RESEARCH PAPER

Comparing the efficiency of *Allium cepa* and *Allium cepa var. aggregatum* peel extract in designing edible biofilm for preservation of cottage cheese

Nandhini S[1]*, Faaiza Suhara I S[2], E. Logeswari[3], K. Revathi[4]*

[1]*Department of Microbiology, Ethiraj College for Women, Chennai – 600008, Tamil Nadu*
[2]*Department of Microbiology, Ethiraj College for Women, Chennai – 600008, Tamil Nadu*
[3]*Research Cell, Sri Venkateshwaraa Medical College Hospital and Research Centre, Ariyur, Puducherry*
[4]*Research Cell, Sri Venkateshwaraa Medical College Hospital and Research Centre, Ariyur, Puducherry*
Corresponding author: Nandhini S; K. Revathi, nandhini_s@ethirajcollege.edu.in; reva63@rediffmail.com

ABSTRACT

Plastic packaging is a major contributor to environmental pollution due to its non-biodegradable nature and greenhouse gas emissions during manufacture. This study compared the antimicrobial activity of water and methanol extracts from Allium cepa (onion) and Allium cepa var. aggregatum (shallot) peels to develop edible biofilms for cottage cheese preservation. Extracts were analysed using FT-IR and GC-MS to determine the presence of bioactive compounds such as quercetin, kaempferol, and allicin. The methanol extract of shallot peel (MESP) showed the highest antimicrobial activity, with zone of inhibition up to 23 mm against *Escherichia coli* ATCC 25922 and 19 mm against *Staphylococcus aureus* ATCC 25923 at a concentration of 500 µg/ml, followed by methanol extract of onion peel (MEOP). Edible biofilms Onion peel methanol wrap (OPMW) and shallot peel methanol wrap (SPMW) (incorporating MESP and MEOP) extended the shelf life of cottage cheese to 28 days at 4°C, which is equivalent to sodium benzoate-treated reference samples. Plate count analysis showed microbial loads increased from too less to count (TLTC) at 10^{-3} dilution to too numerous to count (TNTC) at 10^{-4} dilution in unwrapped controls with visible signs of spoilage, including slime formation, off-odours and discolouration by day 14. Cheese samples coated with OPMW and SPMW retained acceptable quality up to 28 days, comparable to the chemically preserved reference sample. Assays were conducted in duplicates for antimicrobial test and triplicates for plate count to ensure reproducibility of the results. These findings suggest that Allium peel-based biofilms offer a biodegradable, renewable alternative to petroleum-based packaging, with potential for industrial-scale food preservation.

Keywords: Edible biofilm, *Allium cepa*, *Allium cepa var. aggregatum*, antimicrobial activity, cottage cheese preservation, biodegradable packaging, Allium peel extract

How to cite this article: Nandhini S, Suhara IS F, Logeswari E, Revathi K. Comparing the efficiency of Allium cepa and Allium cepa var. aggregatum peel extract in designing edible biofilm for preservation of cottage cheese. Int J Drug Deliv Technol. 2026;16(73s): 1404-1409. DOI: 10.25258/ijddt.16.73s.148

INTRODUCTION

Plastic wraps used for packaging in food industries contribute highly to environmental pollution, right from manufacture to disposal. They are non-biodegradable and persist in the environment for a longer period of time. To overcome the pollution caused by plastic food wraps, researchers are striving to develop more environment friendly, easily biodegradable and edible alternatives such as active packaging film. Active packaging can be treated as primary packaging as it is in direct contact with the food product. It acts as an initial protective barrier to any environmental attack.

Edible active films are designed using natural, biodegradable materials that are safe to the environment and for human consumption. Edible films should have only food-grade components in their compositions.[1,2] These films are made of biopolymers such as proteins or polysaccharides derived from plant or animal sources. Gelatin is an animal protein; it can be used in the development of active packaging films. As gelatin films are transparent and have good mechanical strength, they are ideal to be used as food wraps. The use of plasticizers improves the mechanical and physical properties of the film. Edible plasticizers used are polyols such as glycerol and sorbitol.[3] Glycerol is the common plasticizer used in food. The active ingredients used can be an antimicrobial agent or an antioxidant agent that may be of any natural origin which are not harmful to humans if consumed.

