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Research Article

Optimizing herbal washing for green extraction: a natural solution to microbial control in the pharmaceuticals industry

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ABSTRACT

The increasing global demand for herbal medicinal products necessitates stringent quality control measures especially for herbal water extraction, particularly concerning microbial contamination. This study aimed to determine an optimal washing procedure for Strobilanthes crispus (Kejibeling) and Sonchus arvensis (Tempuyung) leaves, assessing the impact of multiple purified water rinses and a 0.1% chlorine solution wash on microbial reduction (total aerobic bacteria and total yeast and mold counts), sensory attributes (clarity, taste, aroma), and luteolin-7-o-glycoside content of the subsequent decoction extracts. Fresh leaves were subjected to varying washing protocols, followed by boiling water extraction. Microbial counts were determined using plate count agar and Sabouraud dextrose agar. Sensory evaluation was conducted by a panel, and luteolin-7-o-glycoside content was quantified using UV-Vis spectrophotometry. The optimized washing procedure, comprising three water washes followed by a 0.1% chlorine wash, significantly reduced total aerobic bacteria and total yeast and mold counts in both Kejibeling and Tempuyung leaf extracts compared to single or double water washes. Importantly, the subsequent boiling extraction effectively eliminated remaining microbial contamination to within acceptable European Pharmacopoeia limits. Sensory evaluation revealed no adverse effects on taste or aroma with the optimized washing, and clarity improved after filtration. Quantification of luteolin-7-o-glycoside indicated no substantial degradation due to the optimized washing. The successful scale-up of this protocol in a production setting demonstrated its feasibility for enhancing the microbial quality of herbal extracts, contributing to safer herbal medicinal products.

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1. Introduction

Rising global demand for natural products has driven interest in green extraction technologies that focus on sustainability, using less solvent and energy, renewable resources, and safe processes (Tashim et al., 2022). This increased demand spans various cultures and healthcare systems, with a significant portion of the population in developing countries relying on herbal remedies as their primary source of healthcare. While often perceived as natural and inherently safe, herbal products are susceptible to contamination from various sources, raising concerns about their quality and potential health risks (Opuni et al., 2023). Microbial contamination in drug medicines is a critical safety issue because it can pose various health risks to consumers (Kneifel et al., 2002). This risk becomes greater for vulnerable population such as elderly, who tend to consume herbal medicines more frequently and may have weakened immune systems (de Sousa Lima et al., 2020). Herbal raw materials, derived from various parts of plants, such as leaves, stems, flowers, seeds and roots are naturally vulnerable to contaminated by microbial from environment. Such contamination can occur at multiple stages, including harvesting, storage and processing (Kneifel et al., 2002).

WHO and European Pharmacopoeia have recommended acceptable limits for microbial contaminants in herbal medicines. These guidelines establish standards for the maximum level of total aerobic bacteria, total yeast and mold, and specific pathogenic microorganism in herbal product, aiming to ensure consumer safety (WHO., 2007). Common bacterial contaminants identified in herbal medicines include *Escherichia coli*, *Salmonella* species, *Staphylococcus aureus*, and *Pseudomonas aeruginosa* (de Sousa Lima et al., 2020). Fungal contaminants, such as yeasts and molds belonging to the genera *Aspergillus*, *Penicillium*, and *Candida*, are also frequently encountered (Opuni et al., 2023). Bacterial contamination was identified in 98% of the studies, with *Escherichia coli* being the most commonly reported species (62%). Fungal contamination appeared in 70% of the studies, where *Aspergillus* species were the most frequently detected (40%). Parasitic contamination was noted in only 2% of the reviewed studies (Ahiabor et al., 2024). Prior investigations have explored diverse methodologies for reducing microbial load in herbs, including simple washing with water or ethanol solutions (Kumar et al., 2013), exposure to steam, irradiation techniques, treatment with ozone (Mrozek-Szetela et al., 2020), and the application of chemical agents such as ethylene oxide. The use of chlorine solutions has been demonstrated to be effective in reducing microbial contamination on fresh produce (Hartline, n.d. 2025), with evidence suggesting that washing whole leaves prior to cutting enhances the efficacy of chlorine treatment (Nou & Luo, 2010). Furthermore, the practice of using boiling water in the preparation of herbal infusions is often recommended as a means to mitigate microbial risks (Kaume et al., 2012).

