

Proceeding Paper

# Stability of *Cotinus coggygia* Scop. Extract-Loaded Liposomes: The Impact of Storage on Physical and Antioxidant Properties <sup>†</sup>

Aleksandra A. Jovanović <sup>1,\*</sup>, Amjed Karkad <sup>2,3</sup>, Andrea Pirković <sup>1</sup>, Dragana Dekanski <sup>1</sup>, Diana Lupulović <sup>1</sup>, Miroslav Novaković <sup>4</sup> and Aleksandar Marinković <sup>2</sup>

<sup>1</sup> Institute for the Application of Nuclear Energy INEP, University of Belgrade, Banatska 31b, 11080 Belgrade, Serbia; andrea.pirkovic@inep.co.rs (A.P.); dragana.dekanski@inep.co.rs (D.D.); diana.lupulovic@inep.co.rs (D.L.)

<sup>2</sup> Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, 11000 Belgrade, Serbia; 20214044@estudent.tmf.bg.ac.rs (A.K.); marinko@tmf.bg.ac.rs (A.M.)

<sup>3</sup> Faculty of Medical Technology, Elmergib University, Msallata 7310500, Libya

<sup>4</sup> Institute of Chemistry, Technology and Metallurgy, National Institute of the Republic of Serbia, University of Belgrade, Njegoševa 12, 11000 Belgrade, Serbia; mironov@chem.bg.ac.rs

\* Correspondence: ajovanovic@inep.co.rs

<sup>†</sup> Presented at the 2nd International Electronic Conference on Antioxidants—IECAN 2025, Virtually, 7–9 April 2025.

**Abstract:** The stability of *Cotinus coggygia* extract-loaded liposomes (non-treated and UV-irradiated) was determined after 60 days through an investigation of the impact of storage on liposomal physical and antioxidant properties. The liposome size varied in a narrow range for 60 days; PDI was 0.273–0.313 (non-treated) and 0.829–0.911 (UV-irradiated). The zeta potential ranged from –28.2 to –29.6 mV (non-treated) and from –21.5 to –22.0 mV (UV-irradiated). The obtained liposomes with the extract neutralized 81.9% of free DPPH radicals before UV irradiation and 80.9% after irradiation. In the ABTS assay, UV irradiation also significantly reduced the antioxidant capacity, from 12.02 to 10.55 μmol Trolox equivalent (TE)/mL. The ABTS and DPPH radical scavenging activity of the UV-irradiated liposomes significantly decreased after the 60-day storage (8.93 μmol TE/mL and 75.4%, respectively), whereas in the non-treated sample, the mentioned drop in antioxidant capacity was not noticed. Liposomal formulations of *C. coggygia* extract can exhibit significant potential for further development as a functional food or dermo-cosmetic ingredient.

**Keywords:** liposomes; storage stability; antioxidant capacity; *Cotinus coggygia*; extract



Academic Editor: Ren-You Gan

Published: 28 May 2025

**Citation:** Jovanović, A.A.; Karkad, A.; Pirković, A.; Dekanski, D.; Lupulović, D.; Novaković, M.; Marinković, A. Stability of *Cotinus coggygia* Scop. Extract-Loaded Liposomes: The Impact of Storage on Physical and Antioxidant Properties. *Proceedings* **2025**, *119*, 4. <https://doi.org/10.3390/proceedings2025119004>

**Copyright:** © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

Smoke tree (*Cotinus coggygia* Scop., Anacardiaceae family) is an important source of essential oil and extracts, with a wide range of health-promoting effects, such as antioxidant, antibacterial, antigenotoxic, antimicrobial, hepatoprotective, and anti-inflammatory potential [1–3]. According to Matić et al. [2], ethanol extract formulations of the wooden parts of smoke tree were used to cure diarrhea and stomach ulcers, while the extract was employed as a cholagogue, an antipyretic, and in the treatment of cancer and eye diseases as well. *C. coggygia* extracts induced apoptosis in HeLa cells and inhibited their migration in vitro, and they showed protective potential on normal human fibroblasts [4]. The antioxidant activity of plant products is of great interest due to their ability to preserve food, pharmaceutical, and cosmetic formulations from the toxic and degrading influence of oxidants or free radicals [5].

