



Quantification of phenolic compounds in grapes and pineapple peels dried by freeze dryer, air circulation oven and solar dehydrator

Quantificação de componentes fenólicos em cascas de uva e abacaxi secas por liofilizador, estufa com circulação de ar e desidratador solar

J. H. Brighenti; F. Engel; T. F. S. M. Schultz; L. T. Chendynski*; S. C. Uber

Federal Institute of Parana, Campus Ivaiporã, Max Arthur Greipel Street, 505, 86870-00, Ivaiporã, PR, Brazil

**leticia.chendynski@ifpr.edu.br*

(Recebido em 02 de dezembro de 2025; aceito em 15 de agosto de 2026)

The drying stage in food is important for improving the shelf life, but it can alter physicochemical properties like texture, phenolics compounds and antioxidant capacity. This study aimed to evaluate the differences in total phenolic compound contents in samples of grapes and pineapple peels dried in an oven with air circulation, a freeze dryer and a solar fruit dehydrator. The study also aimed to compare drying times using different equipment to remove water from the samples. The use of a solar dehydrator resulted in the shortest drying time for both grapes and pineapple peels. The highest phenolic compound contents were observed for grapes peels, especially those dried by freeze-drying, since oven drying produced the lowest phenolic compound contents. The highest phenolic compound content was also found in pineapple peel extract dried by freeze-drying, followed by oven drying with air circulation. The lowest content was obtained for the extract of pineapple peels dried by solar dehydration. The various drying methods presented different amounts of total phenolic compounds for the grapes peel samples dried by freeze-drying and in an oven with air circulation, and for the grapes peel samples dried by freeze-drying and by solar dehydration, with $0.0013 < p < 0.00035$. The other samples showed no significant differences.

Keywords: Folin-Ciocalteu method, phenolic compounds, rural economy.

A etapa de secagem em alimentos é importante para melhorar o tempo de armazenamento de diversos produtos, porém pode alterar propriedades físico-químicas como textura, compostos fenólicos e capacidade antioxidante. O presente trabalho teve por objetivo a avaliação das diferenças de teores de compostos fenólicos totais em amostras de cascas de uva e abacaxi secas em estufa com circulação de ar, liofilizador e um desidratador de frutas à luz solar. Ainda, o estudo também teve por objetivo comparar o tempo de secagem empregando diferentes equipamentos para a retirada da água das amostras. O emprego do desidratador solar obteve o menor tempo de secagem para as cascas de uva e também para as cascas de abacaxi. Os maiores teores de compostos fenólicos foram observados para as cascas de uva, em especial as que foram secas por liofilização, uma vez que, a secagem por estufa ocorreram os menores teores. O maior teor de compostos fenólicos também foi maior para o extrato de cascas de abacaxi empregando a secagem por liofilização, seguido pela secagem por estufa com circulação de ar. O menor teor foi obtido para o extrato de cascas de abacaxi secas por desidratador solar, indicando uma degradação maior dos compostos fenólicos presentes na casca do abacaxi com esse tipo de secagem. As diversas formas de secagem apresentaram distintas quantidades de compostos fenólicos totais para as amostras de cascas de uva secas por liofilização e em estufa com circulação de ar e para as amostras de cascas de uva secas por liofilização e pelo desidratador solar, com $0,0013 < p < 0,00035$. As demais amostras não apresentaram diferenças significativas pelo Teste de Tukey a 5%.

Palavras-chave: método de Folin-Ciocalteu, compostos fenólicos, economia rural.

1. INTRODUCTION

Drying efficiency depends on the technique. Traditional open-air drying is cost-effective; however, exposure to oxygen, light and environmental conditions can promote enzymatic browning, the loss of volatile compounds and the degradation of heat-sensitive bioactive compounds. Oven drying is faster and yields greater microbiological stability, although high temperatures may degrade certain compounds. Freeze-drying is considered one of the most

effective dehydration techniques for preserving bioactive constituents, owing to the sublimation of ice under low-temperature and reduced-pressure conditions, as described by Barlak et al. (2026) [1].

According to Singh and Sharma (2021) [2], there are several causes of losses in fruit and vegetable production, including crushing, rotting, senescence and wilting. One way to prevent or reduce food waste is to dry food using solar energy. This method requires the acquisition or construction of specialized equipment, which represents a way of generating income for small rural producers. In addition to reducing harvest losses, it also appears to be a sustainable solution using renewable energy, according to Unar et al. (2026) [3].

