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# LED Light Quality Affected Bioactive Compounds, Antioxidant Potential, and Nutritional Value of Red and White Cabbage Microgreens

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**Abstract:** Microgreens are environmentally friendly and have health benefits in addition to their basic nutritional contents. The effect of white (W), white–blue (W + B), and white–red (W + R) light on the bioactive compounds, nutrient composition, and antioxidant potential of red and white cabbage microgreens were investigated using light-emitting diodes (LEDs). The results showed that protein, fat, ash, chlorophylls, and carotenoids were the highest in microgreens under W light, while phenolic compounds were highest in microgreens under W + B light. Supplementation with white light, as well as red or blue light, resulted in higher levels of sugars and total fiber in both white and red microgreens. Twenty-six and thirty-three phenolic compounds were identified in white and red cabbage microgreens, respectively. The identified phenolics belonged to three classes, including phenolic acids, flavonols, and anthocyanins. The antioxidant potential of both cabbage microgreens was determined by four methods (ABTS, DPPH, ORAC, and FRAP). It was found that the highest antioxidant potential was observed in microgreens grown under the W + B light combination. On the other hand, the W + R light combination increased the content of β-sitosterol and campesterol. The results may be helpful in the selection of the type of LED lighting that determines the high nutritional and health-promoting potential of white and red cabbage microgreens.

**Keywords:** cabbage microgreens; light-emitting diodes (LEDs); nutrients; phenolic compounds; chlorophylls; carotenoids; phytosterols; antioxidant capacity



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## 1. Introduction

White and red cabbages (*Brassica oleracea* var. *capitata* f. *alba* and *rubra*, respectively) are commercially valued vegetables, well-recognized for their unique sensory and nutritive attributes in addition to a myriad of health-promoting benefits [1]. The mature-headed cabbage is commonly used in various ways, such as salads, coleslaw, sauerkraut, soup, curries, and other cooking purposes. Additionally, immature forms of cabbage, such as sprouts and microgreens, are also available commercially and are consumed fresh. Microgreens are young, tender greens that are harvested at the first true leaf stage and sold with the stem, cotyledons, and first true leaves [2]. The versatility of this form of cabbage makes it suitable for cultivation in various settings, including outdoor farms, greenhouses, and indoor spaces such as restaurants and individual household. Therefore, microgreens could be a good source of easily accessible, fresh, and nutrient-rich edibles, especially when the availability of fresh plant-based foods is limited. Furthermore, some

studies revealed that microgreens contain higher amounts of important phytocompounds compared to mature plants [3,4]. According to the statement provided by Choe et al., red cabbage microgreens had approximately 260-fold more β-carotene (a precursor of vitamin A), 70-fold more phylloquinone (vitamin $K_1$), a 6-fold higher concentration of vitamin C, and glucoraphanin (glucosinolate) compared to their mature counterparts [5]. In addition, red cabbage microgreens, compared to mature cabbage, were richer in protein, fat, selected minerals, and phenolic compounds and showed higher antioxidant activity [3,4].

There are various factors, including growing conditions such as growth media, temperature, light, and nutrient requirements, that can affect plant growth and the chemical composition of microgreens [6]. In controlled cultivation, light conditions have a strong influence on the physiology of microgreens and the accumulation of biologically active compounds [7,8]. Microgreens are usually grown in a controlled environment with artificial lighting, with light-emitting diode (LED) modules being the best option for indoor and vertical farming [2]. LEDs offer many advantages, including energy efficiency, a long operating lifetime, low heat output, and low environmental costs [9]. Recent advances in LED technology have made it possible to establish an optimized light spectrum, which can elicit an optimal photophysiological response. This can result in high yields and improved nutritional quality of the plants grown. The influence of LED lighting on the quality of microgreens has been reviewed by various authors [10–13]. So far, many studies have also been conducted to determine the effect of lighting on the growth and chemical composition of *Brassica* microgreens [9,14–19]. In addition, according to the best of our knowledge, only three articles concerned cabbage microgreens [14,16,19]. However, the very large variety of the lighting variants used in terms of light type, intensity, and exposure time, as well as the type of plants cultivated, makes it challenging to formulate clear conclusions. For example, blue and combined (blue:red) lighting favorably affected plant development, chlorophyll *a*, and carotenoid content, while red light showed the opposite effect in red cabbage and broccoli microgreens [14]. Brazaitytė et al. [15] recommended a lower proportion (25% or 50%) of blue light as a strategic tool for mustard and kale microgreens to increase chlorophyll, flavonol, anthocyanin, and carotenoids.

There are very few studies examining the effect of light on the composition of microgreens produced from white and red cabbage. To this end, this study aimed to determine a wide range of primary metabolites, such as protein, fat, sugars, fiber, and ash, as well as health-relevant compounds, such as carotenoids, chlorophylls, phytosterols, and phenolic compounds. This study assessed the scavenging efficiency of extractable microgreens components towards synthetic DPPH radicals, synthetic ABTS cation radicals, and peroxyl radicals, as well as their ability to reduce iron(III) ion. The majority of research conducted on the effects of the spectral quality of light on plant growth and development, as well as the nutritional quality of plants, including microgreens, has been conducted using narrow-band LEDs. LEDs with different spectral outputs in various combinations (red, blue, and green) have frequently been used to study plant responses, with the aim of identifying the most effective spectral quality combination that can produce the desired effect on plants [20]. However, white LED light is commonly used for the indoor cultivation of leafy vegetables, including microgreens, because of its broad-spectrum features that are beneficial to plant growth [21]. Therefore, in the current study, instead of combining spectral bands of light, we supplemented a traditional white light with a red or blue tone.

## 2. Materials and Methods

### *2.1. Standards and Reagents*

Chlorogenic acid, isorhamnetin 3-glucoside, and cyanidin 3-glucoside were purchased from Extrasynthese (Lyon, France); quercetin 3-glucoside was obtained from PhytoLab (Vestenbergsgreuth, Germany); and kaempferol 3-glucoside was obtained from Sigma-Aldrich (Steinheim, Germany). Anthrone, 2,2′-azinobis(3-ethyl-benzthiazoline-6-sulphonic acid) (ABTS), 3,5-dimethylphenol, 6-hydroxy-2,5,7,8-tetramethychroman-2-carboxylic acid (Trolox), galacturonic acid, and glucose were obtained from Sigma-Aldrich (Steinheim,

Germany). Acetonitrile (Merck, Germany) and formic acid (Sigma-Aldrich, Germany) were hyper grade for LC–MS. The other reagents were of analytical grade. Ultrapure water (Simplicity$^{TM}$ Water Purification System, Millipore, Marlborough, MA, USA) was used to prepare all solutions.