Washing of herbal raw materials constitutes a critical preliminary step in reducing impurities in surface and microbial load (Noor et al., 2013). However, the efficacy of washing can various depending of water quality, washing duration, mechanical action and the use of sanitizing agents. Cross-contaminations may occur during the washing if the water is not properly treated or regularly replaced (Osei-Asare et al., 2023). Although alternative decontamination method such as steam sterilization, irradiation and ozonation are available, washing remains a fundamental and often preferred initial step due to its simplicity and lower cost (Kneifel et al., 2002). Optimizing washing process has the potential to reduce reliance on more intensive decontamination method and potentially damaging in production process later (Agency, 2015).

This study focuses on *Strobilanthes crispus* (Kejibeling) and *Sonchus arvensis* (Tempuyung), two soil-based medicinal leaves traditionally used for their therapeutic properties (Isrianto, 2020). *Strobilanthes crispus,* commonly known as kejibeling leaves, traditionally used for various diseases, including kidney

stones, diabetic, hypertension and cancer. Its leaves contain various phytochemicals such as polyphenols, flavonoids (including luteolin), alkaloid, and terpenoid (Ghasemzadeh et al., 2015). *Sonchus arvensis*, or tempuyung leaves, is also traditionally used in Indonesia for urinary disorder, inflammation and hypertension. This plants contains a high concentration of flavonoid, including luteolin-7-o-glikosida, as well as mineral ions and phenolic acid (Parisa et al., 2023). The presence of luteolin-7-o-glikosida, specific flavonoid, makes it an appropriate marker compound for assessing the impact of washing process on the chemical integrity of the plant.

This study aims to determine optimal washing procedure for the leaves of *Strobilanthes crispus* and *Sonchus arvensis* by evaluating the effects of various washing method - including multiple rinse with purified water and washing with 0,1% Chlorine solution- on microbial reduction, as assessed by total aerobic bacteria and total yeast and mold counts. Additionally, the study will assess the impact of these washing methods on clarity, taste, aroma, and luteolin-7-o-glikosida content of the extract obtained through decoction green extraction. The research will be conducted at laboratory scale, followed by evaluation of the optimized in production scale before and after implementation.

2. Materials and Methods

Fresh leaves of *Strobilanthes crispus* and *Sonchus arvensis* were collected from a local farmer in west Java. Only mature, healthy leaves that were free from visible signs of pest infestation or environmental pollution were selected (Ariani et al., 2022). Sodium benzoat (merck), sucralose (brataco), methylparaben (merck), povidone (merck), flavour (karya aroma), and ethanol (merck) used as excipient in formula. Plate Count Agar (Himedia), Luteolin-7-O-Glucoside (sigma aldrich), paper filter (whatman), sodium hypochlorite (merck) used as evaluation materials.

2.1 Optimized Washing Procedure

The leaves were washed under gently running purified water in a washing tank to remove any loosely adhered surface dirt and debris. The optimized washing procedures are done by repeating the process 3 times. sodium hypochlorite solution is used in the final wash to remove any remaining microbes, then rinsed until it is odorless and checked for residue. The washed leaves were then centrifuged to reduce water before being subjected to the green extraction procedures. The dried leaves were stored airtight containers until further use in the experiments.

2.2 Extraction Method

The washed leaves were subjected to boiling extraction. The leaves were placed in a clean 5000 mL beaker containing 2000 mL of purified water. The mixture was heated on a hot plate until it reached a rolling boil, ensuring that all leaves were completely submerged in the boiling water. Boiling was continued for 30 minutes to facilitate the extraction of water-soluble compounds and further reduce any remaining microbial load (Kaume et al., 2012). After 30 minutes, the heat was turned off, and the extract was allowed to cool to room temperature. The cooled extract was then filtered through filter paper. The filtered extracts were collected and stored until further analysis. The extraction process on a commercial scale was carried out as much as 2000 L with the same process.

