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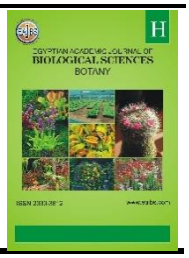

Effect of Ultraviolet C on Morphological Structure, Phenolic and Anthocyanin of Turnip Red Seeds

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ABSTRACT

Background: Ultraviolet C (UVC) irradiation was used in the food industry as an environmentally friendly and safe defense against inducible biological elicitors. Turnips have an excellent nutritional profile. The aim of this research is to study the effect of UVC on the morphological structure and antioxidants of Turnips seeds. **Methods:** The seeds of Turnips red were received from the Egyptian Ministry of Agriculture, and used as research samples. The ultraviolet irradiation system consists of one fluorescent lamp (type- C) which is covered totally with aluminum foil to illuminate the sample from all sides. The total phenolic content was determined using the Florin–Ciocalteu method. The structure of the used samples was studied by x-ray and IR analysis. **Results:** The values of germination height and the weight for turnip red seeds after exposure to UV- C for 1, 2, 3 and 4 hours at 5, 15 and 15 cm from ultraviolet (UV) source are less than non-irradiated seeds. Total phenolic and anthocyanin content in Turnip red seeds increased after exposure to UV- C for 1, 2, 3 and 4 hours at 5, 15 and 15 cm distances from the UV source. Also, an internal structure such as the order or arrangement or position of Turnip red molecules changed after exposure to UVC.

INTRODUCTION

Turnips (*Brassicarapa*) are a root vegetable and member of the cruciferous family, along with other vegetables like bok choy, Brussels sprouts, and kale. Turnips have an excellent nutritional profile. Ultraviolet (UV) radiation is a form of non-ionizing radiation that is emitted by the sun and artificial sources and its beneficial effect is the production of vitamin D. Ultraviolet C radiation has effectively been used for decades to reduce the spread of bacteria, for this reason, UVC lamps are often called "germicidal" lamps. UVC radiation has been shown to destroy the outer protein coating of the SARS-Coronavirus, which is a different virus from the SARS-CoV-2 virus. The chemical and biological effects of UV are greater than simple heating effects, and many practical applications of UV radiation derive from its interactions with organic molecules. UVs possess sufficient energy to break the chemical bonds causing photochemical reactions and inducing changes in plant 2 metabolic enzyme, subsequently triggering the production of secondary metabolites (Zhang & Björn, 2009; Hectors *et al.*, 2014; Ghasemi *et al.*, 2019). Much research was done on the influence of UVC on phenolic compounds, vitamins C and E, growth, internal structure and

antioxidants for different seeds such as *Nigella Sativa, garden cress, Foeniculum vulgare, yellow mustard* and Ammimajus is studied and the results showed that there is a change occurred in phenolic and flavonoids contents, gross, morphological structure and antioxidant after exposed by UVC (Ebrahim *et al.,* 2022; El-Bediwi *et al.,* 2021; El-Bediwi *et al.,* 2020; El-Bediwi *et al.,* 2018; El-Bediwi *et al.,* 2018). This work aimed to study the influence of UVC on morphological structure, and phenolic and anthocyanin contents of Turnips red seeds.

MATERIALS AND METHODS

The seeds of Turnips red were received from the Egyptian Ministry of Agriculture and used as research samples. The ultraviolet irradiation system consists of one fluorescent lamp (type- C) which is covered totally with aluminum foil to illuminate the sample from all sides. The structure of used samples was studied by Shimadzu X-ray diffractometer, (Dx-30, Japan) while the molecular structure was studied by Nicolet™ iS™ 10 FT-IR Spectrometer from USA. The total phenolic content was determined using the Florin–Ciocalteu method (Attard, 2013). The procedure consisted of mixing 10 µL of sample/standard with 100 µL of Folin-Ciocalteu reagent (Diluted 1: 10) in a 96-well microplate. Then, 80 µL of 1M Na_2CO_3 was added and incubated at room temperature (25 °C) for 20 min in the dark. At the end of incubation time, the resulting blue complex color was measured at 630 nm. Data are represented as means ± SD.