As cited by Borgo et al. (2010) [4], plant drying is a process that results in low moisture contents, enabling the prolonged preservation of physical and chemical qualities. Residual moisture contents above 10% of the wet weight base favor bacterial and fungal growth, enabling enzymatic hydrolytic activity in plant cells and oxidation and degradation reactions of active ingredients. Drying is a step that can affect organic compounds such as carotenoids, as the amount of water is critical to their stability. However, lower water contents in dehydrated foods provide a barrier to atmospheric oxygen, increasing their stability and shelf life as described by Aquino et al. [5].

Fruit peels have proven to be a valuable source of nutrients and bioactive compounds. Research shows that, in general, they contain a higher concentration of nutrients than the pulp itself, which is traditionally considered the edible part of the fruit, according to Gondim et al. [6] and Córdova et al. (2005) [7]. Furthermore, peels are notable for being rich in dietary fiber, protein, essential oils, minerals and antioxidants like phenolic compounds. This nutritional richness has sparked increasing interest in using peels in human nutrition. One of the most common uses is drying and processing into flour, which allows them to be used in various recipes or for the extraction of bioactive compounds, as cited by Siebel and Rodrigues (2021) [8].

Coffee and fennel, rosemary leaves, araçá pulp, and bacuri peels, *Campomanesia adamantium* (Guavira) leaves, lemongrass, blackberry, senna leaves, hibiscus, jabuticaba peels and gabioba leaves [9-14] have been highlighted in the production of extracts with antioxidant properties due to the presence of phenolic compounds. Extracts of leaves, fruits and flowers with antioxidant properties minimize the oxidative radical mechanism and it can be studied with the purpose of replacing synthetic compounds commonly added to oils, fats and biodiesel, as studied by Savada et al. (2021) [15].

This study aimed to evaluate the differences in total phenolic compound contents in grape and pineapple peels samples dried in an oven with air circulation, a freeze dryer and a fruit dehydrator under sunlight.

2. MATERIALS AND METHODS

2.1 Sample Preparation

50 g of each sample of grape peels (cultivar Vitória) and pineapple peels (cultivar Pérola) were weighed for each drying method. The samples were dried at 50°C in an air circulation oven (SOLAB, model SL-102/1152). 2 g sample was set aside to determine when the sample reached constant weight and for subsequent moisture content calculations. In another method, 50 g of the samples were dried for 24 h in a freeze dryer (JJ Científica LTDA (R), model Linha LJJ, -34.0°C, 300 mbar). The samples were previously frozen and placed in the freeze dryer. Furthermore, a wooden sunlight-powered fruit dehydrator with a grid to support the samples was developed, as shown in Figure 1, measuring 74 x 44 x 50 cm. The drying of 50 g of peels to constant weight on a sunny day was evaluated. The operation of a dehydrator, in essence, is based on allowing hot air to circulate within the structure of the material, thus evaporating all the moisture around the fruits until they are completely dry, according to Koyuncu (2006) [16]. The internal temperature ranged from 20 to 50°C, depending on the variation in external temperature.



Figure 1: Solar dehydrator developed for the project.

The samples were then ground manually and stored. The time spent in each drying method was recorded.

2.2 Quantitative Analysis of Total Phenolic Compounds

Alcoholic extracts of grapes and pineapple peels were prepared using 5 g of the dried and ground sample and added to 125 mL of absolute ethyl alcohol (ANIDROL[®], CH₃CH₂OH). This mixture was kept protected from light for 48 hours and then filtered. The quantification of the phenolic compounds present in the prepared natural alcoholic extracts was performed by the Folin–Ciocalteu method in the microbiology laboratory of the IFPR Campus Ivaiporã using UV-Vis spectrometry on a Thermo Scientific (model: Evolution 60) equipment. The methodology of Branco et al. (2025) [17] and Romagnoli et al. (2018) [13] was adapted for the extract concentrations. Folin's reagent 0.2 N and sodium carbonate (Na₂CO₃) solution (7.5% (w/w)) were used and the extracts were diluted to adjust the absorbance readings on the equipment. The volumes were stipulated by preliminary studies so that the absorbance values were quantified within the range of the analytical curve. For the blank, 0.5 mL of distilled water, 0.5 mL of 0.2 N Folin Ciocouteau reagent and 0.5 mL of 7.5% Na₂CO₃ solution were added to the test tube. For standards or samples, the following were added to the test tubes: 0.5 mL of standard or sample, 0.5 mL of 0.2 N Folin Ciocouteau reagent, and 0.5 mL of 7.5% Na₂CO₃ solution. The samples were homogenized and kept away from light for one hour and absorbance analysis was performed at 760 nm. The total phenolic content was expressed as gallic acid equivalents (GAE) per gram of dry matter. The assay was performed in duplicate.