2.3 Formulation of Syrup

The extracted liquid is gradually added with excipients while stirring, including Sodium benzoat, sucralose, methylparaben, povidone, flavour, and ethanol. After the temperature drops to room

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temperature, filtering is carried out using a membrane filter. Then control is carried out in the process before being filled into bottles as shown in figure 1.



(**a**) (**b**)

Figure 1. This is a figure of the process of making syrup from tempuyung and kejibeling leaf extract (**a**) Laboratorium scale 2000 mL; (**b**) Production scale 2000L.

2.4 Quality Control Testing

Sensory evaluation of all extract samples was conducted by a panelist. Taste was evaluated on sweetness, bitterness, and refreshing taste. Clarity was assessed visually. Aroma was evaluated descriptively, noting the intensity and characteristics of the scent.

Total Flavonoid Luteolin 7-O-Glucoside) Testing

Weigh the standard Luteolin-7-O-Glucoside into a 50 ppm. Make a concentration series of 1.5; 4.5; 7.5; 10.5; 13.5 ppm by pipetting the stock solution (0.3; 0.9; 1.5; 2.1; 2.7) mL into a 10 mL measuring flask. Add 3.0 mL of methanol, 0.2 mL of 10% Aluminum Chloride and 0.2 mL of 1 M Sodium Acetate dilute with methanol to the limit mark. Incubate for ± 24 hours. Scan the maximum wavelength, and measure at that wavelength.

Preparation of sample solution

Pour 15 mL of sample into a 25 mL measuring flask. Add 10 mL of methanol, 1 mL of 0.5% hexamine solution and 2 mL of 25% HCl solution. Stir with a magnetic stirrer with sonic for 3 hours at a temperature of 40oC. Filter with filter paper into a 25 mL flask, rinse the filter paper with methanol and add methanol to the boundary mark. Pipette 1 mL of the extracted sample into a 10 mL measuring flask, add 3.0 mL of methanol 0.2 mL of 10% Aluminum Chloride, 0.2 mL of 1 M Sodium Acetate and add methanol to the boundary mark. Incubate for ± 24 hours. The solution is ready to be analyzed using UV Vis spectrophotometry. Scan the maximum wavelength, and measure at that wavelength. Wavelength

obtained at ± 411 nm.

Total Plate Count (TPC) Testing

For the enumeration of total viable aerobic bacteria, 1 mL of each extract sample was serially diluted in sterile physiological saline. Appropriate dilutions were plated in duplicate on Plate Count Agar (PCA) using the pour plate method. The plates were incubated at 37 °C for 24-48 hours, and the number of colony-forming units (CFU) per milliliter (CFU/mL) was counted (Ratajczak et al., 2015); (Jamilatun & Lukito, 2024).

Mold and Yeast Count (MYC) Testing

The total mold and yeast count was determined by serially diluting 1 mL of each extract sample in sterile physiological saline and plating appropriate dilutions in duplicate on Sabouraud Dextrose Agar (SDA) supplemented with chloramphenicol to inhibit bacterial growth, using the pour plate method. The plates were incubated at 25 °C for 3-5 days, and the number of CFU/mL was counted (Ratajczak et al., 2015); (Jamilatun & Lukito, 2024). Alternatively, Petrifilm Yeast and Mold Count Plates were used following the manufacturer's instructions for a comparative analysis.