### 2.2. Plant Materials and Microgreens Production

Seeds of two cultivars of cabbage (*Brassica oleracea* var. *capitata*), namely white (f. *alba*, "Kamienna głowa") and red (f. *rubra*, "Haco"), were obtained from the seed company "W. Legutko" in Poland. These seeds were sown in a commercial peat substrate (Hartmann, Poland), specifically designed for vegetable seedling cultivation. The substrate had the following nutrient composition: N-$NH_4$ 21, N-$NO_3$ 252, P 87, K 239, Ca 1457, Mg 166, S-$SO_4$ 221, Fe 27.4, Zn 1.4, Mn 4.9, Cu 0.4, Cl 30, Na 50, with a pH 5.83 and an electrical conductivity of 1.223 mS cm$^{-1}$. Seeds were sown directly on trays (3 g per tray) for seedling cultivation, measuring 30 × 50 × 5 cm (7.5 L). Plants were not additionally fertilized during cultivation; watering was conducted every few days, depending on the needs of the plants.

Cabbages were grown on tables in growth chambers, each equipped with its own independent lighting, and light of different spectral compositions was used in each chamber. The temperature in the growth chamber was set to 23 °C for the first two days and was then maintained at 21 °C during the day and 17 °C at night (±2 °C). The relative humidity was 60–70%. The light sources were modules equipped with semiconductor diodes that provided white light, further enhanced with blue or red light. The red, blue, and white light came from a high-power solid-state lighting module (LED) (SMD type, Seoul Semiconductor, Ansan-si, South Korea). The spectrum of white light was shown in Table 1 and Figure 1.

**Table 1.** Characteristic of the white light source.

| Light Color | Wavelength (nm) | PPFD (W) (µmol m$^{-2}$ s$^{-1}$) | % for W light | PPFD (W) (µmol m$^{-2}$ s$^{-1}$) | % for W + R | % for W + B |
|---|---|---|---|---|---|---|
| UV | 320–380 | 0.69 | 0.3 | 0.5 | 0.2 | 0.2 |
| Violet | 380–450 | 21.10 | 8.9 | 15.4 | 6.6 | 6.6 |
| Blue | 450–495 | 41.51 | 17.6 | 30.3 | 13.0 | 38.9 |
| Green | 495–570 | 73.30 | 31.1 | 53.5 | 23.0 | 23.0 |
| Gold | 570–590 | 25.62 | 10.9 | 18.7 | 8.1 | 8.1 |
| Orange | 590–620 | 29.87 | 12.7 | 21.8 | 9.4 | 9.4 |
| Red (R) | 620–700 | 36.17 | 15.3 | 26.4 | 37.2 | 11.4 |
| Far Red (FR) | 700–780 | 7.67 | 3.3 | 5.6 | 2.4 | 2.4 |
| Sum | 320–780 | 235.9 | 100 | 172.2 | 100 | 100 |
| R:FR | | 4.7 | - | 4.7 | 15.5 | - |

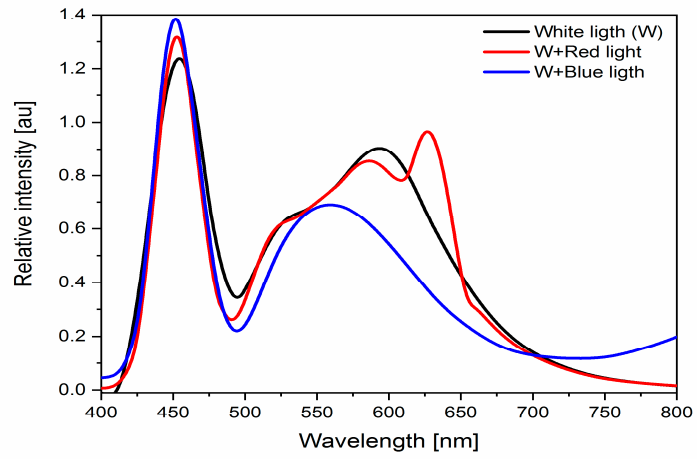


**Figure 1.** The spectral composition of the lamps for white light (W), white light with red light (W + R), and white light with blue light (W + B).

The microgreens were grown under 16 h light/8 h dark conditions with a daylight dose of about 13.2 µmol $m^{-2}$ $s^{-1}$. The proportion of red light to blue light for each combination was as follows: white light: 0.87; white light with red light: 2.86; white light with blue light: 0.29. LED light intensity and spectral distribution were monitored by a PAR-10 quantum sensor (Sonopan, Białystok, Poland) and a BLACK-Comet CXR UV–VIS spectroradiometer (280–900 nm, StellarNet Inc., Tampa, FL, USA), respectively.

All cabbage microgreens were harvested 14 days after sowing, when they started to form the first true leaves. For chemical analyses, the plants were freeze-dried immediately after harvesting (Alpha 1-2/LD Plus freeze dryer, Christ, Osterode am Harz, Germany).

### 2.3. Proximate Analysis

The elementary chemical composition of lyophilized microgreens was determined according to the procedures reported previously [22]. Dry matter and ash were determined by the gravimetric method after drying the samples to a constant weight at 105 °C and after burning the samples in a muffle furnace at 600 °C for 6 h, respectively. Total lipid content was determined according to the Soxhlet method with hexane for 4 h. Crude protein content was calculated from the total nitrogen content determined by the Kjeldahl method using a conversion factor of 6.25. The total content of soluble sugars was determined in defatted microgreens using the method with an anthrone reagent in a sulfuric acid environment and was expressed as glucose equivalents [23,24]. The ash, protein, sugar contents were expressed as g 100 $g^{-1}$ dry weight (DW) of microgreens.

### 2.4. Determination of Total Dietary Fiber and Fiber Fractions

Total dietary fiber (DF) content and its composition were determined according to the procedure described by Gouw et al. [24]. Soluble dietary fiber (SDF) content was the sum of uronic acids (UA) and neutral sugars (NS). Insoluble dietary fiber (IDF) was the sum of UA, NS, and the mass of Klason lignins (KL).

### 2.5. Analysis of Photosynthetic Pigments

Chlorophyll and carotenoid content were assessed based on the protocol detailed by Majdoub et al. [25]. In brief, about 50 mg of microgreens were extracted with 20 mL of 80% acetone (three times) for 10 min on a magnetic stirrer (MS 11 H, Wigo, Piastów, Poland). The pooled organic layer absorbance was measured at 470 nm, 663 nm, and 645 nm against 80% acetone (spectrophotometer SP-830Plus, Metertech, Taipei, Taiwan).