The encapsulation of various plant extracts within delivery systems can provide prolonged and controlled recovery and protection of their antioxidants [6,7]. Both lipophilic and hydrophilic active principles can be delivered via liposomes or nanoliposomes, which are widely used as encapsulating carriers. Hydrophilic compounds in the hydration medium and lipophilic compounds in lipids can be entrapped by liposomes due to the orientation of the polar lipid parts in water [8–10]. Liposomes represent spherical shell structures with a liquid core surrounded by a phospholipid bilayer [7–9]. When phospholipids are placed in water, they associate with one another and create a bilayer sheet arrangement, which protects their hydrophobic sections from water molecules while allowing the hydrophilic head groups to remain in contact with the aqueous phase [8,10]. Protein compounds, aromas, vitamins, drugs, and antioxidant agents have been delivered using liposomal carriers in various branches of industry applications [9–11]. The stability that liposomal systems deliver in products containing a high-water content is their primary benefit over alternative encapsulation technologies [9].

In the current research, the stability of *C. coggygia* extract-loaded liposomes (non-treated and UV-irradiated) was determined after 60 days through an investigation of the impact of storage on liposomal physical and antioxidant properties. Vesicle size, polydispersity index (PDI), and zeta potential were determined using photon correlation spectroscopy in the 60-day storage study at 4 °C.

## 2. Materials and Methods

### 2.1. Chemicals

Wooden parts of the smoke tree (used in the extract preparation) were collected in Belgrade (Serbia, 44°47'34" N 20°26'19" E). Ethanol (96%), 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid), i.e., ABTS, 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid, i.e., Trolox, and 2,2-diphenyl-1-picrylhydrazyl, i.e., DPPH, were purchased from Sigma-Aldrich (Hamburg, Germany), and potassium persulfate was obtained from Centrohem (Stara Pazova, Serbia). Phospholipon (phospholipids used for the liposome preparation) was kindly provided by Lipoid (Ludwigshafen am Rhein, Germany).

### 2.2. Extract Preparation

The liquid smoke tree extract was obtained using intensively ground wooden parts of the plant (1 g) and 80% *v/v* ethyl alcohol (40 mL) and ultrasound-assisted extraction in a Sonorex Super RK ultrasonic bath (Bandelin, Berlin, Germany) for 30 min. After the extraction process, the sample was filtered using fine filter paper, and the extract was used for further liposome preparation.

### 2.3. Liposome Preparation and UV Irradiation

Smoke tree extract-loaded liposomes were prepared using the proliposome method [9]. Phospholipids (2 g) and ethanol smoke tree extract (20 mL) were stirred at 50 °C for 20 min. After ethanol evaporation and cooling to 25 °C, water was transferred, and the emulsion was stirred at 800 rpm for 1 h at ambient temperature.

An AC2-4G8 laminar flow cabinet (Esco Lifesciences, Singapore) was used for the UV irradiation experiment. Developed liposomes (3 mL) in uncovered Petri dishes were exposed to UV-C irradiation (253.7 nm) at ambient temperature for 20 min.

Developed liposomes (non-treated and UV-irradiated) were stored in a refrigerator (4 °C) during the 60-day study.

#### 2.4. Photon Correlation Spectroscopy

The developed smoke tree extract-loaded liposomes' diameter, size distribution (expressed as PDI), and zeta potential were measured before and after UV irradiation. The device used was a Zetasizer Nano Series, Malvern Instruments (Malvern, UK). Samples were diluted 500 times and measured in triplicate at ambient temperature during the 60-day study.

#### 2.5. Determination of the Liposome Antiradical Capacity

The anti-ABTS and anti-DPPH radical activities of the smoke tree extract-loaded liposomes (non-treated and UV-irradiated) were tested by employing spectrophotometric methods. The absorbance was measured using a UV1800 Shimadzu UV spectrophotometer (Kyoto, Japan). The testing of the antioxidant potential of the developed liposomes with smoke tree extract was carried out on the 1st and 60th days.

In the ABTS assay [12], the ABTS<sup>•+</sup> working solution was diluted using ethanol (an absorbance of ~0.700 at 734 nm). ABTS<sup>•+</sup> solution (2 mL) was mixed with liposomes containing smoke tree extract (20 µL, non-treated or UV-irradiated). After 6 min of incubation, the absorbance was measured, and the radical scavenging activity of the liposomes was calculated using the following equation:

$$\Delta A = A_{0\text{ABTS}} - A_x \quad (1)$$

where  $A_{0\text{ABTS}}$  is the absorbance of the control, and  $A_x$  is the absorbance of the ABTS<sup>•+</sup> solution and liposomes. Trolox was used as a standard for the calibration curve. The data are shown as µmol Trolox equivalent (TE)/mL.