RESULTS AND DISCUSSION

Table 1 shows the germination height of Turnips red before and after being exposed to UVC for 1, 2, 3 and 4 hours at 5, 15 and 20 cm from the UV source. The results show that the germination height of treated Turnips red after two weeks is less than the untreated sample. That may be due to the change in bio-compounds such as enzymes or antioxidants which help for growing. The weight of treated Turnips is less than the non-irradiated sample, where Table 2, shows the difference between weights of untreated Turnip red seeds and treated seeds by UVC for 1, 2, 3 and 4 hours at 5, 15 and 15 cm from the UV source. That is because of a change in the size or shape of matrix molecules due to the interaction of UVC rays with it.

Table 1: Germination height of Turnips red after exposure to UV- C

Exposure time/ h	Germination height/cm		
	5 cm	15 cm	20 cm
Untreated	H = 8.55		
1	3.6±0.57	2.77±0.4	8.03±0.9
2	3.82±0.7	6.2±0.88	6.43±0.73
3	5.68±0.87	5.3±0.76	6.57±0.65
4	4.23±0.66	4.1±0.55	6.33±0.44

Table 2: Weight difference of Turnips red after exposure to UV- C

Exposure time/ h	Weight difference/gm		
	5 cm	15 cm	20 cm
	Δg	Δg	Δg
1	0.165±0.1	0.06	0.165
2	0.31±0.17	0.185	0.22
3	0.355±0.2	0.28	0.235
4	0.335±0176	0.37	0.345

Phenolic Content:

Total phenolic content in Turnip red seeds after exposure to UV- C for 1, 2, 3 and 4 hours at 5, 15 and 15 cm distances from UV source as listed in Table 3, where it increased after exposure by UVC. That is because UVC affected the accumulation of phenolic compounds, where capable of breaking hydroxyl bonds of poly phenols thereby releasing soluble phenols of low molecular weight. Also, chemical composition was changed after exposure to UVC which affected phenolic content (Ullah *et al.,* 2019; Cetin, 2014; Lee *et al.,* 2014; Sheng *et al.,* 2018; Tahmaz *et al.,* 2017). The change in the hydroxyl group, O-H, which plays an important role in phenolic compounds transfer; caused a variation in phenolic content.

Table 3: Phenolic content in Turnip red seeds after exposure to UV- C radiation

Exposure time/ h	Total phenol (mg/g)		
	5 cm	15 cm	20 cm
Untreated	16.3±0.52	16.3±0.52	16.3±0.52
1	18.9±0.46	22.3±0.62	20.1±0.50
2	21.7±0.60	26.5±0.51	24.0±0.62
3	24.8±0.71	29.0±0.73	27.3±0.41
4	21.0±0.62	26.6±0.64	24.9±0.51

Anthocyanin Content:

Total anthocyanin content in Turnip red seeds increased after exposure to UV- C for 1, 2, 3 and 4 hours at 5, 15 and 15 cm distances from the UV source as listed in Table 4. Anthocyanins are a group of antioxidants that belong to the flavonoid family and are water-soluble. Anthocyanin content increased because used as a protectant against damage by radiation energy and affected by environmental factors.

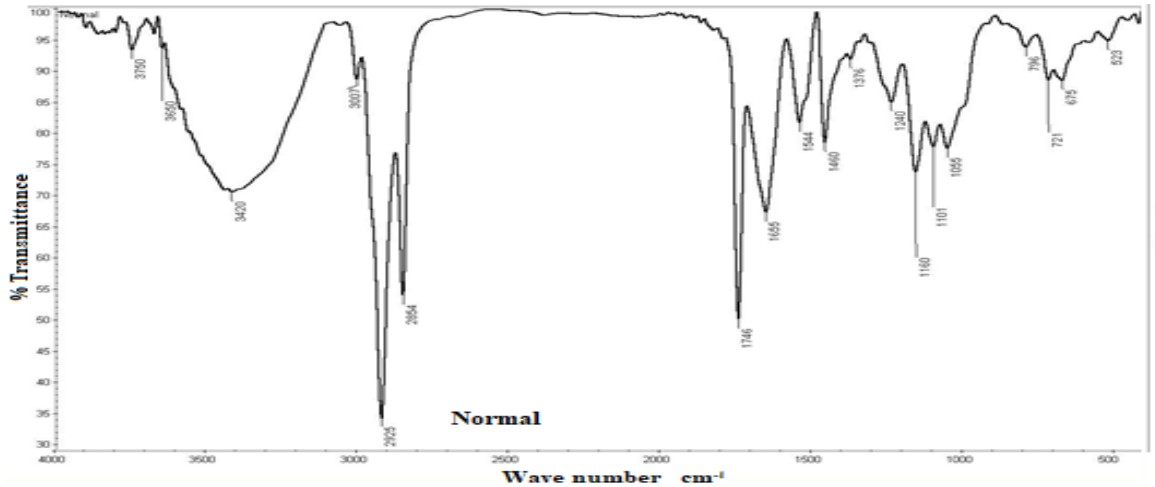
Table 4: Anthocyanin content in Turnip red seeds after exposure to UV- C radiation