### 2.6. Preparation of Extract for Phenolics, Phytosterols, and Antioxidant Potential Analysis

Microgreen lyophilizates (1.0 g) were extracted with 100 mL of 60% ethanol containing 0.1% (*v*/*v*) concentrated hydrochloric acid on a magnetic stirrer for 30 min at room temperature. After centrifugation at 5000 rpm for 10 min (MPW-351R, MPW Med. Instruments, Warszawa, Poland), the residue was extracted with 100 mL of 70% acetone under the same conditions as previously described. The combined methanol and acetone extracts were evaporated at 40 °C under reduced pressure (vacuum rotary evaporator RII, Büchi, Switzerland) to remove alcohols, and reduced to a final volume of 40 mL. The extracts were stored at −24 °C for further studies.

### 2.7. Quantification of Total Phenolics and Anthocyanins

Total phenolics were determined using the Folin–Ciocalteu reagent, while total anthocyanin content was measured using the pH differential method, as described in our previous work [26]. The content of total phenolics and total anthocyanins was expressed as gallic acid equivalents and as cyanidin 3-glucoside equivalents, respectively.

### 2.8. Estimation of Phenolic Compounds by UPLC–Q-TOF-MS

The qualitative and quantitative composition of phenolic compounds was estimated using an Acquity ultra-performance liquid chromatography (UPLC) system that was cou-

pled with a quadruple-time of flight mass spectrometry (Q-TOF-MS) instrument (Waters Corp., Milford, MA, USA) equipped with an electrospray ionization (ESI) source. The conditions of UPLC-PDA and MS/MS were described in our previous study [27]. Chromatographic separation was performed using an Acquity HSS T3 C18 column (150 mm × 2.1 mm, 1.8 µm; Waters, Milford, MA, USA) at 30 °C with a flow rate of 0.45 mL $min^{-1}$, and an injection volume of 5 µL. The mobile phase was composed of two eluent mixtures: 0.1% formic acid (A) and acetonitrile (B). The gradient employed was as follows: 0 min, 99% A; 12 min, 65% A; 12.5 min, 0% A; 13.5 min, 99% A. Phenolic compounds were identified using their UV-Vis characteristics and MS and $MS^2$ properties using data gathered in-house and from the literature.

### 2.9. Determination of Individual Phytosterols

Phytosterol content was evaluated using gas chromatography (GC) coupled with mass spectrometry analysis (Pegasus 4D, LECO Corp., St. Joseph, MI, USA). Briefly, 0.5 mL of ethyl acetate and 100 µL of a cholesterol (Merck KGaA, Darmstadt, Germany) solution in ethyl acetate as an internal standard (c = 30 µg $mL^{-1}$) were added to the lyophilized extract (1 mL). Next, an ultrasound-assisted extraction was performed for 5 min. The extract was then decanted, and a solution of phytosterols was analyzed as trimethylsilyl derivatives according to the previously described procedure [28].

### 2.10. Determination of Antioxidant Potential

The antioxidant potential of cabbage microgreens was determined using four different methods. These include the scavenging potential of stable, synthetic $ABTS^{\bullet+}$ radical cation (ABTS) and $DPPH^{\bullet}$ radical (DPPH), as well as towards peroxyl radical (ORAC), and the potential to reduce ferric to ferrous ion (FRAP), as previously described [22,29]. The results were expressed as µM Trolox equivalents (TE) per g DW of microgreens.

### 2.11. Statistical Analysis

All experiments were conducted in triplicate. Data are expressed as the mean ± standard deviation. Statistical analysis was performed using a one-way ANOVA followed by a Tukey post hoc test for comparisons between the light treatments. $p$ values less than 0.05 were considered statistically significant.

## 3. Results and Discussion

### 3.1. Effect of LED Light Treatments on Nutrients

As a new culinary sensation with a variety of colors and flavors, microgreens have gained popularity in recent years. In addition to their short growth period and high market value, they also have interesting nutritional properties. The nutrient composition of microgreens such as mature vegetables is complex. The content of protein, fat, sugars, ash, and fiber of cabbage microgreens grown under the illumination of white (W), white with red (W + R), and white with blue (W + B) light is reported in Table 2. The results revealed that LED light treatment had a great influence on the primary metabolite contents of cultivated microgreens. The white cabbage microgreens differed statistically ($p < 0.05$) in their protein, ash, fat, and soluble dietary fiber contents. On the contrary, red cabbage microgreens differed statistically in ash content. The highest protein (about 30 g 100 $g^{-1}$ DW), fat (7.33 and 7.97 g 100 $g^{-1}$ DW), and ash (21.36 and 25.60 g 100 $g^{-1}$ DW) content was observed in both white and red cabbage microgreens grown under white light. The opposite trend was observed for sugar content because the red and white cabbage microgreens grown under white light contained the least of them. To the best of our knowledge, there are a few reports on the basic chemical composition of white and red cabbage microgreens, which mainly relate to the content of vitamins and minerals [3,16,30,31].

**Table 2.** Effect of LED light treatments (white, white with red, and white with blue) on the elementary chemical composition (g 100 $g^{-1}$ DW) of white and red cabbage microgreens.

| Factor | White Cabbage Microgreens | | | Red Cabbage Microgreens | | |
|---|---|---|---|---|---|---|
| | White | White + Red | White + Blue | White | White + Red | White + Blue |
| Ash | 21.36 ± 0.21 c | 18.79 ± 0.47 b | 16.06 ± 0.23 a | 25.60 ± 0.37 c | 20.14 ± 0.03 b | 19.15 ± 0.12 a |
| Protein | 30.48 ± 1.29 c | 13.66 ± 0.71 b | 10.67 ± 0.07 a | 29.27 ± 0.95 b | 16.70 ± 0.14 a | 15.94 ± 0.65 a |
| Fat | 7.33 ± 0.27 c | 5.05 ± 0.14 b | 3.78 ± 0.11 a | 7.97 ± 0.30 b | 5.36 ± 0.30 a | 4.90 ± 0.21 a |
| Sugars | 2.43 ± 0.12 a | 6.05 ± 0.38 b | 9.76 ± 0.13 c | 5.84 ± 0.26 a | 6.57 ± 0.47 ab | 6.90 ± 0.23 b |
| Fiber total | 39.07 ± 0.30 a | 55.42 ± 1.16 b | 53.69 ± 2.03 b | 35.49 ± 0.30 a | 41.18 ± 1.08 b | 38.21 ± 0.55 a |
| SDF total | 1.53 ± 0.10 a | 2.71 ± 0.02 b | 3.51 ± 0.22 c | 2.12 ± 0.10 b | 1.90 ± 0.10 ab | 1.67 ± 0.12 a |
| IDF total | 37.54 ± 0.41 a | 52.71 ± 1.18 b | 50.18 ± 1.82 b | 33.37 ± 0.39 a | 39.28 ± 0.89 b | 36.54 ± 0.43 a |

Values are expressed as mean ± SD ($n = 3$); values with different letters in each row represent significant differences at $p < 0.05$ separately for each cultivar. SDF—soluble dietary fiber; IDF—insoluble dietary fiber.

