °C in 1:100 ratio (Jiménez-Moreno et al., 2019). In another study, the coffee pulp was extracted using various solvents (distilled water, 25% EtOH, 50% EtOH and 75% EtOH) to maximize the total phenolic content of the extract. 50% EtOH was concluded as the most suitable solvent to extract the phenolic compounds in the coffee pulp (Kusumocahyo et al., 2019). The different results were obtained in various solvent usage. It may be explained by the solvent polarity. Because solvent polarity has a significant effect on extraction efficiency (Ghaffar and Perveen, 2024). Moreover, the solubility of phenolics may also vary depending on the degree of polymerization of phenolics and the formation of insoluble complexes with other components (Yolci et al., 2022).

Flavonoids are probably the most important phenolic compounds (Rahardhian et al., 2019). These compounds possess a broad spectrum of chemical and biological activities such as antioxidant, hepatoprotective, antibacterial, anti-inflammatory, anticancer and antiviral (Kumar and Pandey, 2013). The effects of different solvent types and different solid:solvent ratios on TFC are presented in Table 2.

Table 2. Effect of different solvents and different solid:solvent ratios on total flavonoid compounds

	TFC (mg QE/g DW)	
Solvents	**0.2 g/5 mL**	**0.2 g/10 mL**
EtOH	$12.15\pm0.13^{h*}$	8.74 ± 0.53^{h}
MeOH	23.17 ± 0.73^{f}	24.02 ± 1.19^{f}
Distilled water	12.67 ± 0.46^{h}	14.36 ± 0.27^{g}
50% EtOH	52.56 ± 0.53^{a}	56.83 ± 1.19^{a}
50% MeOH	42.38 ± 0.86^{c}	46.80 ± 0.53^{c}
40% EtOH	44.78 ± 0.80^{b}	50.74 ± 1.06^{b}
40% MeOH	43.28 ± 0.80^{bc}	46.71 ± 2.25^{c}
30% EtOH	42.48 ± 0.73^{c}	44.83 ± 1.19^{c}
30% MeOH	38.54 ± 1.26^{d}	38.93 ± 0.80^{d}
20% EtOH	25.65 ± 0.53^{e}	29.08 ± 1.99^{e}
20% MeOH	21.48 ± 0.33^{g}	27.58 ± 1.46^{e}

Results are given as mean ± standard deviation.

* Small letters in the same column indicate statistical difference between extraction solvents ($p<0.05$)

In terms of TFC values for 0.2 g/5 mL, the difference between EtOH and distilled water was statistically insignificant ($p>0.05$), while the difference of EtOH and distilled water

from MeOH was statistically significant ($p<0.05$). For 0.2 g/10 mL, the difference between EtOH, MeOH and distilled water was statistically significant ($p<0.05$).

It was determined that TFC values varied between 12.15-52.56 mg QE/g DW for different solvents used at 0.2 g/5 mL solid:solvent ratio, and between 8.74-56.83 mg QE/g DW for different solvents used at 0.2 g/10 mL solid:solvent ratio. For both samples, the lowest TFC values were detected in the EtOH extract, while the highest TFC value was detected in the 50% EtOH extract. Similar to the TPC results, a decrease in TFC values was detected as the EtOH concentration decreased from 50% EtOH to 20% EtOH. Sagar et al. (2020) determined the total flavonoid content of onion skin (fifteen Indian cultivars) using methanol (1:25, 25 times diluted). TFC values were found ranged between 1.31-168.77 mg QE/g DW. Viera et al. (2017) evaluated the content of total flavonoids of red onion skin extract (*Allium cepa* L.) that was obtained by conventional extraction method using different concentrations of EtOH (20, 40, 60 and 80%) at different times (30, 60, 120 and 240 minutes). TFC values were found ranged between 22.60 mg QE/g DW (20% EtOH, 60 minute)-40.90 mg QE/g DW (60% EtOH, 60 minute).

3.2. Effect of Different Extraction Times on Amount of Total Phenolic and Total Flavonoid Compounds

In the second stage, the solvent (50% EtOH) in which the highest phenolic compound was obtained in the first stage was selected as the extraction solvent. The effect on TPC of solid: solvent ratios (0.2g/5 mL and 0.2g/10 mL) and extraction times (10, 30, 60, 90, 120, 150, 180, 210, 240, 270 and 300 minutes) were investigated. The effects of different extraction times and different solid:solvent ratios on TPC are presented in Table 3.

Table 3. Effect of different extraction times and different solid:solvent ratios on total phenolic compounds

	TPC (mg GAE/g DW)	
Extraction times (minutes)	**0.2 g/5 mL**	**0.2 g/10 mL**
10	40.55 ± 1.03^{g}	40.99 ± 0.49^{f}
30	48.92 ± 0.14^{f}	53.74 ± 1.13^{e}
60	50.65 ± 1.52^{ef}	56.09 ± 0.49^{c}
90	55.25 ± 0.11^{a}	58.54 ± 0.00^{b}
120	54.77 ± 0.42^{ab}	60.14 ± 0.57^{a}
150	53.95 ± 0.60^{abc}	57.74 ± 0.42^{b}
180	53.67 ± 1.27^{abcd}	55.94 ± 0.28^{c}
210	53.10 ± 0.32^{bcd}	55.64 ± 0.85^{cd}
240	52.30 ± 1.24^{cde}	54.29 ± 0.78^{de}
270	51.65 ± 0.81^{de}	54.99 ± 0.35^{cde}
300	52.60 ± 0.11^{cde}	53.99 ± 0.35^{e}

Results are given as mean ± standard deviation.
* Small letters in the same column indicate statistical difference between extraction times ($p<0.05$)

In terms of TPC values for 0.2 g/5 mL and 0.2 g/10 mL, the difference between 10 minute and 300 minute was found statistically significant($p<0.05$).
It was determined that TPC values varied between 40.55-55.25 mg GAE/g DW for different extraction times used at 0.2 g/5 mL solid:solvent ratio, and between 40.99-60.14 mg GAE/g DW for different extraction times used at 0.2 g/10 mL solid:solvent ratio.