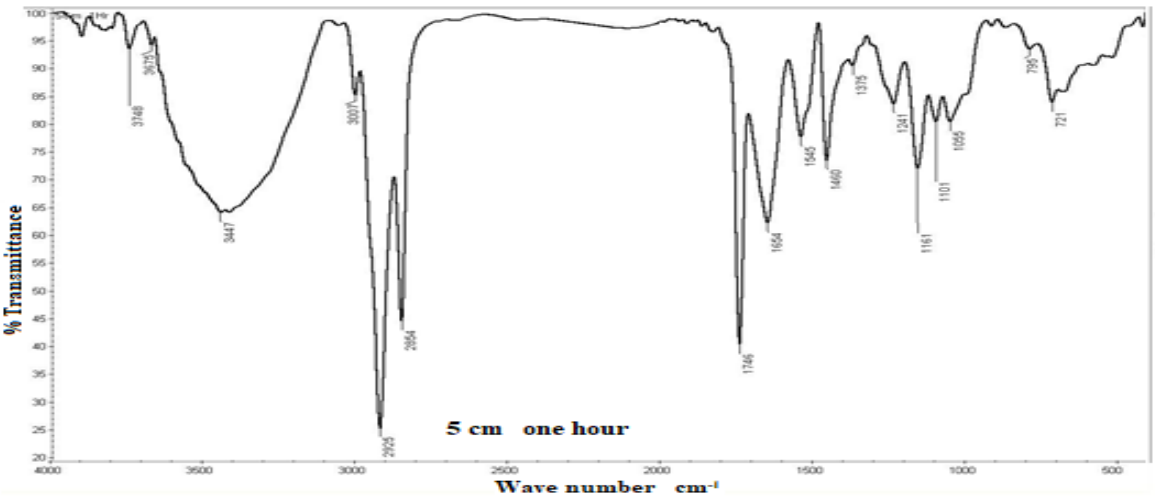
Exposure time/ h	Total anthocyanin (mg/g)		
	5 cm	15 cm	20 cm
Untreated	5.6±0.31	5.6±0.31	5.6±0.31
1	9.3±0.34	12.9±0.37	10.0±0.30
2	11.2±0.40	14.0±0.40	12.9±0.44
3	13.4±0.43	17.4±0.50	14.9±0.51
4	11.8±0.35	15.3±0.5	12.0±0.40