The levels of ash and protein of 14-day red cabbage (cv. Haco) young shoots cultivated in a greenhouse under natural light were in accordance with our results for red cabbage (cv. Haco) microgreens under white light [3]. Only microgreens grown in a greenhouse were characterized by three times lower fat content. Ten-day-old red cabbage microgreens were obtained after seeds sprouted in the dark for 5 days and were then exposed to white fluorescent light for 5 days. These microgreens contained less ash (14.1 g 100 $g^{-1}$ DW), more protein (35.3 g 100 $g^{-1}$ DW), and a comparable amount of fat (7.1 g 100 $g^{-1}$ DW) to the red cabbage analyzed in this study grown 14 days under white light [30].

Concerning dietary fiber, both red and white cabbage microgreens grown under white light supplemented with red light were characterized by the highest total and insoluble dietary fiber content (Table 2). However, white cabbage microgreens under white light with blue light and red cabbage microgreens under white light showed the highest soluble dietary content. The total fiber content ranged from 39.07 to 55.42 g 100 $g^{-1}$ DW of white cabbage microgreens and from 35.49 to 41.18 g 100 $g^{-1}$ DW of red cabbage microgreens. The content of total fiber determined in this study is in accordance with the results of Drozdowska et al. for young red cabbage shoots cultivated in a greenhouse under natural light [3]. The results presented in Table 2 demonstrated the predominance of insoluble dietary fiber (IDF) in all microgreens analyzed. The contribution of this fraction to the total fiber content ranged from 93.5% in white cabbage under blue light to 96.1% in white cabbage under white light treatment. Generally, in microgreens tested, the decreasing rank of contents of particular IDF fractions was as follows: neutral sugars > Klason lignin > uronic acids (Figure 2). The exception was red cabbage microgreens under white light, in which IDF was dominated by Klason lignin over neutral sugars and uronic acids. The soluble dietary fraction (SDF) in all microgreens was dominated by neutral sugars, followed by uronic acids. The SDF after ingestion is fermented by bacterial flora in the gut, leading to the production of the short-chain fatty acids acetate, propionate, and butyrate, which have various beneficial health effects [32]. The results for white and red cabbage microgreens are consistent with the data for mature forms of head cabbages. The total dietary fiber content of fresh red cabbage and steamed green cabbage was 23.1 g 100 $g^{-1}$ DW, with IDF as the predominant fraction [33]. In addition, the authors showed that the IDF fraction was also dominated by neutral sugars, but contrary to the results for microgreens, the content of uronic acids exceeded the amount of Klason lignin. Furthermore, contrary to our results, in mature forms of cabbage, uronic acids dominated over neutral sugars in the SDF. The presented differences may indicate the transformation of fiber components during the further growth of cabbages. To the best of our knowledge, this is probably the first study looking into the dietary fiber profiles of white and red cabbage microgreens.


**Figure 2.** Contribution (%) of soluble and insoluble fiber fraction components of white and red cabbage microgreens under white, white with red, and white with blue LED lights.

### *3.2. Effect of LED Light Treatments on Photosynthetic Pigments*

Following exposure to light, microgreens undergo photomorphogenesis and inevitably synthesize photosynthetic pigments, such as chlorophylls and carotenoids [15]. Additionally, the color of microgreens is important for the visual appearance of the product and may influence the choice of customers. They are also very important plant-derived components of the human diet. The beneficial health effects of carotenoids are not only related to their role as vitamin A precursors, but they may also reduce the risk of developing degenerative chronic diseases such as age-related macular degeneration, type 2 diabetes, obesity, certain types of cancer, and cardiovascular diseases, among others [34]. Chlorophyll and its derivatives can stimulate the immune system, act against sinusitis, fluid accumulation, and skin rashes, eliminate toxins from the body, prevent cancer, normalize blood pressure, and fight bad odors and bad breath [35]. The results summarized in Table 3 indicate that supplementation of white light with red or blue light has negative effects on the photosynthetic pigment content of both cabbage microgreens. Significant differences ($p < 0.05$) were found between the content of pigments in microgreens grown under different light treatments. The highest total carotenoids (689 mg 100 $g^{-1}$ DW), total chlorophylls (1312 mg 100 $g^{-1}$ DW), chlorophyll *a* (445 mg 100 $g^{-1}$ DW), and chlorophyll *b* (870 mg 100 $g^{-1}$ DW) content was observed in red cabbage microgreens under white light. Generally, red cabbage microgreens were characterized by higher levels of chlorophyll and carotenoids compared to white cabbage microgreens at the same light treatments.

**Table 3.** Content (mg 100 $g^{-1}$ DW) of total carotenoids, total chlorophylls, chlorophyll *a*, and chlorophyll *b* of white and red cabbage microgreens under white, white with red, and white with blue LED light.

| Factor | White Cabbage Microgreens | | | Red Cabbage Microgreens | | |
|---|---|---|---|---|---|---|
| | White | White + Red | White + Blue | White | White + Red | White + Blue |
| Total carotenoids | 582 ± 9 c | 281 ± 13 b | 167 ± 5 a | 689 ± 16 c | 431 ± 2 b | 350 ± 2 a |
| Total chlorophylls | 1129 ± 22 c | 555 ± 17 b | 324 ± 22 a | 1312 ± 31 c | 856 ± 6 b | 693 ±19 a |
| Chlorophyll *a* | 391 ± 11 c | 184 ± 4 b | 117 ± 2 a | 445 ± 18 c | 283 ± 8 b | 229 ± 10 a |
| Chlorophyll *b* | 738 ± 10 c | 369 ± 12 b | 207 ± 3 a | 870 ± 3 c | 571 ± 13 b | 464 ± 11 a |

Values are expressed as mean ± SD ($n = 3$); values with different letters in each row represent significant differences at $p < 0.05$ between the treatments, separately for each cultivar.