The lowest TPC value for both solid:solvent ratios were determined after 10 minute of extraction time. The highest TPC value was detected at the end of 90 minutes for 0.2 g/5 mL and at the end of 120 minutes for 0.2 g/10 mL. The TPC value increased in the first stage depending on time. However, little decrease was detected as the extraction time was further extended. A decrease in TPC values was detected after the 120th minute of extraction. This may be associated with the degradation of phenolic compounds due to extraction temperature depending on time. Mostly, the TPC content is highest at 60-80 °C for traditional extractions. Therefore, phenolic compounds are generally acknowledged as heat-labile compounds (Antony and Farid, 2022). In this study, the extraction temperature of phenolic compound extraction from onion skin was kept constant at 50 °C. A slight decrease in phenolic compounds was detected due to the extension of extraction time in this research data. This situation can be associated with the decomposition of phenolic compounds by the interaction of temperature and time. Additionally, the profile of individual phenolic compounds found in onion skin may also be a factor in this case. In a study conducted in the literature, thermal effects were tested on black currants between 20-60 °C. Initially, it was observed that the increase in temperature caused an increase in the extraction of anthocyanins, which are in the flavonoid group. However, a sharp decrease in anthocyanin extraction was detected at 45 °C (Cacace and Mazza, 2003). In literature 50% EtOH extract of *Cotinus coggygria* were analyzed for 120 minutes. The highest TPC of the 50% EtOH extract of the *Cotinus coggygria* in 90 minute and stopped in 120 minutes (Christova-Bagdassarian et al., 2016). In another study, the optimum extraction time to maximize the total phenolic content was found 60 minutes for coffee pulp at 50% EtOH and 60 °C (Kusumocahyo et al., 2019). Güldane and Cingöz (2023) was researched the effect of EtOH concentration (50%, 75%, 100%), extraction temperature (30, 40, 50 °C), and sonication time (10, 20, 30 minute) to optimize the ultrasound-assisted extraction process of onion skin powders. The TPC content of onion skin extracts was found between 24.80 mg GAE/g (100% EtOH, 40 °C, 10 minute) and 33.83 mg GAE/g (75% EtOH, 50 °C, 10 minute).

The effects of different extraction times and different solid:solvent ratios on TFC are presented in Table 4.

Table 4. Effect of different extraction times and different solid:solvent ratios on total flavonoid compounds

Extraction times (minutes)	**TFC (mg QE/g DW)**	
	0.2 g/5 mL	**0.2 g/10 mL**
10	31.18±0.40^{f}	34.61±0.27^{e}
30	40.13±0.33^{e}	43.52±1.72^{d}
60	44.21±0.66^{d}	49.14±0.93^{c}
90	48.53±0.53^{b}	52.89±1.46^{b}
120	51.06±1.06^{a}	56.55±0.80^{a}
150	48.76±1.13^{b}	55.80±0.53^{a}
180	48.20±0.73^{b}	52.80±0.53^{b}
210	47.03±0.00^{bc}	51.11±0.27^{bc}
240	45.62±1.46^{cd}	50.74±1.86^{bc}
270	45.06±0.13^{d}	49.99±0.00^{c}
300	44.96±0.53^{d}	49.24±1.86^{c}

Results are given as mean ± standard deviation.

* Small letters in the same column indicate statistical difference between extraction times ($p<0.05$)

In terms of TFC values for 0.2 g/5 mL and 0.2 g/10 mL, the difference between 10 minute and 300 minute was found statistically significant($p<0.05$).

It was determined that TFC values varied between 31.18-51.06 mg QE/g DW for different extraction times used at 0.2 g/5 mL solid:solvent ratio, and between 34.61-56.55 mg QE/g DW for different extraction times used at 0.2 g/10 mL solid:solvent ratio. While, the lowest TFC values for both solid:solvent ratios were determined after 10 minute of extraction time, the highest TFC values for both solid:solvent ratios were detected at the end of 120 minutes. The time-dependent change of TFC values is similar to TPC values. TFC value increased in the first stage depending on time. However, little decrease was detected as the extraction time was further extended. Similar to the TPC results, a decrease in TFC values was detected after the 120^{th} minute. This may be associated with the degradation of phenolic compounds due to extraction temperature depending on time. Studies conducted in the literature show that flavonoids are more sensitive to heat than other phenolic compounds and that the degradation of flavones and flavanols/flavanones occurs at lower temperatures (Antony and Farid, 2022).

4. Conclusion

The extraction solvent, solid:solvent ratio and the extraction time are important factors affecting the TPC and TFC of the onion skin extract. The optimization of the extraction condition is important to maximize the phenolic compounds of the extract. 50%EtOH in 0.2 g/10 mL solid:solvent ratio was concluded as the most suitable solvent and solid:solvent ratio to extract the phenolic compounds in the onion skin. The highest TPC and TFC value at 0.2 g/10 mL were determined at the end of 120 min. For 0.2 g/5 mL, the highest TPC was found at 90 minutes, while the highest TFC was detected at 120 minutes. It was determined that the TPC and TFC onion skin rises rapidly with time at first, and then little decrease was detected as the extraction time was further extended. The result of this study showed that onion skin extract has great source of phenolic compounds. There are many parameters that affect the extraction of phenolic compounds from onion skin. These parameters and their interactions should be investigated in detail and studies should be carried out to optimize these conditions.

5. Acknowledgment

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