Statistical analyses of the results were performed using Statistica[®] software (v. 12) [18] through analysis of variance, ANOVA, and when significant, the means were compared using Tukey's test with $p \leq 0.05$.

3. RESULTS AND DISCUSSION

After two days of extraction in ethyl alcohol, the mixtures had different colors, as shown in Figure 2, indicating extraction of different substances depending on the drying method. It is important to note that the phenolic compound content can also be affected by differences in solvent polarity and extraction time, as cited by Rockenbach et al. (2008) [19].



Figure 2: Alcoholic extract of pineapple peels dried by (1) Freeze dryer; (2) Oven with air circulation; (3) solar dehydrator and extract of grape peels dried by (4) Oven with air circulation; (5) Solar dehydrator; (6) Freeze dryer.

Table 1 presents the quantification values of total phenolic compounds for the different extracts. The analytical curve used was $Abs = 0.0116 \times + 0.1548$, $R^2 = 0.993$. The average moisture content was 75.58% for grape peels and 79.44% for pineapple peels.

Table 1: Absorbance (Abs) values obtained for sample dilutions and their determined phenolic amounts.

Sample	Dilution factor	Drying time (hours)	Abs (1)	Abs (2)	Phenolic compound content (mg GAE g dry peels ⁻¹)	
					1	2
Freeze-dried grapes peels extract	0.75:50	24h00	0.356	0.355	28.91	28.76
Extract of grapes peels dried in an oven with air circulation	0.75:50	18h30	0.293	0.304	19.85	21.44
Extract of grapes peels dried by solar dehydrator	0.75:50	7h00	0.321	0.310	23.88	22.30
Freeze-dried pineapple peels extract	1.5:25	24h00	0.273	0.290	4.25	4.85
Extract from pineapple peels dried in an oven with air circulation	2:25	13h30	0.272	0.280	3.16	3.37
Extract of pineapple peels dried by solar dehydrator	2:25	10h00	0.235	0.221	2.16	1.78

It is important to highlight that the use of a solar dehydrator resulted in the shortest drying time for grape and pineapple peels. This method, in addition to being faster, also has lower costs, as it does not involve electricity costs. The box developed in this work costs less than a freeze dryer and an oven and uses solar energy, a sustainable energy source.

Solar energy has several characteristics that characterize its use as sustainable, such as not releasing waste into the atmosphere, being renewable, and having great potential, being available almost everywhere in Brazil, as described by Machado and Miranda [20]. The dehydration process serves as an option to avoid waste and variation in the natural flavor of the fruit. Studies of drying methods show that fruit dryers that use the sun as the sole energy source are frequently used. A well-known example is the sun-dried fruit dryers used by Feiden et al. (2016) [21], which can be constructed from simple materials such as wood, glass, and metal. Another model, as mentioned above, combines solar heat and electrical heat, which significantly reduces dehydration time. To increase heating efficiency, a design with flat plates and fins was adopted, based on Deng et al. (2016) [22], allowing greater heat exchange and better heat retention. Koyuncu (2006) [16] compared six solar collector models and found the flat plate

model with top flow to be the most efficient. Inspired by this, the final design combined flat plates, fins, and top flow for improved thermal performance.

Table 2 presents the mean values quantified in the samples, the standard deviation of the duplicate, and the respective coefficient of variation (CV) in percentage. The lower the CV, the more homogeneous the data. According to Pimentel-Gomes (2023) [23], who classified the coefficients of variation obtained in agricultural trials, most of the results found for this trial were below 10%, being classified as having a low coefficient of variation. Only the phenolic compound content of the pineapple peel extract dried by a solar dehydrator presented an intermediate CV, indicating less homogeneity of the samples. This may have occurred due to the difficulty in grinding these samples, since they were resistant to manual grinding.

Table 2: Average values for the quantities of total phenolic compounds, standard deviation and coefficient of variation of the samples.