In the DPPH assay [13], liposomes containing smoke tree extract (20 µL, non-treated or UV-irradiated) were mixed with 2 mL of ethanol DPPH<sup>•</sup> radical solution (an absorbance of ~0.800 at 517 nm). The absorbance was recorded after 20 min of incubation, and the percentage of inhibition was calculated using the following equation:

$$\% \text{ inhibition} = (A_{0\text{DPPH}} - A_x) \times 100 / A_{0\text{DPPH}} \quad (2)$$

where  $A_{0\text{DPPH}}$  is the absorbance of the control, and  $A_x$  is the absorbance of the DPPH<sup>•</sup> solution and liposomes. The data are shown as a percentage of the DPPH radical neutralization.

#### 2.6. Statistical Analysis

The statistical data processing was carried out by one-way ANOVA and Duncan's post hoc test (STATISTICA 7.0). The differences were considered statistically significant at  $p < 0.05$ , and measurements were performed in triplicate.

### 3. Results and Discussion

The particle size, PDI, zeta potential, and antioxidant activity of smoke tree extract-loaded liposomal vesicles were examined using photon correlation spectroscopy and two antioxidant assays (ABTS and DPPH methods), respectively. The measurements were performed on the 1st and 60th days of storage. The data are shown in Table 1 (physical characteristics) and Table 2 (antioxidant potential) as mean values ± standard deviations, while different letters and numbers in superscript show the presence of statistically significant differences.

As can be seen from Table 1, during storage at 4 °C, the liposome size varied in a narrow range, from 3131.0 ± 17.0 nm to 3078.0 ± 42.0 nm (for the non-treated liposomal sample with smoke tree extract) and from 2092.0 ± 22.0 nm to 2136.0 ± 37.0 nm (for the UV-irradiated liposomal samples with smoke tree extract). PDI values were between

0.273 ± 0.089 (1st day) and 0.313 ± 0.051 (60th day) (for the non-treated liposome system) and 0.829 ± 0.074 (1st day) and 0.911 ± 0.078 (60th day) (for the UV-irradiated liposome system). It can also be noted that there was a significant difference in size and PDI between the non-treated and UV-irradiated samples. Namely, the UV-irradiated liposomal system with smoke tree extract showed a significantly lower diameter of liposome vesicles and a higher PDI value (Table 1). The presence of giant liposomes in both cases (non-treated and UV-irradiated smoke tree extract-loaded liposomes) was expected due to the occurrence of the hydration step of the proliposome protocol used in the development of these liposomes, where the phospholipids swell and become hydrated, resulting in swelling and hydration of the phospholipid components and causing the formation of highly diverse and large multilamellar lipid particles [14]. The significantly higher PDI of the UV-irradiated liposomes with smoke tree extract in comparison to the non-treated parallel can be explained by their significantly lower diameter, since smaller lipid particles possess a higher PDI than giant vesicles [15].

**Table 1.** Particle size, polydispersity index (PDI), and zeta potential of phospholipid liposomes with encapsulated smoke tree extract, before and after UV irradiation, measured on the 1st and 60th days of storage at 4 °C.

Samples	Particle Size (nm) <sup>1</sup>		PDI		Zeta Potential (mV)	
	1st Day	60th Day	1st Day	60th Day	1st Day	60th Day
Non-treated liposomes	3131.0 ± 17.0 <sup>a,1</sup>	3078.0 ± 42.0 <sup>a,1</sup>	0.273 ± 0.089 <sup>a,2</sup>	0.313 ± 0.051 <sup>a,2</sup>	−28.2 ± 0.7 <sup>a,1</sup>	−29.6 ± 0.9 <sup>a,1</sup>
UV-irradiated liposomes	2092.0 ± 22.0 <sup>a,2</sup>	2136.0 ± 37.0 <sup>a,2</sup>	0.829 ± 0.074 <sup>a,1</sup>	0.911 ± 0.078 <sup>a,1</sup>	−21.5 ± 0.8 <sup>a,2</sup>	−22.0 ± 1.1 <sup>a,2</sup>

<sup>1</sup> Values with the same letter (a and b) in each row and the same number (1 and 2) in each column in the superscript showed no statistically significant difference ( $p > 0.05$ ;  $n = 3$ ; analysis of variance, Duncan's post hoc test).