3. Results and Discussions

The results of the microbial count tests (TPC and MYC) for the extract samples under different washing conditions are presented in Table 1. The microbial count results indicate a trend of decreasing bacterial and fungal loads with an increasing number of water washes. The three-time water wash demonstrated a noticeable reduction in both TPC and MYC values compared to the single and double washes. The inclusion of a 0.1% chlorine wash after the three water washes resulted in the most significant reduction in microbial contamination for both Kejibeling and Tempuyung extracts (Muñoz-Castellanos et al., 2021). The concentration of 0.1% chlorine was selected based on a review of literature that suggests its efficacy in reducing microbial load on plant materials at low concentrations, thereby minimizing the risk of damage to the herbal matrix and potential degradation of active compounds (Muñoz-Castellanos et al., 2021). This suggests that while multiple water washes help remove surface contaminants, the low concentration chlorine solution is effective in further reducing the microbial burden. These results align with studies that evaluated washing lettuce with chlorinated water before versus after cutting, showing that precut washing significantly reduces cross-contamination in mixed samples and enhances overall microbial safety (Nou & Luo, 2010). This is also consistent with a study that evaluated sodium hypochlorite (NaOCl) and peracetic acid (PAA) for washing baby spinach under varying organic loads, where both sanitizers reduced *E. coli* in a dose-dependent manner (Gao et al., 2025). The importance of washing in reducing microbial load on plant materials is demonstrated in a study where washing with water at 60 ºC or 50% ethanol effectively reduced microbial contamination, ensuring compliance with the Ayurvedic Pharmacopoeia of India standards (Kumar et al., 2013). The enhanced efficacy observed with multiple washes and the addition of a low concentration chlorine solution is consistent with studies on fresh produce (Muñoz-Castellanos et al., 2021).

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Table 1. Microbial Test after rinse with purified water and chlorine

Herbs Leaf Sample	Washing Step	TPC Test (CFU/mL)	MYC Test (CFU/mL)	Entero Test (QN)
Kejibeling	1 x	15.500	34.500	<1000 & >100
	2 x	12.900	17.500	<100 & >10
	3 x[1]	9.450	14.000	<100 & >10
Tempuyung	1 x	129.500	42.500	<1000 & >100
	2 x	15.250	32.000	<100 & >10
	3 x[1]	16.950	31.000	<1000 & >100

[1] Washing leaf Using Chlorine 0,1%

The luteolin-7-o-glycoside content in the extracts varied across the washing conditions. The microbial counts for laboratory and production scale samples before and after optimization are included in Table 2.

Table 2. Microbial Test and Assay of Product

Sample Name	Luteolin -7-O-glucoside Assay (%)	TPC Test (CFU/mL)	MYC Test (CFU/mL)	Patogen Bacteria Test
Extract	0,0165	< 10^5	< 10^1	Negatif (-)
Laboratorium scale	0,0134	< 10^5	< 10^1	Negatif (-)
Production scale	0,0042	< 10^5	< 10^3	Negatif (-)
Control[1]	0,0043	> 10^5	> 10^3	Positif (+)

[1] Without multiple rinse and adding chlorine in production scale

Following the boiling extraction process, the microbial counts in all samples, including those subjected to the optimized washing protocol, were found to be below the detection limit or within the acceptable pharmaceutical specifications outlined in relevant pharmacopoeias and guidelines (European Pharmacopoeia, 2019; BPOM, 2023). This highlights the crucial role of heat treatment in ensuring the final product meets stringent microbial quality standards (Kaume et al., 2012). Comparing the laboratory-scale results with the production-scale samples before optimization provided a baseline understanding of the microbial contamination levels present in the existing manufacturing process. The production-scale samples before optimization showed more than 10^5 and 10^3 for TPC and MYC test, respectively. After the implementation of the optimized washing protocol, three water washes followed by 0.1% chlorine wash in the production process, a significant reduction in both TPC and MYC values was observed in the production-scale samples less than 10^5 and 10^3 for TPC and MYC test, respectively. This highlights the successful application of laboratory findings in an industrial setting, demonstrating how the optimized washing protocol enhances the microbial quality of herbal extracts at a larger scale. Similar to the study that identified vinegar as the most effective method for reducing microbial contamination on vegetables, this approach can be adapted to improve the microbial quality of herbal extracts in industrial production (Alreshoodi et al., 2024). The findings of this study align with previous research highlighting the effectiveness of boiling in eliminating remaining microorganisms corroborates established practices in herbal medicine preparation (Kaume et al., 2012). Herbal infusions brewed below boiling temperatures can retain or even activate harmful microbes (Roggentin et al., 2005).