In all cases, a higher content of chlorophyll *b* than chlorophyll *a* was found. Alrifai et al. demonstrated that amber LED was involved in the regulatory mechanism of carotenoid biosynthesis, and generally carotenoid content increased under dose-dependent increasing amber–blue light and decreasing red light [18]. The content of chlorophylls and carotenoids in 13-day-old red cabbage microgreens grown in a glasshouse under red, blue, or combined red and blue (1:1) lights was favorably influenced by the blue spectrum. The lowest contents were obtained when a combination of red and blue lighting was used [14]. The study by Kamal et al. observed that microgreens of green and red cabbage grown under red:blue (20:80) LEDs had the highest β-carotene content, compared to those grown under red:blue (80:20) LEDs, and when green light was added to the mixture of red and blue lights [16]. According to Ying et al., the blue light percentage (from 5 to 30%) supplied from LEDs did not affect chlorophyll *a* and *b* concentrations or carotenoid concentrations in red cabbage microgreens [19].

### *3.3. Effect of LED Light Treatments on Phenolic Compounds*

Phenolic compounds are the key contributors to the responses of plants toward biotic and abiotic stresses, and some of them are involved in pigmentation [36]. They are highly valuable in human nutrition because phenolic compounds have been linked to the prevention of cardiovascular diseases, cancer, diabetes, Alzheimer's, and other age-related diseases [37]. These secondary plant metabolites range from simple, low molecular weight, single aromatic-ringed compounds to large and complex flavonoids and tannins, with a wide range of biological activities. Mature white and red cabbage phenolic compound profiles have been extensively investigated [38–42]. In addition, data on the qualitative composition of phenolic compounds in red cabbage microgreens have been published [43]. The qualitative and quantitative composition of phenolic compounds is very important because the structure of phenolics significantly affects their properties.

In connection with the above statement, the ethanolic extracts of tested microgreens were characterized for their individual phenolic compound content using LC/Q-TOF-MS in both negative and positive ion modes. The results of the phenolic composition of white and red cabbage microgreens grown under three LED lights are summarized in Tables 4 and 5. The results revealed that twenty-six and thirty-three phenolic compounds were identified in white and red cabbage microgreens, respectively. Regardless of the type of cabbage, the identified compounds belonged to phenolic acids, flavonols, and anthocyanins. Sun et al. identified fifty phenolic compounds, including eighteen anthocyanins, eleven phenolic acids, and twenty-one flavonols (eleven quercetin derivatives and ten kaempferol derivatives) in red cabbage microgreens [43]. In the present study, the profile of phenolic compounds in white cabbage microgreens was determined for the first time. Three and eleven anthocyanins were detected in white and red cabbage microgreens, respectively. The profile of red cabbage anthocyanins is very complex, and so far thirty-six different pigments have been found in mature red cabbage [42]. As with mature vegetables, red cabbage microgreens contained acylated cyanidin-3-diglucoside-5-glucoside deriva-

tives highly conjugated with acyl groups (sinapoyl, *p*-coumaroyl, feruloyl)—Table 5. The 14-day-old white cabbage microgreens, unlike the ripe white cabbage, also contained acylated cyanidin-3-diglucoside-5-glucoside derivatives (Table 4).

**Table 4.** Identification and phenolic compound content (mg $g^{-1}$ DW) of white cabbage microgreens under different light treatments.

| tR UPLC (min) | [MS-H]- [MS + H]+ (*m*/*z*) | MS/MS (*m*/*z*) | Tentative Identification | Light Treatments | | |
|---|---|---|---|---|---|---|
| | | | | White | White + Red | White + Blue |
| 1.45 | 191 | 173/146 | Quinic acid [38] | 0.28 ± 0.02 | 0.10 ± 0.01 | 0.10 ± 0.00 |
| 3.49 | 353 | | Chlorogenic acid | 0.15 ± 0.01 | 0.30 ± 0.00 | 0.26 ± 0.01 |
| 3.60 | 447 | 198/141/170/139 | Rhamnosyl-ellagic acid [43] | 0.46 ± 0.01 | 0.51 ± 0.00 | 0.60 ± 0.06 |
| 3.94 | 547 | 190/171/115/208 | Sinapic acid diglucoside [38] | 0.08 ± 0.01 | - | - |
| 4.26 | 355 | 121/132/160/193 | Ferulic acid glucoside [38] | 0.17 ± 0.01 | 2.38 ± 0.02 | 3.12 ± 0.01 |
| 4.33 | 385 | 175/247/190/119 | Sinapic acid glucose [43] | 1.66 ± 0.01 | 1.09 ± 0.02 | 1.39 ± 0.02 |
| 5.72 | 753 | 240/205/190/164 | 1,2-disinapoylgentiobioside [39] | 0.33 ± 0.00 | 0.63 ± 0.00 | - |
| 6.51 | 723 | 193/178/134/223 | Sinapoyl-feruloylgentiobioside [43] | - | 0.25 ± 0.01 | - |
| 7.22 | 753 | 161/223/179 | Disinapoylgentiobioside [43] | 2.63 ± 0.02 | 2.39 ± 0.00 | 2.98 ± 0.02 |
| 7.44 | 723 | 193/175/134/223 | Sinapoyl-feruloylgentiobioside [43] | 0.73 ± 0.01 | 3.51 ± 0.01 | 4.59 ± 0.09 |
| 7.88 | 753 | 161/223/179 | Disinapoylgentiobioside [43] | 0.24 ± 0.00 | - | - |
| 8.40 | 959 | 161/223/205/511 | Trisinapoylgentionbioside [43] | 4.64 ± 0.02 | 1.68 ± 0.00 | 1.58 ± 0.05 |
| 8.64 | 929 | 191/511/390/205 | Feruloyl-disinapoylgentionbioside [43] | 0.36 ± 0.02 | 1.34 ± 0.00 | 1.53 ± 0.03 |
| | | | Total phenolic acids | 11.73 ± 0.08 a | 14.18 ± 0.06 b | 16.15 ± 0.60 c |
| 3.37 | 787 | 191/432/179/300 | Quercetin-3-diglucoside-7-glucoside [38] | - | 0.03 ± 0.00 | 0.19 ± 0.01 |
| 3.70 | 1111 | 787/949/625/301/462 | Quercetin-3-diglucoside-7-triglucoside [38] | - | - | 0.30 ± 0.01 |
| 3.63 | 1125 | 771/963 | Kaempferol-3-hydroxyferuloyldiglucoside-7-glucoside [43] | - | - | 0.37 ± 0.01 |
| 3.67 | 1095 | 609/771 | Kaempferol-3-triglucoside-7-diglucoside [38] | - | 0.18 ± 0.02 | 0.09 ± 0.00 |
| 3.70 | 933 | 609/447/414/301/576 | Kaempferol-3-caffeoyldiglucoside-7-glucoside [43] | - | - | 0.35 ± 0.00 |
| 4.15 | 1109 | 771/609/284/591 | Kaempferol-3-feruloyldiglucoside-7-glucoside [38] | - | 0.16 ± 0.00 | - |
| 4.19 | 477 | 169/139/144/162 | Isorhamnetin-glucoside [39] | 0.06 ± 0.00 | 0.06 ± 0.00 | 0.19 ± 0.01 |
| 4.21 | 947 | 462/609/300/285 | Kaempferol-3-feruloyldiglucoside-7-glucoside [43] | - | - | 0.15 ± 0.01 |
| 4.34 | 477 | 190/175/147 | Isorhamnetin-glucoside [39] | 0.02 ± 0.00 | 0.03 ± 0.00 | 0.13 ± 0.01 |
| 6.23 | 1477 | 1153/285/947 | Kaempferol-3-sinapoyl-feruloyltriglucoside-7-diglucoside [39] | - | 0.36 ± 0.00 | - |
| | | | Total flavonols | 0.08 ± 0.00 a | 0.82 ± 0.02 b | 1.76 ± 0.04 c |
| 5.79 | 1155+ | 287/993 | Cyanidin-3-sinapoyl-feruloyldiglucoside-5-glucoside [38] | - | 0.05 ± 0.00 | 0.10 ± 0.01 |
| 5.85 | 1185+ | 287/449/1023 | Cyanidin-3-disinapoyldiglucosude-5-glucoside [38] | 0.03 ± 0.00 | 0.06 ± 0.00 | 0.09 ± 0.01 |
| 5.94 | 1125+ | 287 | Cyanidin-3-sinapoyl-feruloyldiglucoside-5-glucoside [43] | - | - | 0.06 ± 0.01 |
| | | | Total anthocyanins | 0.03 ± 0.00 a | 0.11 ± 0.00 b | 0.25 ± 0.01 c |
| | | | Sum of phenolic compounds | 11.84 ± 0.08 a | 15.11 ± 0.06 b | 18.16 ± 0.64 c |