Sample	Mean (mg GAE g _{dry peels} ⁻¹) ± Standard Deviation	CV (%)
Freeze-dried grapes peels extract	28.84 ± 0.11	0.37
Extract of grapes peels dried in an oven with air circulation	20.65 ± 1.12	5.45
Extract of grapes peels dried by solar dehydrator	23.09 ± 1.12	4.84
Freeze-dried pineapple peel extract	4.55 ± 0.43	9.39
Extract from pineapple peels dried in an oven with air circulation	3.27 ± 0.15	4.55
Extract of pineapple peels dried by solar dehydrator	1.97 ± 0.27	13.67

Table 2 shows that grape peel extracts exhibited higher phenolic compound contents compared to pineapple peel extracts. Freeze-dried grape peels (28.84 ± 0.11) yielded the highest levels, followed by grape peel extract dried in a solar dehydrator (23.09 ± 1.12). Regarding pineapple peel extracts specifically, the highest phenolic compound content was also found in the freeze-dried extract (4.55 ± 0.43), followed by the extract dried in a forced-air oven (3.27 ± 0.15). The lowest content was observed in the solar-dehydrated pineapple peel extract (1.97 ± 0.27), indicating greater degradation of the phenolic compounds present in pineapple peel with this drying method.

Total phenolic compound levels vary according to the grape species, the solvent used, and the type and duration of extraction. The levels found for the grape extract are close to the results reported by Caldas et al. (2018) [24] for extraction with 92% ethanol. The total phenolic content of the pineapple peel extract is lower than the values found by Azizan et al. (2020) using 100% ethanol [25].

Phenolic compounds undergo degradation at high temperatures and, as freeze-drying does not employ high temperatures, larger amounts of phenolic compounds are justified [26]. The different drying methods presented different amounts of total phenolic compounds for the grapes peels samples dried by freeze-drying and in an oven with air circulation and for the grapes peels samples dried by freeze-drying and by the solar dehydrator, with $0.0013 < p < 0.00035$. There was no significant difference in the Tukey (R) test with $p = 0.08$ between the total phenol content in the grapes peels samples dried by the oven and by the fruit dehydrator with sunlight. The different drying methods for pineapple peels samples did not differ significantly according to Tukey (R) with a variation of $0.22 < p < 0.92$. The extraction process can result in a lower phenolic compound content due to drying, which generates chemical and enzymatic modifications, and the volatilization of substances with lower boiling temperatures. Thermal degradation is reported as the main cause of the reduction of these compounds, as during this process, the phenols react and prevent their extraction. Therefore, the phenolic compound content of the peels decreases with increasing temperature [26-28].

High temperatures drying increases the reaction rate of bioactive compounds. ElGamal et al. (2023) [26] present the degradation mechanisms of organic compounds and state that the ideal drying temperatures for preserving vitamin C, polyphenols, flavonoids, glycosides, volatile compounds, and their respective antioxidant activity were, respectively: 50–60 °C, 55–60 °C, 60–70 °C, 45–50 °C, 40–50 °C, and 50–70 °C. The authors recommend convection drying at low temperatures to preserve bioactive compounds of plant origin. Vitamin C isomers can be converted into ascorbic acid at high temperatures. Phenols, flavonoids, and glycosides are also heat-sensitive compounds. Phenols oxidize during the drying process, and higher temperatures correlate with an increased rate of degradation [26]. Teles et al. (2017) [27] argued that bioactive components could undergo oxidation by polyphenol oxidase, as temperatures of 50 °C and 40 °C were likely insufficient to inactivate this enzyme in grape pomace dried below 60 °C. The preservation of phenolic compounds can be favored by both the temperature and the reduction of water activity achieved through drying. Gąsecka et al. (2019) [28] reported that the greatest reductions in bioactive compounds from *Leccinum scabrum* occurred at 70 °C. Antioxidant activity was highest in fresh samples, followed by air-dried samples and those dried at 40 °C, while the lowest activity was found in samples dried at 70 °C.

4. FINAL CONSIDERATIONS

The use of a solar dehydrator resulted in the shortest drying time for both grapes and pineapple peels. This method, in addition to being faster, is also less expensive because it does not involve electricity costs, providing small producers with alternative ways to dry their products. The average moisture content was 75.58% for grapes peels and 79.44% for pineapple peels. The grapes peels had the highest phenolic compound levels, especially in freeze-dried peels, while oven drying produced the lowest phenolic compounds. The pineapple peel extract also had the highest phenolic compound levels when freeze-dried, followed by oven drying with air circulation. The lowest phenolic content was obtained for the pineapple peel extract dried using a solar dehydrator, indicating greater degradation of the phenolic compounds present in pineapple peels with this drying method. The different drying methods presented different amounts of total phenolic compounds for the samples of grape peels dried by freeze-drying and in an oven with air circulation and for the samples of grape peels dried by freeze-drying and by solar dehydrator, with $0.0013 < p < 0.00035$. The other samples did not present significant differences by the Tukey test at 5%.