The sensory evaluation provided insights into the effect of the washing methods on the organoleptic properties of the extracts. There was no change in taste after rinsing, but the taste became lighter after filtration. Additionally, the clarity of the solution improved after filtration (Frangipane et al., 2023). Notably, the chlorine-washed leaf showed no strong residual chlorine odor or taste following the rinsing process, suggesting that the protocol effectively minimizes undesirable sensory effects (Crider et al., 2018). The quantification of luteolin-7-O-glycoside revealed that the optimized washing protocol did not cause significant degradation of this potential active constituent, indicating its suitability for preserving the chemical integrity of the herbal material. This finding is supported by other studies, which have shown that luteolin-7-O-glycoside is stable under heat conditions, further confirming the effectiveness of the optimized washing method in maintaining its stability during processing (Chaaban et al., 2017).

A potential threshold effect for water washes was observed, where the reduction in microbial load between two and three washes was less significant compared to the reduction between one and two washes, suggesting that three washes may provide an optimal balance between effectiveness and resource utilization (Das et al. 2019). The successful implementation of the optimized washing protocol at the production scale demonstrates its feasibility and potential for widespread adoption within the herbal pharmaceutical industry. However, a limitation of this study is its focus on total aerobic bacteria and total mold and yeast counts. Future research should investigate the impact of the optimized washing protocol on specific pathogenic microorganisms and assess the potential for biofilm formation on leaf surfaces.

4. Conclusions

This research provides compelling evidence for the effectiveness of an optimized washing protocol, consisting of three washes with water followed by a wash with 0.1% chlorine solution, in significantly reducing microbial contamination on the soil-based medicinal leaves of *Strobilanthes crispus* and *Sonchus arvensis*. The subsequent boiling extraction process further ensures that the final herbal extracts meet stringent pharmaceutical microbial quality specifications. The optimized washing protocol did not negatively impact the sensory attributes or the luteolin-7-o-glycoside content of the extracts. The successful implementation of this protocol at the production scale demonstrates its potential as a natural and effective strategy for microbial control in the herbal pharmaceutical industry, contributing to the production of safer and higher quality herbal medicinal products. Future research could focus on identifying specific microorganisms and further refining the washing parameters for even greater efficacy.

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6. References

Ahiabor, W. K., Darkwah, S., & Donkor, E. S. (2024). Microbial Contamination of Herbal Medicines in Africa, 2000-2024: A Systematic Review. *Environmental Health Insights*, *18*(2). https://doi.org/10.1177/11786302241293345

Agency, E. M. (2015). *Reflection paper on microbiological aspects of herbal medicinal products and traditional herbal medicinal products Table of contents*. *44*(January), 1–21.

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Alreshoodi, F. M., Alsuliman, B., Alotaibi, N. M., Althobaiti, A., Mukhtar, L. E., Alsaleh, S., Alajlan, A. A., Alakeel, S. I., Alshabrmi, F. M., Sarwar, T., & Alajel, S. M. (2024). Impact of Various Washing Protocols on the Mitigation of *Escherichia coli* Contamination in Raw Salad Vegetables. *Microorganisms*, *12*(10), 2103. https://doi.org/10.3390/microorganisms12102103

Ariani, A. P., Febrianti, Y., & Widiya, M. (2022). Antibacterial Test of Keji Beling Leaf Starch Extract (Strobilanthes crispus) Against Inhibition Zone Salmonella thypi. *Journal Of Biology Education Research (JBER)*, *3*(1), 1–10. https://doi.org/10.55215/jber.v3i1.4939

Badan Pengawas Obat dan Makanan. (2023). *Peraturan Badan Pengawas Obat dan Makanan Nomor 29 Tahun 2023 tentang persyaratan keamanan dan mutu obat bahan alam*. Badan Pengawas Obat dan Makanan Republik Indonesia.