Values are expressed as mean ± SD ($n$ = 3); "-"—not detected; Cy—cyanidin; Kaempferol derivatives were expressed as kaempferol 3-glucoside equivalents. Quercetin derivatives were expressed as quercetin 3-glucoside equivalents; isorhamnetin derivatives were expressed as isorhamnetin 3-glucoside equivalents; cyanidin derivatives were expressed as cyanidin 3-glucoside equivalents. Values with different letters in each row represent significant differences at $p < 0.05$ between the light treatments, separately for each cultivar; the numbers next to the names of the compounds correspond to the reference number.

**Table 5.** Identification and phenolic compound content (mg $g^{-1}$ DW) of red cabbage microgreens under different light treatments.

| tR UPLC (min) | [MS-H]- [MS + H]+ (*m*/*z*) | MS/MS (*m*/*z*) | Tentative Identification | Light Treatments | | |
|---|---|---|---|---|---|---|
| | | | | White | White + Red | White + Blue |
| 1.48 | 191 | 173/146 | Quinic acid [38] | 0.10 ± 0.00 | 0.18 ± 0.00 | 0.20 ± 0.01 |
| 3.42 | 289 | 285/267/192/149 | Di-(α-OH-dihydrosinapoyl-glucoside) [40] | 0.11 ± 0.00 | 0.18 ± 00 | 0.26 ± 00 |
| 3.52 | 353 | | Chlorogenic acid | 0.67 ± 0.00 | 1.23 ± 0.01 | 2.09 ± 0.01 |
| 3.66 | 547 | 161/133/179/208 | Sinapoylgentiobioside [39] | 0.07 ± 0.00 | - | - |
| 3.88 | 447 | 198/141/170/139 | Rhamnosyl-ellagic acid [43] | 0.16 ± 0.00 | - | - |
| 3.90 | 337 | 119/135/179 | p-Coumaroyl-quinic acid [41] | 3.17 ± 0.01 | 3.38 ± 0.01 | 6.81 ± 0.03 |
| 4.28 | 355 | 121/132/160/193 | Ferulic acid glucoside [38] | 0.67 ± 0.01 | 1.30 ± 0.01 | 1.99 ± 0.01 |
| 4.34 | 385 | 175/147/190/119 | Sinapic acid glucose [43] | 1.10 ± 0.00 | 1.11 ± 0.02 | 1.30 ± 0.01 |
| 4.46 | 935 | 285/267/192/149 | Diglucoside-dihydro-p-coumaroyl/Sinapoyl-dihydrosinapic acid [40] | 0.56 ± 0.01 | 0.71 ± 0.02 | 0.90 ± 0.01 |
| 4.65 | 965 | 285/267/192/149 | Diglucoside-dihydroferuloyl/Sinapoyl-dihydrosinapic acid [40] | 0.19 ± 0.00 | 0.37 ± 0.00 | 0.51 ± 0.02 |
| 7.14 | 753 | 205/190/164/149 | Disinapoylgentiobioside [43] | 3.46 ± 0.01 | 1.70 ± 0.01 | 2.02 ± 0.01 |
| 8.31 | 959 | 205/223/190/164 | Trisinapoylgentionbioside [43] | 0.85 ± 0.03 | 0.55 ± 0.01 | 0.60 ± 0.02 |
| | | | Total phenolic acids | 11.11 ± 0.04 b | 10.70 ± 0.06 a | 16.68 ± 0.11 c |
| 3.60 | 771 | 383/285/229/357 | Kaempferol-3-diglucoside-7-glucoside [43] | - | 0,27 ± 0.00 | - |
| 3.70 | 1125 | 609/771/801/285 | Quercetin-3-diglucoside-7-feruloyldiglucoside [43] | - | 0.30 ± 0.01 | - |
| 3.70 | 1111 | 625/787/949/300 | Quercetin-3-diglucoside-7-triglucoside [38] | - | - | 0.56 ± 0.00 |
| 3.75 | 949 | 462/625/300/787 | Quercetin-3-triglucoside-7-glucoside [38] | - | - | 0.21 ± 0.00 |
| 3.80 | 1125 | 609/771/801/285 | Kaempferol-3-hydroxyferuloyldiglucoside-7-glucoside [43] | - | - | 0.49 ± 0.00 |
| 3.75 | 1095 | 609/771 | Kaempferol-3-triglucoside-7-diglucoside [38] | - | 0.33 ± 0.00 | - |
| 3.86 | 963 | 609/284/191/446 | Kaempferol-3-hydroxyferuloyldiglucoside-7-glucoside [43] | - | - | 0.62 ± 0.01 |
| 4.09 | 1109 | 391/728/537/337/285 | Kaempferol-3-feruloyldiglucoside-7-glucoside [43] | 0.06 ± 0.01 | 0.24 ± 0.00 | 0.24 ± 0.00 |
| 4.13 | 977 | 285/609/446/255 | Kaempferol-3-sinapoyldiglucoside-7-glucoside [38] | - | - | 0.49 ± 0.01 |
| 4.17 | 477 | (190/175/147) | Isorhamnetin-glucoside [39] | 0.20 ± 0.00 | 0.25 ± 0.03 | 0.35 ± 0.03 |
| | | | Total flavonols | 0.26 ± 0.02 a | 1.39 ± 0.03 b | 2.96 ± 0.01 c |
| 3.64 | 773+ | 287 | Cy-3-diglucoside-5-glucoside [40] | 0.36 ± 0.02 | 0.47 ± 0.01 | 0.74 ± 0.04 |
| 4.01 | 979+ | 287 | Cy-3-sinapoyldiglucoside-5-glucoside [40] | 0.15 ± 0.00 | 0.32 ± 0.00 | 0.36 ± 0.00 |
| 4.90 | 979+ | 287 | Cy-3-sinapoyldiglucoside-5-glucoside [40] | 0.04 ± 0.00 | 0.12 ± 0.00 | 0.07 ± 0.00 |
| 5.81 | 979+ | 287 | Cy-3-sinapoyldiglucoside-5-glucoside [40] | - | 1.56 ± 0.02 | 2.15 ± 0.00 |
| 6.20 | 1347+ | 287 | Cy-3-disinapoyltriglucoside-5-glucoside [40] | - | 0.06 ± 0.00 | 0.07 ± 0.00 |
| 6.32 | 1081+ | 287 | Cy-3-p-coumaroyldiglucoside-5-glucoside [40] | - | 0.07 ± 0.00 | 0.10 ± 0.00 |
| 6.38 | 1125+ | 287 | Cy-3-sinapoyl-feruloyldiglucoside-5-glucoside [43] | 0.31 ± 0.00 | 0.64 ± 0.00 | 0.66 ± 0.01 |
| 6.50 | 1155+ | 287/993 | Cy-3-sinapoyl-feruloyldiglucoside-5-glucoside [38] | 0.24 ± 0.01 | 0.78 ± 0.01 | 0.64 ± 0.01 |
| 6.57 | 1185+ | 287/449/1023 | Cy-3-disinapoyldiglucoside-5-glucoside [38] | 0.78 ± 0.01 | 1.08 ± 0.01 | 0.72 ± 0.01 |
| 6.68 | 1125+ | 287 | Cy-3-sinapoyl-feruloyldiglucoside-5-glucoside [43] | - | 0.22 ± 0.00 | 0.25 ± 0.00 |
| 6.74 | 1155+ | 287 | Cy-3-disinapoyldiglucoside-5-glucoside [43] | - | 0.18 ± 0.00 | 0.15 ± 0.01 |
| | | | Total anthocyanins | 1.88 ± 0.02 a | 5.50 ± 0.05 b | 5.91 ± 0.01 c |
| | | | Sum of phenolic compounds | 13.25 ± 0.07 a | 17.59 ± 0.11 b | 25.55 ± 0.09 c |