5. ACKNOWLEDGMENTS

The authors would like to acknowledge the academic scholarships granted by Itaipu Parquetec Agreement - Extension for Territorial Sustainability No. 4500074501 - EDU.DNE. We thank the IFPR for supporting the research (Edital PIAPA 65/2025).

6. REFERENCES

1. Barlak E, Gündoğdu A, Baltac C, Bulut VN. Comparative effects of freeze-drying, oven drying, and air drying on physicochemical properties and bioactive compounds of five wild fruit species. *Turkish J Analytical Chem.* 2026;8(2):129-39. doi: 10.51435/turkjac.1949938
2. Singh D, Sharma RR, Amit Kumar Kesharwani. *Postharvest losses of horticultural produce*. Boca Raton, FL (US): CRC Press eBooks; 2021.
3. Unar SG, Khatri SA, Mirjat NH, Shaikh PH, Zaidi SARA, Arain MF. Solar drying technologies: A review of design, efficiency, and environmental impacts. *Renew Sustain Energy Rev.* 2026;226:116339. doi: 10.1016/j.rser.2025.116339
4. Borgo J, Augusto C, Moura DJ, Richter MF, Suyenaga ES. Influência dos processos de secagem sobre o teor de flavonoides e na atividade antioxidante dos extratos de *Baccharis articulata* (Lam.) Pers., Asteraceae. *Rev Bras Farmacogn.* 2010 Mar;20(1):12-7. doi: 10.1590/S0102-695X2010000100004