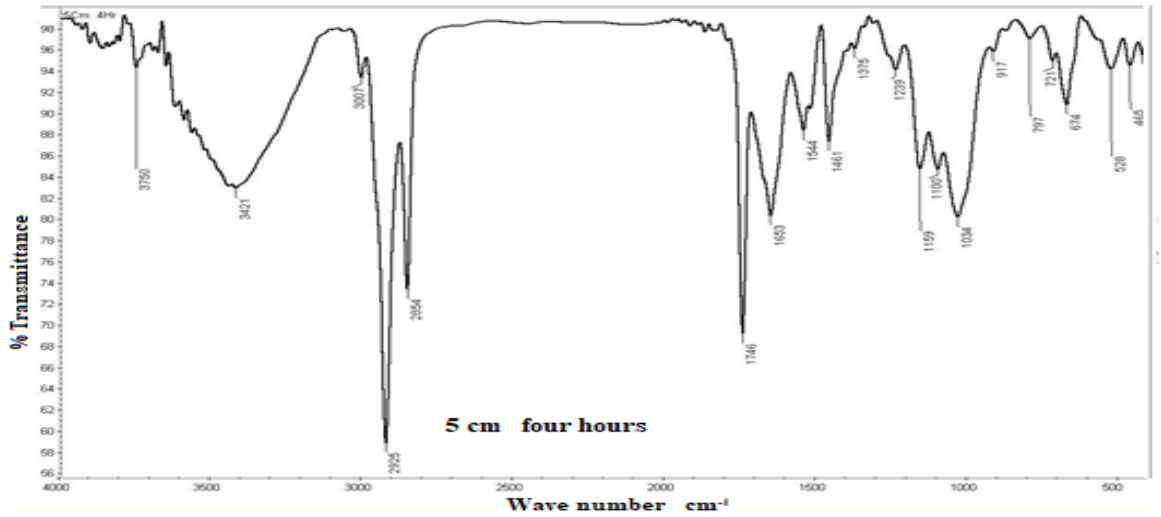
Figure 1, shows the infrared spectrum (IR) for Turnip red seeds after being exposed to UVC for 1 and 4 hours at 5, 15 and 15 cm distances from the UV source, where there is a significant change in both position and intensity of hydroxyl group, O-H. Also, the transmittance intensity, (which indicates the strength or weakness of the bond), of bands changed after exposure to UVC as presented in Table 5.

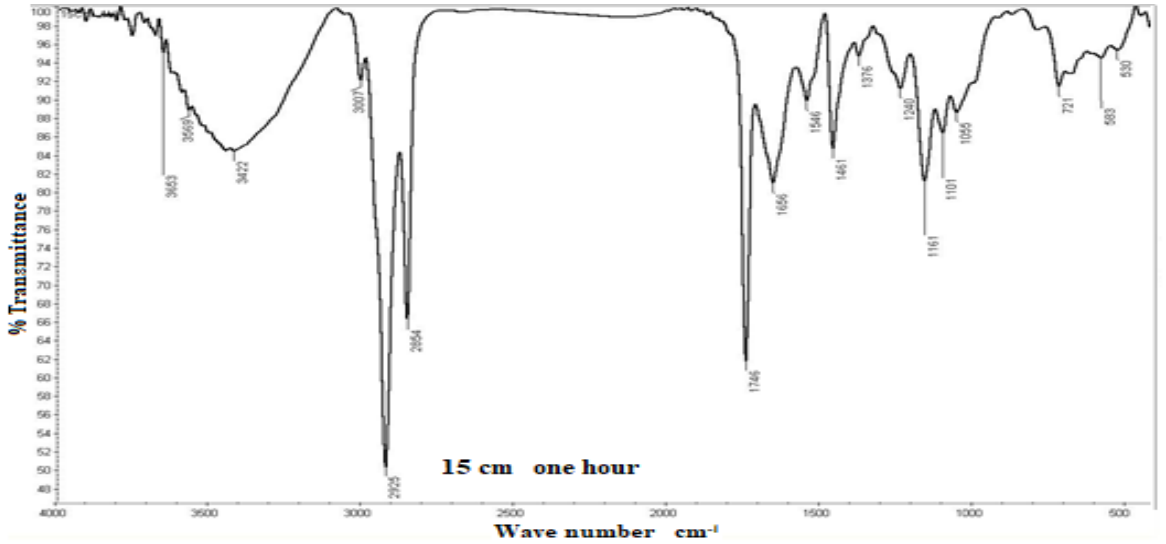
Table 5: characteristics parameters of IR bands for Turnip red seeds after exposure to UV-C radiation