Values are expressed as mean ± SD ($n$ = 3); "-"—not detected; Cy—cyanidin; Kaempferol derivatives were expressed as kaempferol 3-glucoside equivalents. Quercetin derivatives were expressed as quercetin 3-glucoside equivalents; isorhamnetin derivatives were expressed as isorhamnetin 3-glucoside equivalents; cyanidin derivatives were expressed as cyanidin 3-glucoside equivalents. Values with different letters in each row represent significant differences at $p < 0.05$ between the light treatments, separately for each cultivar; the numbers next to the names of the compounds correspond to the reference number.

To address the incomplete and tentative identification of phenolic compounds as well as the lack of standards and expression of their content in equivalents of selected compounds, spectrophotometric methods were used to supplement the results presented in Tables 4 and 5. Therefore, the total phenolics were also determined by the colorimetric method with the Folin–Ciocalteu reagent and expressed as gallic acid equivalents (Table 6). Moreover, the content of total anthocyanins was estimated by pH-differential methods and expressed as cyanidin-3-glucoside equivalents. Both methods have been used in *Brassica oleracea* microgreens research [30,44–47].

**Table 6.** Content of the total phenolics and anthocyanins (mg 100 $g^{-1}$ DW) of white and red cabbage microgreens under different LED light treatments.

| Microgreens | Light Treatments | Total Phenolics | Anthocyanins |
|---|---|---|---|
| White cabbage | White | 3480 ± 62 a | 8.51 ± 0.15 a |
| | White + red | 3986 ± 65 b | 19.35 ± 0.14 b |
| | White + blue | 6944 ± 27 c | 39.09 ± 0.41 c |
| Red cabbage | White | 6091 ± 51 a | 326 ± 3 a |
| | White + red | 6723 ± 72 b | 565 ± 16 b |
| | White + blue | 8771 ± 67 c | 547 ± 10 b |

Values are expressed as mean ± SD ($n$ = 3); different letters in the column denote a statistical difference at $p < 0.05$.

The results presented in Table 6 proved that the addition of red or blue light to white light significantly increased the content of both total phenolics and anthocyanins, except for anthocyanins in red cabbage microgreens. The accumulation of phenolic compounds in microgreens was particularly favored by the addition of blue light, causing a 2.0–4.6-fold and 1.4–1.7-fold increase in the content of phenolic compounds and anthocyanins, respectively. Furthermore, greater content increases were found in the case of white cabbage microgreens. Total phenolic compounds and anthocyanin levels were higher in red cabbage microgreens.

The content of total phenols and anthocyanins in red cabbage microgreens in our study exceeded the content determined in 10-day-old microgreens grown using soilless culture and white fluorescent light [30]. For comparison, these microgreens contained 2106 mg of phenolics and 4.62 mg of anthocyanins per 100 g DW. Similar observations in different *Brassica* vegetables that blue light has a pronounced effect on flavonoids and phenolic acid synthesis have been made by others [46,48]. Light is necessary for the biosynthesis of anthocyanins, which of course depends on the quality and intensity of the lighting. Short-wavelength light, such as blue light and UV light, might be more effective at increasing anthocyanin content [12]. The total anthocyanin concentration was enhanced by 75% in red cabbage microgreens in response to an increased proportion of blue light (from 5 to 30%) supplied from LED arrays during cultivation in a controlled environment [19]. Contrary to this, Ying et al. showed that the content of total phenolics in red cabbage microgreens has not been impacted by varying the blue light percentage [19]. The combination of red and blue LEDs increased the concentration of total phenolic content and anthocyanin content in amaranth microgreens as compared to sole red and sole blue treatments [49].