The active films made of agricultural wastes such as vegetable peels offer various benefits such as waste reduction in environment and value addition to food waste by products. Edible films made in combination with vegetable peel extract, extend the shelf life and quality of easily perishable food products such as cheese due to their antimicrobial properties. More than 35 plant species have been used as primary ingredients in the production of edible films in the form of extracts or juices such as carrot, pomegranate, hibiscus and fennel etc.[2,4] Onion (*Allium cepa*) and Shallot (*Allium cepa var. aggregatum*) are commonly used vegetables in food processing. Onion processing generates high quantity of outer skin waste[5]. Onion and shallot peel are rich in flavonoids. Studies have shown that the outer skin of onions contains significantly higher levels of flavonoids compared to the edible portion.[6,7] These compounds provide the peel with antioxidant properties and antimicrobial activity making them a best component to be used in formation of active packaging films.

The edible biofilm made of onion peel extract can be used as a primary packaging material to cover cheese which acts as both protective covering and as a bio-preservative. The effective preservation of cottage cheese is important to extend its shelf life as it can last only 7-10 days under refrigeration without any preservatives. The high moisture and protein content of cottage cheese make them to easily perish. The spoilage is mainly caused by gram negative psychrotrophic bacteria, mold and yeast.[8] Thus, to extend the shelf life, the researchers have come up with various preservative techniques such as chemical and natural preservatives from plants, modified atmosphere packaging and edible coating.[9] Most of the techniques involves adding the active compounds during the manufacturing process, which may alter the natural taste of the cheese. To overcome this, edible coating and film can be best option, because most times they are tasteless and odourless thus imparting no unpalatable taste to the food. This study aims to compare the antimicrobial activity of water and methanol extracts of *Allium cepa* (Onion) and *Allium cepa var. aggregatum* (Shallot) peel. Edible biofilm designing using the extracts as active ingredient to evaluate its potential as a bio preservative in cottage cheese.

MATERIALS AND METHODS

Sample collection and preparation: *Allium cepa var. aggregatum* (Shallot) and *Allium cepa* (Onion) peel samples were collected from (Koyambedu market, Chennai). The peels were washed, dried and powdered.

Solvent extraction: The peels were extracted using water and methanol as solvents. The water extract of *Allium cepa var. aggregatum* (WESP) and *Allium cepa* (WEOP) peel were prepared by mixing 5g of peel powder in water respectively and extracted. The methanol extract of *Allium cepa var. aggregatum* (MESP) and *Allium cepa* (MEOP) peel were prepared by mixing 5g of peel powder in 70% methanol respectively and extracted[6].

Antimicrobial activity testing: The antimicrobial activity of the extracts was tested by following agar well diffusion assay with modifications.[10] It was tested against *E. coli* ATCC 25922 and *S. aureus* ATCC 25923 at the concentration of 300 µg/ml, 400 µg/ml and 500 µg/ml of the extracts. The assay was conducted in duplicates to ensure the reliability and reproducibility of the results.

Phytochemical analysis using GC-MS and FT- IR: MEOP and MESP were analyzed using an Agilent 8890 GC at SAIF, IIT Madras. WEOP and WESP were analyzed using an FT-IR spectrometer 4000-400 cm^{-1}, 4 cm^{-1} resolution, at VIT in ATR mode.

Edible film preparation: Films were prepared by heating distilled water to 130°C and mixing gelatin, glycerol and extract. The solution was cooled and cast to dry producing onion peel methanol wrap (OPMW), shallot peel methanol wrap (SPMW), onion peel water wrap (OPWW), shallot peel water wrap (SPWW).[11-13]

Preparation of cottage cheese: The cottage cheese was prepared by coagulating milk. The obtained cottage cheese block was cut into pieces of (2 × 2 cm) size.

Preservation using edible biofilm: The prepared cheese cubes were covered using OPMW and SPMW respectively. This was taken as test and unwrapped cubes were taken as control. The reference sample was prepared using standard chemical preservative (sodium benzoate). All the samples were stored at 4°C.

Microbiological analysis of preserved cheese: The microbial load of the cottage cheese cube was analysed by following plate count method. The sample was serially diluted and plated on nutrient agar. It was performed at an interval of 7 days for 28 days to determine its shelf life. The plate count assay was performed in triplicates to ensure the reliability of the results.

Physical analysis of preserved cheese: The physical properties such as colour, texture and surface appearance were also observed at an interval of 7 days for 28 days.