Chaaban, H., Ioannou, I., Chebil, L., Slimane, M., Gerardin, C., Paris, C., Charbonnel, C., Chekir-Ghedira, L., & Ghoul, M. (2017). Effect of heat processing on thermal stability and antioxidant activity of six flavonoids. *Journal of Food Processing and Preservation, 41*(1), e13203. https://doi.org/10.1111/jfpp.13203

Crider, Y., Sultana, S., Unicomb, L., Davis, J., Luby, S. P., & Pickering, A. J. (2018). Can you taste it? Taste detection and acceptability thresholds for chlorine residual in drinking water in Dhaka, Bangladesh. *Science of the Total Environment, 613–614*, 840–846. https://doi.org/10.1016/j.scitotenv.2017.09.135

Das, A., Sultana, Z., Kabir, A., & Kabir, M. (2019). Effect of washing on reducing bacterial loads in common vegetables sold in Dhaka City. *Bangladesh Journal of Microbiology, 35*(2), 96–101. https://doi.org/10.3329/bjm.v35i2.42637

De Sousa Lima, C. M., Fujishima, M. A. T., de Paula Lima, B., Mastroianni, P. C., de Sousa, F. F. O., & da Silva, J. O. (2020). Microbial contamination in herbal medicines: a serious health hazard to elderly consumers. *BMC Complementary Medicine and Therapies*, *20*(1), 1–10. https://doi.org/10.1186/s12906-019-2723-1

European Pharmacopoeia, 2019, European Pharmacopoeia, 10th ed., Council of Europe, Strasbourg.

Frangipane, M. T., Cecchini, M., Monarca, D., & Massantini, R. (2023). Effects of Filtration Processes on the Quality of Extra-Virgin Olive Oil—Literature Update. *Foods*, *12*(15), 2918. https://doi.org/10.3390/foods12152918

Gao, Z., Jha, A., Hudson, C. L., Hopper, A. L., Critzer, F. J., Micallef, S. A., Schaffner, D. W., & Tikekar, R. V. (2025). Efficacy of sodium hypochlorite and peracetic acid in reducing cross-contamination during washing of baby spinach at different water quality levels. *Journal of Food Science*, *90*(1), 1–12. https://doi.org/10.1111/1750-3841.17657

Ghasemzadeh, A., Jaafar, H. Z. E., & Rahmat, A. (2015). Phytochemical constituents and biological activities of different extracts of Strobilanthes crispus (L.) Bremek leaves grown in different locations of Malaysia. *BMC Complementary and Alternative Medicine*, *15*(1), 1–10. https://doi.org/10.1186/s12906-015-0873-3

Hartline, R. (n.d.). No TitleEosin-Methylene Blue (EMB) Medium. 29 desember 2024. https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_Laboratory_Manual_(Hartline)

Isrianto, P. L. (2020). KEFIR OF KEJI BELING TEA (Strobilanthes crispus) AS FUNCTIONAL BEVERAGE FOR GLUCOSE INTOLERANCE. *International Journal of Applied Biology*, 31–36. https://journal.unhas.ac.id/index.php/ijoab/article/view/11509%0Ahttps://journal.unhas.ac.id/index.php/ijoab/article/download/11509/6262

Kaume, L., Foote, J. C., & Gbur, E. E. (2012). Microbial contamination of herbs marketed to HIV-infected people in Nairobi (Kenya). *South African Journal of Science*, *108*(9–10), 10–13. https://doi.org/10.4102/sajs.v108i9/10.563

Kneifel, W., Czech, E., & Kopp, B. (2002). Microbial contamination of medicinal plants - A review. *Planta Medica*, *68*(1), 5–15. https://doi.org/10.1055/s-2002-20060

Kumar, K. N. S., Holla, B. S., & Ravishankar, B. (2013). *Simple modus operandi to bring down microbial load of herbal drugs to Pharmacopoeial limit - A study on ingredients of Hutabhugadi curna*. *2*(6), 1040–1043.