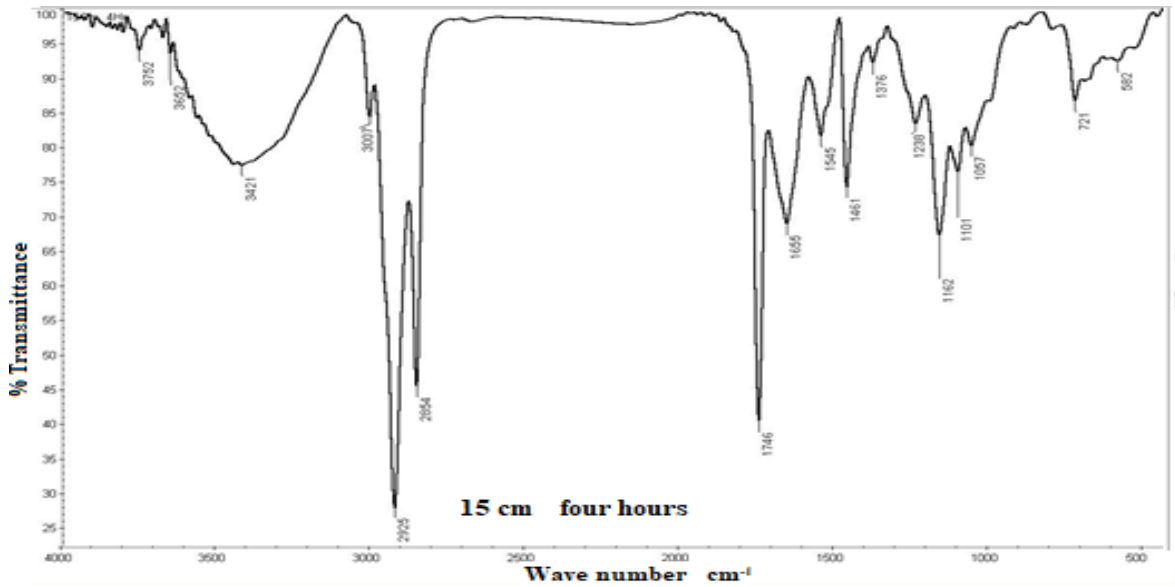
Exposure Time	Position cm^{-1}	%Transmittance	Band
Untreated	1746	50.03	C-O
	2925	34.11	C-H
	3420	70.45	O-H
One hour (5 cm)	1746	40.28	C-O
	2925	25.16	C-H
	3447	63.96	O-H
Two hours	1746	42.27	C-O
	2925	28.37	C-H
	3420	67.89	O-H
Three hours	1746	52.42	C-O
	2925	37.41	C-H
	3420	76.09	O-H
Four hours	1746	69.12	C-O
	2926	58.76	C-H
	3421	82.88	O-H