**Table 2.** Antioxidant capacity of phospholipid liposomes with encapsulated smoke tree extract, before and after UV irradiation, measured on the 1st and 60th days of storage at 4 °C.

Samples	ABTS Assay (µmol TE/mL)		DPPH Assay (% of Radical Neutralization)	
	1st Day	60th Day	1st Day	60th Day
Non-treated liposomes	12.02 ± 0.54 <sup>a,1</sup>	11.30 ± 0.32 <sup>a,1</sup>	81.9 ± 0.4 <sup>a,1</sup>	82.1 ± 1.0 <sup>a,1</sup>
UV-irradiated liposomes	10.55 ± 0.28 <sup>a,2</sup>	8.93 ± 0.45 <sup>b,2</sup>	80.9 ± 0.4 <sup>a,2</sup>	75.4 ± 0.7 <sup>b,2</sup>

ABTS, 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid); TE, Trolox equivalent; DPPH, 2,2-diphenyl-1-picrylhydrazyl; values with the same letter (a and b) in each row and the same number (1 and 2) in each column in the superscript showed no statistically significant difference ( $p > 0.05$ ;  $n = 3$ ; analysis of variance, Duncan's post hoc test).

The zeta potential was  $-28.2 \pm 0.7$  mV on the 1st day and  $-29.6 \pm 0.9$  mV on the 60th day for the non-treated sample, while for the UV-irradiated liposomes, the zeta potential was  $-21.5 \pm 0.8$  mV on the 1st day and  $-22.0 \pm 1.1$  mV on the 60th day (Table 1). Therefore, the zeta potential of the developed liposomes with the smoke tree extract did not change during storage in the refrigerator. Additionally, UV light exposure caused a significant decrease in the absolute value of the zeta potential of the extract-loaded liposomes compared to the non-treated parallel (Table 1). Changes in the zeta potential values after UV irradiation were expected according to the literature data, where the change in liposomes after UV exposure includes, among others, a decrease in zeta potential (absolute value), as well as the occurrence of an aggregation process [16].

In the case of the ABTS assay, UV irradiation also significantly reduced the antioxidant capacity of the liposomes with extract, from  $12.02 \pm 0.54$  µmol TE/mL to

$10.55 \pm 0.28 \mu\text{mol TE/mL}$  (Table 2). The obtained liposomes with smoke tree extract neutralized  $81.9 \pm 0.4\%$  of free DPPH radicals before UV irradiation and  $80.9 \pm 0.4\%$  after irradiation (Table 2). Furthermore, the ABTS and DPPH radical scavenging activities of the UV-irradiated liposomes significantly decreased after the 60-day storage ( $8.93 \pm 0.45 \mu\text{mol TE/mL}$  and  $75.4 \pm 0.7\%$ , respectively), whereas in the non-treated sample, the mentioned drop in the antioxidant capacity was not noticed ( $11.30 \pm 0.32 \mu\text{mol TE/mL}$  and  $75.4 \pm 0.7\%$ , respectively) (Table 2).

Regarding the influence of UV light exposure on the antioxidant potential of the liposomes with smoke tree extract, the decreased radical neutralization capacity of the UV-irradiated liposomal population can be explained by reactive oxygen species damage of the phospholipid bilayer upon irradiation [17]. The application of liposomal formulations in the food, cosmetic, and pharmaceutical industries, particularly in products such as wound and burn dressings, requires effective sterilization methods that preserve the integrity of the liposomal carriers. However, sterilization remains a significant challenge due to the inherent physicochemical sensitivity of liposomes, which are prone to degradation under conventional sterilization conditions [18]. Ultraviolet (UV) irradiation has emerged as a promising alternative, offering a rapid and efficient method for microbial inactivation without the use of harmful chemicals or the formation of carcinogenic by-products. This technique has demonstrated broad-spectrum antimicrobial activity, making it a viable candidate for the sterilization of liposomal systems while minimizing adverse effects on their structural and functional properties [19]. Furthermore, the impact of UV light irradiation on the stability and functionality of ingredients commonly used in pharmaceutical and cosmetic skin formulations—such as liposomes—warrants thorough investigation, particularly as a means of simulating the effects of sunlight exposure [20]. Thus, it was important to investigate the influence of UV irradiation on the liposomal characteristics, including antioxidant potential.