Mrozek-Szetela, A., Rejda, P., & Wińska, K. (2020). A review of hygienization methods of herbal raw materials. *Applied Sciences (Switzerland)*, *10*(22), 1–13. https://doi.org/10.3390/app10228268

Muñoz-Castellanos, L. N., Borrego-Loya, A., Villalba-Bejarano, C. V., González-Escobedo, R., Orduño-Cruz, N., Villezcas-Villegas, G. P., Rodríguez-Roque, M. J., Avila-Quezada, G. D., & Vargas-Arispuro, I. (2021). Chlorine and its importance in the inactivation of bacteria, can it inactivate viruses? *Revista Mexicana de Fitopatología, Mexican Journal of Phytopathology*, *39*(4), 198–206. https://doi.org/10.18781/r.mex.fit.2021-4

Noor, R., Huda, N., Rahman, F., Bashar, T., & Munshi, S. K. (2013). Microbial contamination in herbal medicines available in Bangladesh. *Bangladesh Medical Research Council Bulletin*, *39*(3), 124–129. https://doi.org/10.3329/bmrcb.v39i3.20313

Nou, X., & Luo, Y. (2010). Whole-leaf wash improves chlorine efficacy for microbial reduction and prevents pathogen cross-contamination during fresh-cut lettuce processing. *Journal of Food Science*, *75*(5). https://doi.org/10.1111/j.1750-3841.2010.01630.x

Opuni, K. F. M., Kretchy, J. P., Agyabeng, K., Boadu, J. A., Adanu, T., Ankamah, S., Appiah, A., Amoah, G. B., Baidoo, M., & Kretchy, I. A. (2023). Contamination of herbal medicinal products in low-and-middle-income countries: A systematic review. In *Heliyon* (Vol. 9, Issue 9). Elsevier Ltd. https://doi.org/10.1016/j.heliyon.2023.e19370

Opuni, K. F. M., Kretchy, J. P., Agyabeng, K., Boadu, J. A., Adanu, T., Ankamah, S., Appiah, A., Amoah, G. B., Baidoo, M., & Kretchy, I. A. (2023). Contamination of herbal medicinal products in low-and-middle-income countries: A systematic review. In *Heliyon* (Vol. 9, Issue 9). Elsevier Ltd. https://doi.org/10.1016/j.heliyon.2023.e19370

Osei-Asare, C., Akuffo Owusu, F. W., Apenteng, J. A., Entsie, P., Adi-Dako, O., Kumadoh, D., Voado, A., Aloni, E., & Osei, Y. A. (2023). Evaluation of the microbial quality of commercial liquid herbal preparations on the Ghanaian market. *INNOSC Theranostics and Pharmacological Sciences*, *6*(2), 0425. https://doi.org/10.36922/itps.0425

Parisa, N., Kamaluddin, M. T., Saleh, M. I., Sinaga, E., Partan, R. U., & Irfannuddin. (2023). Flavonoids as Antioxidants: A Review on Tempuyung Plant (Sonchus Arvensis). *Journal of Medicinal and Chemical Sciences*, *6*(10), 2310–2318. https://doi.org/10.26655/JMCHEMSCI.2021.10.6

Ratajczak, M., Kubicka, M. M., Kamińska, D., Sawicka, P., & Długaszewska, J. (2015). Microbiological quality of non-sterile pharmaceutical products. *Saudi Pharmaceutical Journal*, *23*(3), 303–307. https://doi.org/10.1016/j.jsps.2014.11.015

Roggentin, P., Kolb, N., & Bockemühl, J. (2005). Influence of brewing temperature and brewing period on the microbial kinetics in herbal infusions. *Archiv Fur Lebensmittelhygiene*, *56*, 100–104.

Tashim, N., Sharifulazar, H., Lim, S., & Basri, A. (2022). *Green Extraction Technology for Plant-Based Natural Products* (pp. 1–9). https://doi.org/10.1007/978-981-16-4921-9_124-1

WHO. (2007). WHO guidelines for assessing quality of herbal medicines with reference to contaminants and residues. ISBN 978 92 4 159444 8

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