5. Aquino LP, Ferrua FQ, Borges SV, Antoniassi R, Correa JLG, Cirillo MA. Influência da secagem do pequi (*Caryocar brasiliense* Camb.) na qualidade do óleo extraído. *Cienc Technol Aliment*. 2009 Jun;29(2):354-7. doi: 10.1590/S0101-20612009000200018
6. Gondim JAM, Moura MFV, Dantas AS, Medeiros RLS, Santos KM. Composição centesimal e de minerais em cascas de frutas. *Cienc Technol Aliment*. 2005 Dec;25(4):825-7. doi: 10.1590/S0101-20612005000400032
7. Córdova KRV, Gama TMMTB, Winter CMG, Kaskantzis Neto GK, Freitas RJS. Características físico-químicas da casca do maracujá-amarelo (*Passiflora edulis* Flavicarpa Degener) obtidas por secagem. *BoletimCEPPA*. 2005;23(2):221-30.
8. Seibel NF, Rodrigues DD. Aproveitamento de resíduos agroindustriais de origem vegetal para alimentação humana. In: *Ciência e Tecnologia de Alimentos: Pesquisa e práticas contemporâneas*. Guarujá (SP): Editora Científica Digital; 2021. p. 90-105. doi: 10.37885/210504550
9. Jeyakumar N, Huang Z, Balasubramanian D, Le AT, Nguyen XP, Pandian PL, et al. Experimental evaluation over the effects of natural antioxidants on oxidation stability of binary biodiesel blend. *Int J Energy Res*. 2022 Apr 14;46(14):20437-61. doi: doi.org/10.1002/er.7956.
10. Chendynski LT, Cordeiro TS, Messias GB, Mantovani ACG, Spacino KR, Zeraik ML, et al. Evaluation and application of extracts of rosemary leaves, araçá pulp and peel of bacuri in the inhibition of the oxidation reaction of biodiesel. *Fuel*. 2020 Feb 1;261:116379-9. doi: 10.1016/j.fuel.2019.116379
11. Castro TLA, Machado GE, Vieira MC, Cardoso CAL. The relationship between leaf morphology on the chemical composition and antioxidant potential of *Campomanesia adamantium* (Cambess.) O. Berg tea. *Sci Plena*. 2025 Nov;21(10):107201. doi: 10.14808/sci.plena.2025.107201
12. Martins TR, de Freitas RV, Palheta HCO, Figueira MS, Ferreira LMMC, Vasconcelos dos Santos O. Análise do conteúdo de compostos bioativos em capim-limão (*Cymbopogon citratus*) em sua forma natural e extrato de infusão. *Sci Plena*. 2026 Jul 17;22(6):061501. doi: 10.14808/sci.plena.2026.061501
13. Romagnoli ÊS, Borsato D, Silva LRC, Chendynski LT, Angilelli KG, Canesin EA. Kinetic parameters of the oxidation reaction of commercial biodiesel with natural antioxidant additives. *Ind Crops Prod*. 2018 Sep 6;125:59-64. doi: 10.1016/j.indcrop.2018.08.077
14. Branco IG, Campos JW, Silva NF, Clemente MAJ, Mantovani ACG, Chendynski LT, et al. Mathematical modeling of the biodiesel oxidation process in the presence of natural ethanolic extracts of jabuticaba peels, gabirola leaves, and hibiscus flowers. *Quim Nova*. 2024 Jan;47:1-7. doi: 10.21577/0100-4042.20230090
15. Savada FY, Silva HC, Mantovani ACG, Chendynski LT, Angilelli KB, Borsato D. Predictive model for determining the mass of BHA and BHT to be added in commercial biodiesel. *Quim Nova*. 2021;45(4):365-73. doi: 10.21577/0100-4042.20170827
16. Koyuncu T. Performance of various design of solar air heaters for crop drying applications. *Renew Energy*. 2006 Jun;31(7):1073-88. doi: 10.1016/j.renene.2005.05.017
17. Branco IG, Silva NF, Campos JW, Mantovani ACG, Chendynski LT, Borsato D. Use of natural extracts with antioxidant properties in biodiesel: optimization of extract formulation applying the simplex centroid method. *Acta Sci Technology*. 2025;47:e73074. doi: 10.4025/actascitechnol.v47i1.73074
18. STATSOFT, INC. STATISTICA (data analysis software system), version 12; 2014. Available from: www.statsoft.com.
19. Rockenbach II, Silva GL, Rodrigues E, Kuskoski EM, Fett R. Influência do solvente no conteúdo total de polifenóis, antocianinas e atividade antioxidante de extratos de bagaço de uva (*Vitis vinifera*) variedades Tannat e Ancelota. *Cienc Technol Aliment*. 2008 Dec;28:238-44. doi: 10.1590/S0101-20612008000500036
20. Machado CT, Miranda FS. Energia solar fotovoltaica: Uma breve revisão. *Rev Virtual Quím*. 2015;7(1):126-43. doi: 10.5935/1984-6835.20150008
21. Feiden A, Feiden A, Galvani F, Campolin AI. Desidratação de frutas utilizando secador solar. Corumbá (MS): Embrapa. 2015. (Comunicado Técnico, 98). Available from: <https://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/1037117>.
22. Deng J, Yang M, Ma R, Zhu X, Fan J, Yuan G, et al. Validation of a simple dynamic thermal performance characterization model based on the piston flow concept for flat-plate solar collectors. *Sol Energy*. 2016 Dec;139:171-8. doi: 10.1016/j.solener.2016.09.040
23. Pimentel-Gomes F. Curso de estatística experimental. 1. ed. Piracicaba: Nobel; 1985.
24. Caldas TW, Mazza KE, Teles AS, Mattos GN, Brigid AIS, Conte-Junior CA, et al. Phenolic compounds recovery from grape skin using conventional and non-conventional extraction methods. *Ind Crops Prod*. 2018;111:86-91. doi: 10.1016/j.indcrop.2017.10.012

25. Azizan A, Lee AX, Abdul Hamid NA, Maulidiani M, Mediani A, Abdul Ghafar SZ, et al. Potentially bioactive metabolites from pineapple waste extracts and their antioxidant and α -glucosidase inhibitory activities by ¹H NMR. *Foods*. 2020;9(2):173. doi: 10.3390/foods9020173
26. ElGamal R, Song C, Rayan AM, Liu C, Al-Rejaie S, ElMasry G. Thermal degradation of bioactive compounds during drying process of horticultural and agronomic products: A comprehensive overview. *Agronomy*. 2023;13(6):1580. doi: 10.3390/agronomy13061580
27. Teles ASC, Chávez DWH, Gomes FDS, Cabral LMC, Tonon RV. Effect of temperature on the degradation of bioactive compounds of Pinot Noir grape pomace during drying. *Braz J Food Technol*. 2017;21:e2017059. doi: 10.1590/1981-6723.5917
28. Gąsecka M, Siwulski M, Magdziak Z, Budzyńska S, Stuper-Szablewska K, Niedzielski P, et al. The effect of drying temperature on bioactive compounds and antioxidant activity of *Leccinum scabrum* (Bull.) Gray and *Hericium erinaceus* (Bull.) Pers *J Food Sci Technol*. 2019;57:513-25. doi: 10.1007/s13197-019-04081-1