RESULT

The phytochemical content of MEOP, MESP, WEOP and WESP is shown in the Table 1-4. Pictorial representation of the study is given in fig 1-6.

Table 1. GC-MS peak values of MEOP

S. No	Peak (RT)	Compound
1	15.947	Quercetin
2	16.963	Kaempferol
3	29.452	Ferulic acid

Table 2. GC-MS peak values of MESP

S. No	Peak (RT)	Compound
1	16.904	Quercetin
2	18.721	Kaempferol
3	25.219	Allicin

Table 3. FT-IR peak values of WEOP

S. No	Peak value	Functional group	Possible compound
1	2942.48	Alkane	Fatty acids
2	1604.50	Aromatic ring	Flavonoids
3	629.79	Aromatic	Quercetin

Table 4. FT-IR peak values of WESP

S. No	Peak value	Functional group	Possible compound
1	2942.48	Alkane	Fatty acids
2	1599.30	Aromatic ring	Kaempferol
4	629.02	Aromatic	Allicin

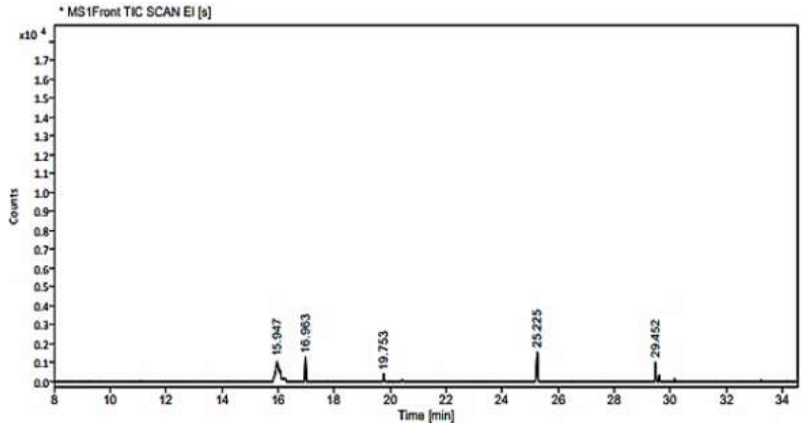

Figure 1. GC-MS spectrum of MEOP

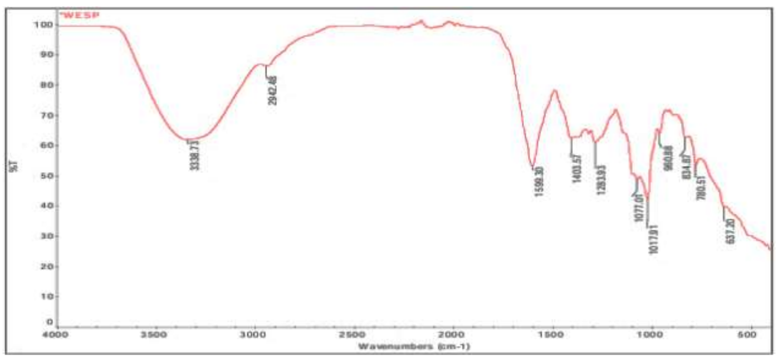

Figure 2. GC-MS spectrum of MESP

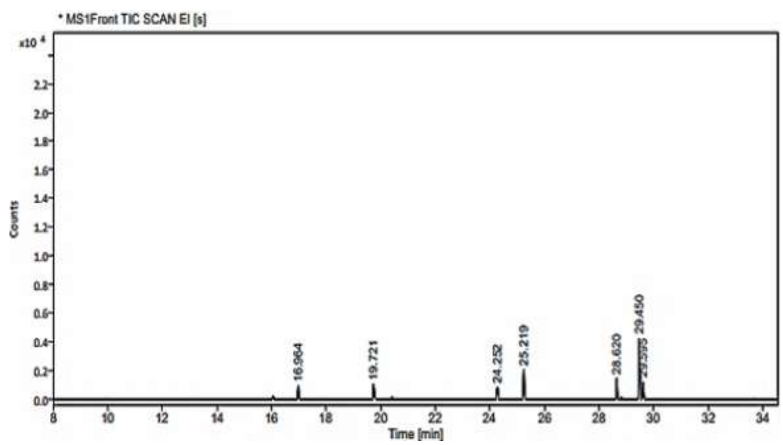

Figure 3. GC-MS spectrum of MESP

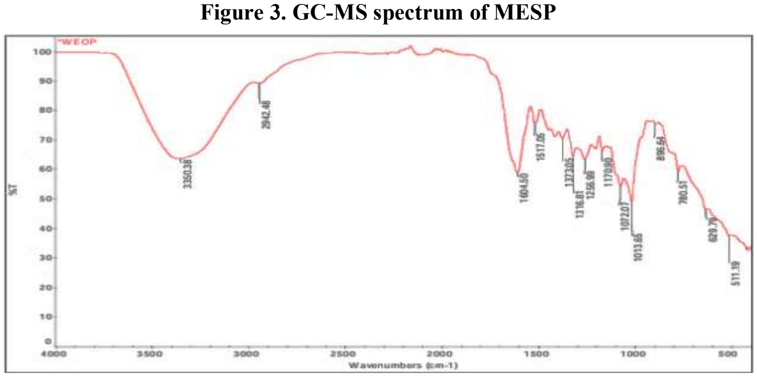

Figure 4. FT-IR spectrum of WESP

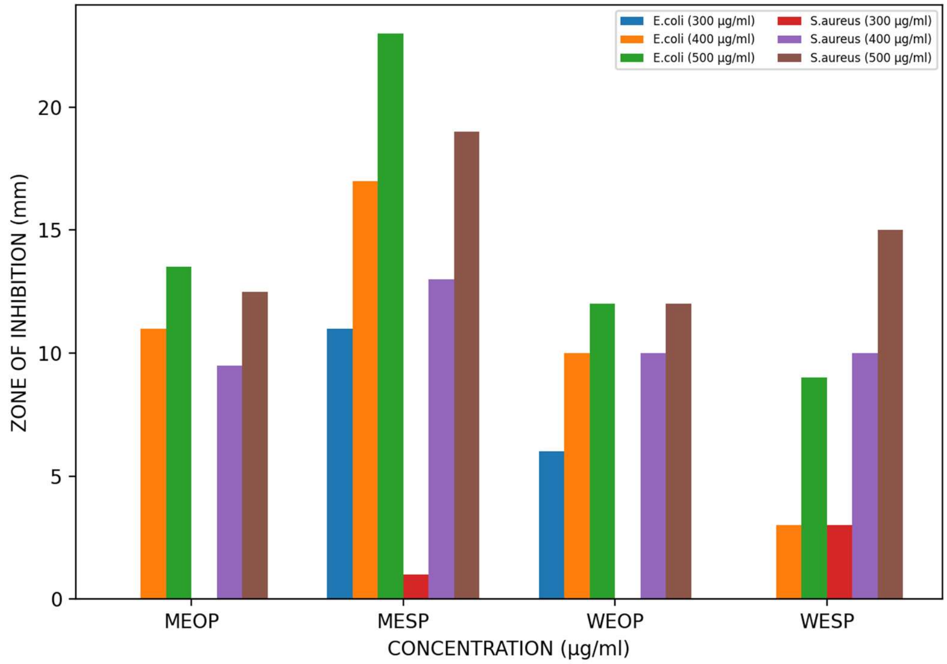

Figure 5. The graph depicting zone of inhibition

Figure 6. *Allium cepa* peel methanol wrap (OPMW) and *Allium cepa var. aggregatum* peel methanol wrap (SPMW)