% Transmittance
5 cm four hours
Wave number cm-1


% Transmittance
15 cm one hour
Wave number cm-1


% Transmittance
15 cm four hours
Wave number cm-1

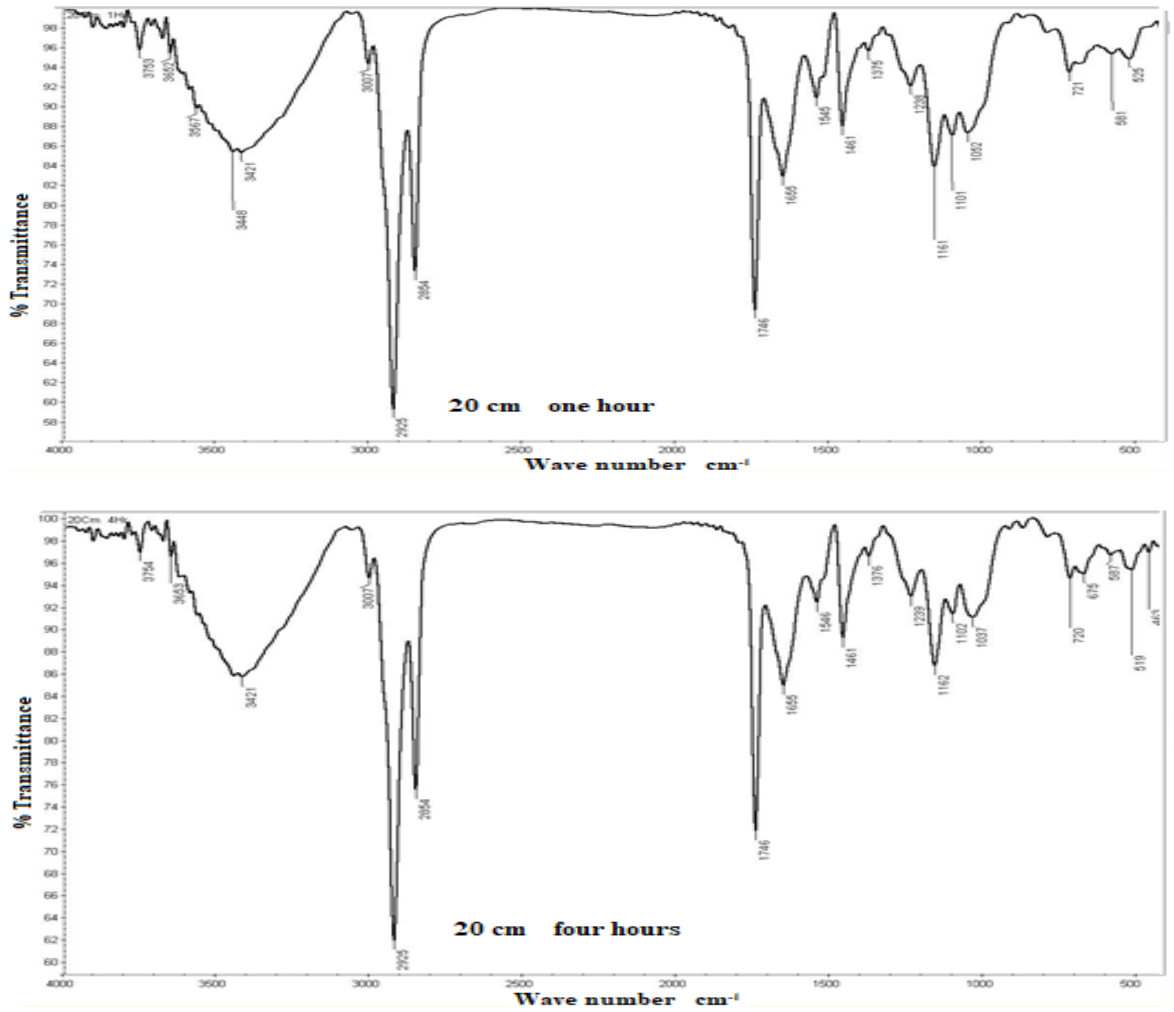
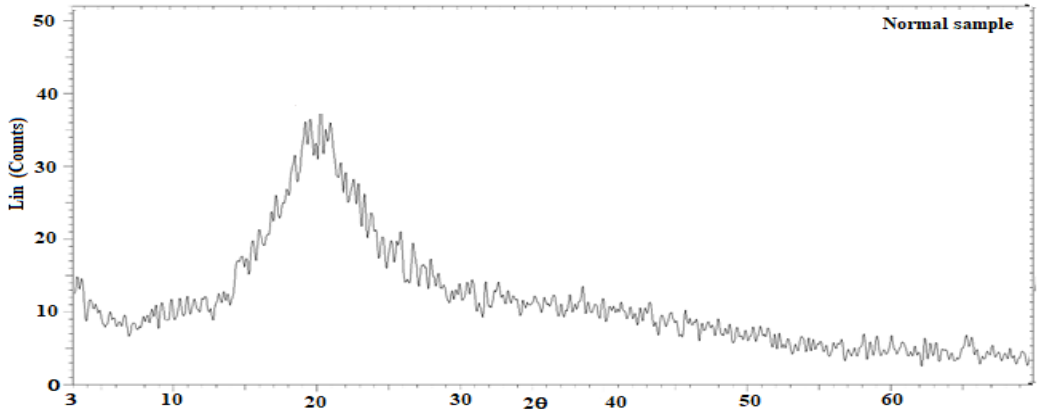


Fig. 1: IR of Turnip red seeds after exposure to UVC

X-ray Analysis:

X-ray diffraction patterns of Turnip red seeds after exposure to UVC for 1 and 4 hours at 5 and 20 cm distances from UV source were shown in Figure 2, where there is a variation occurred in the started baseline, main peak area, position and width after exposure by UVC. Size, arrangement, accumulation and interconnections of matrix molecules changed due to the interaction of UVC rays with it causing destroying or modifying the bond matrix, due to losing energy during absorbing or penetrating in it.