### *3.4. Effect of LED Light Treatments on Antioxidant Potential of Cabbage Microgreens*

Antioxidant properties of white, green, and red cabbage result from the presence of bioactive components in the plant, such as phenolic compounds, vitamin C, carotenoids, and chlorophylls. As reported by several authors, red cabbage is superior to white cabbage in terms of antioxidant content and consequently also has a higher antioxidant potential [29,50–53]. The antioxidant potential of white and red cabbage microgreens cultivated under different LED light treatments was estimated by four different methods. These include the scavenging potential of stable, synthetic $ABTS^{\cdot+}$ radical cation (ABTS) and toward synthetic $DPPH^{\cdot}$ radical (DPPH), as well as the potential toward peroxyl radical (ORAC) and the potential to reduce ferric ion to ferrous ion (FRAP). Trolox, a water-

soluble analog of vitamin E, was used as an antioxidant standard to determine the Trolox Equivalent (TE). The results for the antioxidant potential of microgreens are presented in Table 7.

**Table 7.** Antioxidant potential (μM TE* $g^{-1}$ DW) of white and red cabbage microgreens grown under different LED light treatments.

| Microgreens | Antioxidant Potential Assay | Light Treatments | | |
|---|---|---|---|---|
| | | White | White + Red | White + Blue |
| White cabbage | ABTS | 25.47 ± 0.59 a | 27.57 ± 0.55 a | 47.72 ± 1.03 b |
| | DPPH | 28.64 ± 0.36 a | 27.82 ± 0.47 a | 44.19 ± 0.21 b |
| | ORAC | 191.23 ± 4.36 a | 192.69 ± 0.40 a | 293.12 ± 12.52 b |
| | FRAP | 33.20 ± 0.58 a | 43.84 ± 0.38 b | 80.67 ± 2.14 c |
| Red cabbage | ABTS | 43.56 ± 1.20 a | 77.10 ± 0.89 b | 100.12 ± 1.38 c |
| | DPPH | 39.75 ± 0.56 a | 55.87 ± 1.11 b | 67.96 ± 1.55 c |
| | ORAC | 280.44 ± 4.73 a | 406.19 ± 3.19 b | 457.28 ± 20.04 c |
| | FRAP | 74.45 ± 1.01 a | 100.01 ± 2.91 b | 122.56 ± 2.12 c |

*—Trolox equivalent. Values are expressed as mean ± SD ($n$ = 3); different letters in the row denote a statistical difference at $p < 0.05$.

Significant differences ($p < 0.05$) were found in the antioxidant capacity among the light treatments of red cabbage microgreens. In the case of white cabbage microgreens, the TE values did not differ statistically significantly between the use of white light without and with the addition of red light. Generally, the antioxidant potential of both cabbage microgreens was in the following decreasing order: white with blue light > white with red light > white light, regardless of the method used. The TE values clearly reflect that white light supplemented with blue light showed the greatest influence on the antioxidant potential. The addition of blue light to white light caused an almost 2-fold increase in the antioxidant potential determined by the FRAP method for white cabbage microgreens and by the ABTS method for red cabbage microgreens. In the remaining methods, supplementation of white light with blue light resulted in an increase in TE values of 53.3–87.3% and 63.0–71.0% for white and red cabbage microgreens, respectively (Table 7). Similar to the results of Kapusta-Duch and Kusznierewicz, red cabbage microgreens showed higher radical scavenging activity in comparison to white cabbage microgreens [54].

### *3.5. Effect of LED Light Treatments on Phytosterols*

Phytosterols are known to decrease plasma cholesterol, mainly atherogenic low-density lipoprotein cholesterol. Campesterol and β-sitosterol were the main phytosterols in mature white and red cabbage [53,55]. The results of phytosterols from white and red cabbage microgreens grown under three LED lights are presented in Table 8.

**Table 8.** Content of β-sitosterol and campesterol (μg 100 $g^{-1}$ DW) of white and red cabbage microgreens under different LED light treatments.

| Microgreens | Light Treatments | β-Sitosterol | Campesterol |
|---|---|---|---|
| White cabbage | White | 343 ± 17 b | 0 |
| | White + red | 493 ± 21 c | 298 ± 8 |
| | White + blue | 123 ± 8 a | 0 |
| Red cabbage | White | 169 ± 7 a | 0 |
| | White + red | 448 ± 41 b | 244 ± 12 |
| | White + blue | 203 ± 12 a | 0 |

Values are expressed as mean ± SD ($n$ = 3); different letters in the column denote a statistical difference at $p < 0.05$.

β-Sitosterol was present in all analyzed microgreens, and campesterol was identified only in both types of microgreens growing under white light with the addition of red light. Moreover, microgreens growing under this light treatment were characterized by the highest content of β-sitosterol. White light supplementation with blue light resulted in a 2.8-fold decrease in β-sitosterol content in white cabbage microgreens and an increase in its level by 20% in red cabbage microgreens. Likewise, mature white and red cabbage contained much more β-sitosterol than campesterol [53]. To the best of our knowledge, there are no previous studies on the phytosterol composition of white and red cabbage microgreens.

## 4. Conclusions

The level of both primary and secondary metabolites in white and red cabbage microgreens can be modified by the lighting conditions used during plant growth. Our findings revealed that microgreens under white and blue light treatments had the highest sugars, phenolic acids, flavonols, and anthocyanins. These microgreens also demonstrated the highest antioxidant potential. On the other hand, cabbage microgreens growing under white light with red light were characterized by the highest levels of phytosterols and fiber, including its insoluble fraction. However, supplementation of white light with red or blue light negatively affected the content of protein, fat, and photosynthetic pigments such as carotenoids and chlorophyll *a* and *b*. The composition of phenolic compounds was found to be influenced by the type of lighting used, with microgreens grown under white light with red or blue light showing a more similar composition than those grown under white light alone. In summary, the use of a combination of LED white light with blue or red light can be a useful tool to produce white and red cabbage microgreens with targeted improvement in phytonutrient content. Based on the research conducted, it can be concluded that the proportion of 15% blue and red light is too low to significantly increase the content of active substances in both red and white cabbage seedlings. A share of approximately 30% of the red or blue color in the spectrum resulted in a clear increase in the nutritional value of microgreens. However, the increase in phenolics, antioxidants, soluble and insoluble dietary fiber, as well as antioxidant potential content, was at the expense of a lower content of carotenoids and chlorophylls. Therefore, it can be concluded that to obtain microgreens with high nutritional value, it is important to provide not only high levels of red light but also blue light in the spectrum.

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