The melting point of the prepared biofilm was less than 37℃. The preservation study carried out using OPMW and SPMW wraps revealed that homemade cottage cheese wrapped with these films had an extended shelf life of 28 days. The plate count assay also showed low microbial count which is equivalent to the chemical preservative used as reference which is given in Table 5.

Table 5. Bacterial plate count analysis at different time intervals for control, reference, OPMW and SPMW

Day	Control dilution 1	Control count 1	Control dilution 2	Control count 2	Reference dilution 1	Reference count 1	Reference dilution 2	Reference count 2	OPMW dilution 1	OPMW count 1	OPMW dilution 2	OPMW count 2	SPMW dilution 1	SPMW count 1	SPMW dilution 2	SPMW count 2
0	No growth				No growth				No growth				No growth			
7	10^-2	TLTC	10^-3	TLTC	10^-2	No growth	10^-3	No growth	10^-2	No growth	10^-3	No growth	10^-2	No growth	10^-3	No growth
14	10^-4	TNTC	10^-5	TNTC	10^-4	TLTC	10^-5	TLTC	10^-4	TLTC	10^-5	TLTC	10^-4	TLTC	10^-5	TLTC
21	10^-4	TNTC	10^-5	TNTC	10^-4	TLTC	10^-5	TLTC	10^-4	TLTC	10^-5	TLTC	10^-4	TLTC	10^-5	TLTC
28	10^-5	TNTC	10^-6	TNTC	10^-5	TLTC	10^-6	TLTC	10^-5	TLTC	10^-6	TLTC	10^-5	TLTC	10^-5	TLTC