#### 4. Conclusions

In this research, the changes in the physical characteristics and antioxidant potential of smoke tree extract-loaded liposomes (non-treated and UV-irradiated) were determined before and after 60 days of storage. Size, PDI, and zeta potential did not change in both types of liposomes, while UV light exposure significantly affected the mentioned variables. On the other hand, UV irradiation significantly reduced the antioxidant capacity of the developed liposomes with smoke tree extract, which continued to decrease up to the 60th day of storage. Future work will include *in vitro* testing of antimicrobial and anti-inflammatory properties, *in vivo* testing on animal models, as well as the development of film carriers with incorporated extract-loaded liposomes and their characterization.

**Author Contributions:** Conceptualization, A.A.J., D.D. and M.N.; methodology, A.A.J. and A.K.; formal analysis, A.P.; investigation, D.D. and A.P.; resources, M.N.; data curation, A.A.J.; writing—original draft preparation, A.A.J.; writing—review and editing, D.D., D.L. and A.M.; visualization, D.L.; supervision, A.M.; funding acquisition, D.D. and A.M. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by the Ministry of Science, Technology Development, and Innovation of the Republic of Serbia, contract numbers 451-03-136/2025-03/200019, 451-03-136/2025-03/200026, and 451-03-66/2025-03/200135.

**Data Availability Statement:** The datasets generated during and/or analysed during the current study are available from the corresponding author upon reasonable request.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## Abbreviations

The following abbreviations are used in this manuscript:

ABTS	2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)
DPPH	2,2-diphenyl-1-picrylhydrazyl
PDI	Polydispersity index
TE	Trolox equivalent