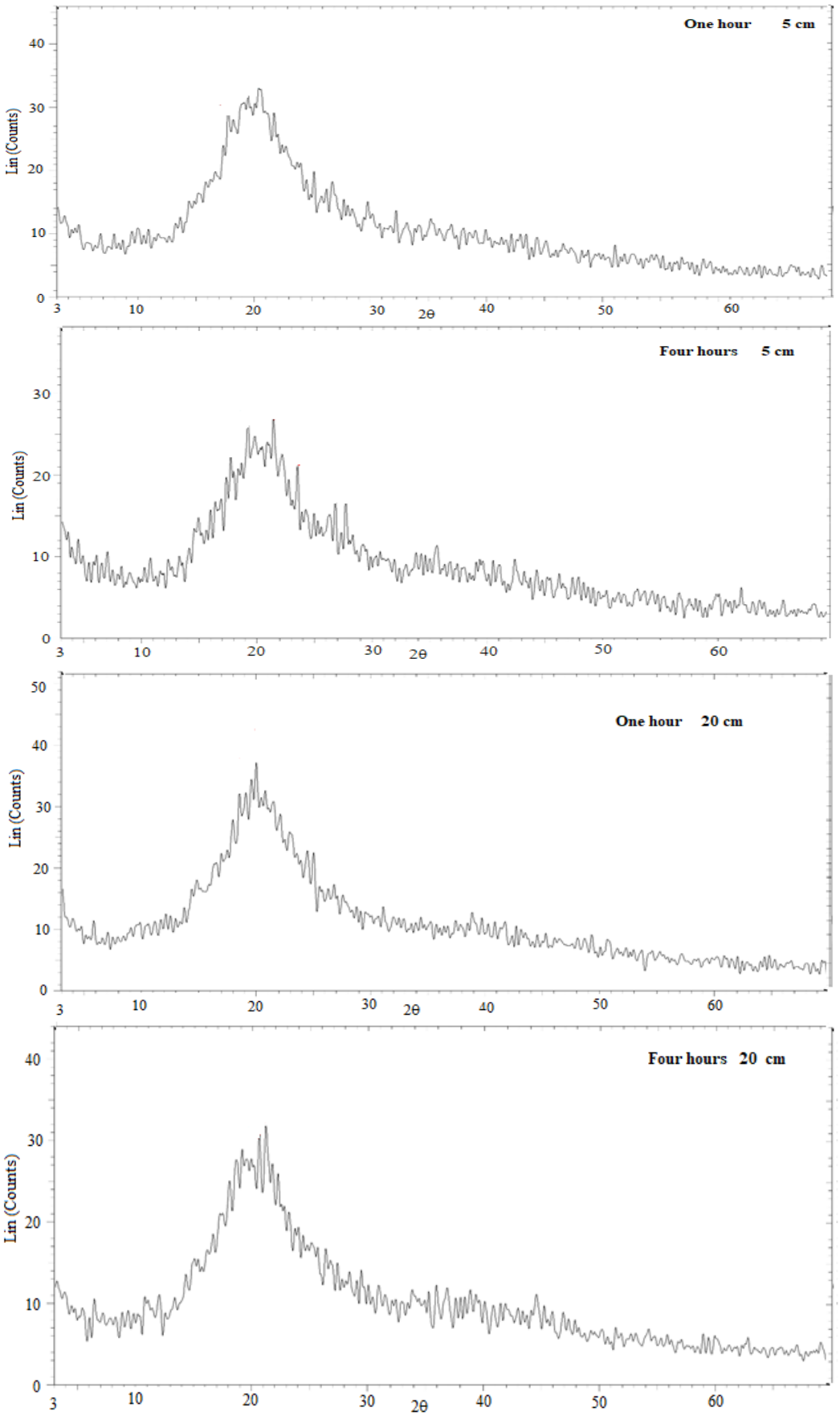


Fig. 2: x-ray diffraction patterns of Turnip red seeds after exposure to UVC

Conclusion

The results of this research show that there is a change in morphological structure and bio-content such as phenolic and anthocyanin content for Turnip red seeds after exposure to UVC at different times at dissimilar distances from the UV source.

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