In the first two weeks no changes in the physical appearance of the control pieces were observed. But in the following weeks visible changes were observed. There were no changes in the physical appearance and microbial load in the reference and test samples as shown in Table 6.

Table 6. Comparative evaluation of physical attributes in test, control and reference samples

ATTRIBUTE	TEST SAMPLES (OPMW, SPMW)	CONTROL	REFERENCE
Colour	Retained original off-white colour throughout storage	Discoloration and yellowing after 7 days	Retained original off-white colour throughout storage
Texture	Maintained firmness	Became soft and watery over time	Maintained firmness
Surface appearance	Smooth surface	Slimy surface in later stages	Smooth surface

DISCUSSION

This study specifically focused on assessing the antimicrobial efficiency, physicochemical stability and practical applicability of active edible films in cottage cheese packaging. The antimicrobial assay demonstrated that both methanol and water extracts of onion and shallot peels possess inhibitory activity against spoilage bacteria. Among the extracts, the MESP exhibited the most significant antimicrobial activity. This can be due to its higher concentration of flavonoids, phenolic compounds, and sulfur-containing bioactives, which are more effectively extracted in methanol due to its higher solvent polarity for phytochemicals.[14,15]

The GC-MS and FT-IR spectroscopy confirmed the presence of key bioactive compounds with higher peak intensities observed in shallot peel extracts, indicating the richer phytochemical profile of shallot peels.[16]

The edible biofilms formulated using gelatin as the biopolymer, with both methanol and water extracts showed good film-forming ability, flexibility and adherence to the cheese surface. As the antimicrobial activity of methanol extracts were high when compared to water extracts, the biofilms formulated using methanol extracts (OPMW and SPMW) were used in further studies. Methanol based films exhibited better antimicrobial performance and preservation by extending the shelf life of cottage cheese up to 28 days, which is comparable to chemical preservative-treated reference samples.

During the storage of cheese samples at 4°C, reduction in microbial growth was observed in test samples coated with methanol extract-based films SPMW, followed by OPMW. It retained acceptable quality up to 28 days, comparable to the reference sample.

The microbial plate count assay demonstrated that the films significantly inhibited bacterial growth, maintaining microbial levels similar to sodium benzoate-treated reference. In contrast, the control samples showed a sharp increase in microbial load by the second week, along with spoilage. These findings highlight the preservative efficacy of onion and shallot peel biofilms.

In terms of physical quality, test samples retained better texture, colour and visual appeal, compared to uncoated controls indicating that the films not only extended shelf life but also preserved product quality. The moisture-retaining ability of the biofilm helped prevent desiccation and texture degradation, a common issue in uncoated soft cheeses during storage.

The differences observed between *Allium cepa var. aggregatum* (shallot) peel extract over *Allium cepa* (onion) peel extract shows the variability in phytochemical composition among different Allium species. This can be due to the higher antioxidant potential of shallot peel. Antioxidants play a crucial role in retarding oxidative rancidity in cheese and maintaining sensory quality.

CONCLUSION

The findings of this study indicates that both *Allium cepa (onion) and Allium* cepa var. aggregatum (shallot) peel extracts possess significant antimicrobial and antioxidant properties, which contribute to extend the shelf life and improve the quality of cheese during refrigerated storage. Shallot peel extract, particularly in methanol-based biofilms, demonstrated superior antimicrobial activity compared to onion peel extract, making it a promising candidate for natural food preservation. The selected biofilm-based preservation technique in this study offers a natural, cost- effective and environment friendly alternative to synthetic preservatives and plastic-based packaging materials. These findings suggest the potential for industrial scalability of Allium-based edible biofilms in dairy preservation and packaging of other perishable food products.

REFERENCES

1. Nesic, A., Cabrera-Barjas, G., Dimitrijevic-Brankovic, S., Davidovic, S., Radovanovic, N., and Delattre, C. 2019. Prospect of Polysaccharide-Based Materials as Advanced Food Packaging. Molecules, 25(1), 135.