## References

1. Teixeira Da Silva, J.A.; Pacholczak, A.; Ilczuk, A. Smoke tree (*Cotinus coggygria* Scop.) propagation and biotechnology: A mini-review. *S. Afr. J. Bot.* **2018**, *114*, 232–240. [[CrossRef](#)]
2. Matić, S.; Stanić, S.; Mihailović, M.; Bogojević, D. *Cotinus coggygria* Scop.: An overview of its chemical constituents, pharmacological and toxicological potential. *Saudi J. Biol. Sci.* **2016**, *23*, 452–461. [[CrossRef](#)] [[PubMed](#)]
3. Stojković, D.; Dragičević, N.; Ivanov, M.; Gajović, N.; Jurišević, M.; Jovanović, I.; Tomović, M.; Živković, J. New Evidence for *Cotinus coggygria* Scop. Extracts Application in Gastrointestinal Ailments. *Pharmaceuticals* **2025**, *18*, 98. [[CrossRef](#)] [[PubMed](#)]
4. Pašić, I.; Novaković, M.; Tešević, V.; Milosavljević, S.; Petrović, N.; Stanojković, T.; Matić, I.Z. Exploring the anticancer potential of extracts and compounds from the heartwood of *Cotinus coggygria* Scop. wild growing in Serbia. *BMC Complement. Med. Ther.* **2025**, *25*, 36. [[CrossRef](#)] [[PubMed](#)]
5. Jovanović, A.; Đorđević, V.; Zdunić, G.; Pljevljakušić, D.; Šavikin, K.; Gođevac, D.; Bugarski, B. Optimization of the extraction process of polyphenols from *Thymus serpyllum* L. herb using maceration, heat- and ultrasound-assisted techniques. *Sep. Pur. Techn.* **2017**, *179*, 369–380. [[CrossRef](#)]
6. Panthi, K.P.; Gyawali, A.; Pandeya, S.; Sharma Bhusal, M.L.; Neupane, B.B.; Tiwari, A.P.; Joshi, M.K. The encapsulation of bioactive plant extracts into the cellulose microfiber isolated from *G. optiva* species for biomedical applications. *Membranes* **2022**, *12*, 1089. [[CrossRef](#)]
7. Munin, A.; Edwards-Lévy, F. Encapsulation of natural polyphenolic compounds; a review. *Pharmaceutics* **2011**, *3*, 793–829. [[CrossRef](#)] [[PubMed](#)]
8. Emami, S.; Azadmard-Damirchi, S.; Peighamardoust, S.H.; Valizadeh, S.; Hesari, J. Liposomes as carrier vehicles for functional compounds in food sector. *J. Exp. Nanosci.* **2016**, *11*, 737–759. [[CrossRef](#)]
9. Isailović, B.; Kostić, I.; Zvonar, A.; Đorđević, V.; Gašperlin, M.; Nedović, V.; Bugarski, B. Resveratrol loaded liposomes produced by different techniques. *Innov. Food Sci. Emerg. Technol.* **2013**, *19*, 181–189. [[CrossRef](#)]
10. Mozafari, M.R.; Johnson, C.; Hatziantoniou, S.; Demetzos, C. Nanoliposomes and their applications in food nanotechnology. *J. Liposome Res.* **2008**, *18*, 309–327. [[CrossRef](#)] [[PubMed](#)]
11. McGarry, S.V.; Cruickshank, D.; Iloba, I.; Jensen, G.S. Enhanced Bioavailability and Immune Benefits of Liposome-Encapsulated Vitamin C: A Combination of the Effects of Ascorbic Acid and Phospholipid Membranes. *Nutraceuticals* **2024**, *4*, 626–642. [[CrossRef](#)]
12. Li, L.; Yang, Y.; Hou, X.; Gu, D.; Ba, H.; Abdulla, R.; Wu, G.; Xin, X.; Aisa, H.A. Bioassay-guided separation and purification of water-soluble antioxidants from *Carthamus tinctorius* L. by combination of chromatographic techniques. *Sep. Purif. Technol.* **2013**, *104*, 200–207. [[CrossRef](#)]
13. Xi, J.; Yan, L. Optimization of pressure-enhanced solid-liquid extraction of flavonoids from *Flos Sophorae* and evaluation of their antioxidant activity. *Sep. Purif. Technol.* **2017**, *175*, 170–176. [[CrossRef](#)]
14. Lombardo, D.; Kiselev, M.A. Methods of liposomes preparation: Formation and control factors of versatile nanocarriers for biomedical and nanomedicine application. *Pharmaceutics* **2022**, *14*, 543. [[CrossRef](#)] [[PubMed](#)]
15. Jovanović, A.; Balanč, B.; Ota, A.; Ahlin Grabnar, P.; Djordjević, V.; Šavikin, K.; Bugarski, B.; Nedović, V.; Poklar-Ulrih, N. Comparative effects of cholesterol and  $\beta$ -sitosterol on the liposome membrane characteristics. *Eur. J. Lipid Sci. Technol.* **2018**, *120*, 1800039. [[CrossRef](#)]
16. Freitas, C.; Müller, R.H. Effect of light and temperature on zeta potential and physical stability in solid lipid nanoparticle (SLN<sup>TM</sup>) dispersions. *Int. J. Pharm.* **1998**, *168*, 221–229. [[CrossRef](#)]
17. Dave, N.; Liu, J. Protection and promotion of UV radiation-induced liposome leakage via DNA-directed assembly with gold nanoparticles. *Adv. Mater.* **2011**, *23*, 3182–3186. [[CrossRef](#)] [[PubMed](#)]
18. Delma, K.L.; Lechanteur, A.; Evrard, B.; Semd , R.; Piel, G. Sterilization methods of liposomes: Drawbacks of conventional methods and perspectives. *Int. J. Pharm.* **2021**, *597*, 120271. [[CrossRef](#)] [[PubMed](#)]

19. Meunier, S.M.; Sasges, M.R.; Aucoin, M.G. Evaluating ultraviolet sensitivity of adventitious agents in biopharmaceutical manufacturing. *J. Ind. Microbiol. Biotechnol.* **2017**, *44*, 893–909. [[CrossRef](#)] [[PubMed](#)]
20. Lee, Y.H.; Lin, Y.C.; Feng, C.H.; Tseng, W.-L.; Lu, C.-Y. A derivatization-enhanced detection strategy in mass spectrometry: Analysis of 4-hydroxybenzoates and their metabolites after keratinocytes are exposed to UV radiation. *Sci. Rep.* **2017**, *7*, 39907. [[CrossRef](#)] [[PubMed](#)]

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.