2. Otoni, C. G., Avena-Bustillos, R. J., Azeredo, H. M. C., Lorevice, M. V., Moura, M. R., Mattoso, L. H. C., and McHugh, T. H. 2017. Recent Advances on Edible Films Based on Fruits and Vegetables - A Review. Comprehensive Reviews in Food Science and Food Safety, pp. 1151–1169.

3. Akhtar, J., Omre, P. K., and Ahmad Azad, Z. R. A. 2015. Edible coating for preservation of perishable foods: A review. Journal of Ready to Eat Food, pp. 81-88.

4. Galus, S., Kibar, E. A. A., Gniewosz, M., and Krasniewska, K. 2020. Novel Materials in the Preparation of Edible Films and Coatings - A Review. Coatings, 10(7), 674.

5. Gawlik-Dziki, U., Kaszuba, K., Piwowarczyk, K., Swieca, M., Dziki, D., and Czyz, J. 2015. Onion skin—Raw material for the production of supplement that enhances the health-beneficial properties of wheat bread. Food Research International, pp. 97–106.

6. Duan, Y., Jin, D. H., Kim, H. S., Seong, J. H., Lee, Y. G., Kim, D.-S., Chung, H.-S., and Jang, S.-H. 2015. Analysis of Total Phenol, Flavonoid content and Antioxidant Activity of Various Extraction Solvents Extracts from Onion (Allium cepa L.) Peels. Journal of Oil & Applied Science, pp. 418–426.

7. Anh, P. T. H., Truc, L. T. G., & An, T. T. T. 2023. Shallot peel (Allium ascalonicum L.) extract, the antioxidative, antibacterial properties and fish preservation capacity. Vietnam Journal of Chemistry, 61(2), pp 253-261.

8. Herve, A.-G., Tang, J., Luedecke, L., and Feng, H. 1998. Dielectric properties of cottage cheese and surface treatment using microwaves. Journal of Food Engineering, pp. 389–410.

9. Mohamed, S. A. A., El-Sakhawy, M., and El-Sakhawy, M. A.-M. 2020. Polysaccharides, Protein and Lipid -Based Natural Edible Films in Food Packaging: A Review. Carbohydrate Polymers, 238, 116178.

10. Bhimba, B. V., Meenupriya, J., Joel, E. L., Naveena, D. E., Kumar, S., and Thangaraj, M. 2010. Antibacterial activity and characterization of secondary metabolites isolated from mangrove plant Avicennia officinalis. Asian Pacific Journal of Tropical Medicine, pp. 544-546.

11. Schieber, A., Stintzing, F. C., & Carle, R. 2001. By-products of plant food processing as a source of functional compounds—Recent developments. Trends in Food Science & Technology, 12(11), pp 401–413.

12. Tran, T. T. V., Nguyen, N.-N., Nguyen, Q.-D., Nguyen, T.-P., & Lien, T.-N. 2023. Gelatin/ carboxymethyl cellulose edible films: Modification of physical 34 properties by different hydrocolloids and application in beef preservation in combination with shallot waste powder. RSC Advances, 13(15), 10005–10014.

13. Youssef, A. M., Assem, F. M., El-Sayed, S. M., Salama, H., & Abd El-Salam, M. H. 2017. Utilization of Edible Films and Coatings as Packaging Materials for Preservation of Cheeses. Journal of Packaging Technology and Research, 1(2), pp 87–99.

14. Jokovic, N., Matejic, J., Zvezdanovic, J., Stojanovic-Radic, Z., Stankovic, N., Mihajilov-Krstev, T., & Bernstein, N. 2024. Onion peel as a potential source of antioxidants and antimicrobial agents. Agronomy, 14(3), 453.

15. Sagar, N. A., Pareek, S., Benkeblia, N., & Xiao, J. 2022. Onion (Allium cepa L.) bioactives: Chemistry, pharmacotherapeutic functions, and industrial applications. Food Frontiers, 3(3), pp 380–412.

16. Liguori, L., Califano, R., Albanese, D., Raimo, F., Crescitelli, A., & Di Matteo, M. 2017. Chemical Composition and Antioxidant Properties of Five White Onion (Allium cepa L.) Landraces. Journal of Food Quality, pp 1–9