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Effects of different processing methods on nutrients, bioactive compounds, and biological activities of Chanterelle mushroom (*Cantharellus cibarius*): A review

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ABSTRACT

Edible wild mushrooms (EWM) known as "forest meat" are highly demanded functional foods and nutraceuticals due to their rich macro and micronutrients, aroma compounds, bioactive components, and high commercial significance. *Cantharellus cibarius* Fr. is an ectomycorrhizal, culinary-medicinal mushroom that has been consumed as a food and therapeutic agent from Eurasia to the Americas and Africa for centuries. Fresh and processed *C. cibarius* are among the most economically significant species of the EWM trade in Turkey and all over the world. These mushrooms not only have a wonderful apricot-like flavor but also a soft, non-crumbling texture. However, like all fresh EWM, *C. cibarius* deteriorate so quickly that once harvested from nature, rapidly progressive changes are observed in nutritional quality, biological activity, and physical and sensorial properties. Therefore, apart from traditional methods such as cooking, drying, freezing, and pickling, new processing technologies with different pretreatments and various post-harvest storage conditions are applied to extend the shelf life of *C. cibarius* mushrooms and to maintain their nutritional, phytochemical, and sensorial quality. This review focuses on recent studies on these different mushroom preservation and processing methods, and their effects on nutrients, bioactive compounds, sensorial and bioactivity properties of *C. cibarius*.

1. Introduction

Edible wild mushrooms (EWM) have been demanded and highly appreciated for being valuable sources of daily food, traditional medicine, and commercial income from ancient times to present (Azeem et al., 2020). They have been known as sustainable "forest meat" or "meat of poverty" which are not of animal origin in various countries (Dimitrijevic et al., 2018). Since EWM have a unique flavor and pleasant taste, healthy macro and micronutrients with high biological value, and health benefits owing to their mycochemicals, their consumption and global market value have expanded from year to year (Cateni et al., 2021; Niego et al., 2021). Their fresh or dried fruiting bodies and mycelia, and therapeutic, bioactive compounds and extracts have been incorporated as an ingredient to develop mushroom-based formulations of functional food, nutraceutical, nutriceutical, dietary supplement, mycopharmaceutical and cosmeceutical (Thakur, 2018; Üstün et al., 2018; Bulam et al., 2019a; Azeem et al., 2020; Badalyan & Rapior, 2020; Ho et al., 2020; Cateni et al., 2021).

Cantharellus cibarius Fr. is one of ectomycorrhizal EWM belonging to family Cantharellaceae and phylum Basidiomycota which is globally called as "Chanterelle" or "Golden Chanterelle". Chanterelle commonly lives in symbiosis with host trees of pine, spruce, oak, and hornbeam. It widely grows from June to October and is well-recognized as a delicacy in several European countries, Asia, America, and Africa. Its young fruiting bodies can be prepared by traditional culinary methods including frying, marinating, cooking, and preserved by freezing, drying etc. (Muszyńska et al., 2016a; Thu et al., 2020). Chantarelle is preferred in risotto dishes and omelets, tasty soups, or sauces to be served with chicken or fish dishes (Kozarski et al., 2015). In Europe, it was the second most collected EWM after Penny Buns as 188,000 tons year^{-1} (Lovrić et al., 2021) with an economic value of 1.0 billion € year^{-1} (Lovrić et al., 2020). On the other hand, it is considered as a natural adjuvant of traditional Asian and European Medicines in treatment of stomach, spleen, liver, lungs diseases, and eyesight improvement. It is also utilized in boils and abscesses and as an anthelmintic agent

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(Panchak et al., 2020). Moreover, Chantarelle decoction was recently used as a food ingredient to produce functional frankfurters with high antioxidant, antimicrobial properties, and low sensorial modifications (Novakovic et al., 2019; 2020).

In Turkey, *C. cibarius* is locally known as "Tavuk Mantarı, Sarı Mantar" (Pekşen et al., 2016; Bulam et al., 2018a) and "Tavuk Kirmiti, Horoz Mantarı" and "Yumurta Mantarı" (Pekşen & Kaplan, 2017) especially in Eastern Black Sea Region. It is consumed as food after sautéing and preserved by traditional culinary methods of freezing and pickling by households. It is also a commercially significant species which is both sold at local markets and exported abroad as fresh, dried, frozen, and pickled (Pekşen et al., 2016; Pekşen & Kaplan, 2017; Bulam et al., 2018a, b).

During post-harvest storage period, continuous quality degradation of fresh edible mushroom occurs with presenting cap expansion and opening, stipe elongation, discoloration, browning, moisture/weight loss, texture changes, microbial count increasing, and nutrient and flavor losses. The fast quality degradation is affected by both external factors related to storage conditions and internal factors related to mushroom structure. The short shelf life of seasonal edible mushrooms limits their economic value, preservation, storage, processing, distribution, marketing, value-addition, and consumer purchasing behavior (Ramteke et al., 2020; Marçal et al., 2021). Therefore, short-term and long-term preservation techniques including physical (packaging, irradiation, pulsed electric field, ultrasound), chemical (immersion/steeping/washing solutions, canning, edible coatings and films, fermentation/pickling, ozone, electrolyzed water) and thermal processes (drying, cooling, freezing) are essential in order to maintain the post-harvest quality and to extend shelf life of edible mushrooms. These preservation techniques change chemical composition of edible mushrooms and have effects on their nutritional value, bioactive and organoleptic properties, and commercial value (Xue et al., 2017; Thakur, 2018; Zhang et al., 2018; Ramteke et al., 2020; Marçal et al., 2021). This review evaluates the recent post-harvest preservation and processing methods with different pretreatments, various post-harvest storage conditions and their effects on nutrients and bioactive compounds, and sensorial and bioactivity properties of *C. cibarius*.

2. Nutritional Composition, Sensorial Properties, Bioactive Compounds, and Biological Activities of *C. cibarius*

C. cibarius possesses a significant nutritional value due to its high content of proteins (up to 53.7% dry weight (DW)), carbohydrates (31.9% DW), dietary fiber, and β-glucans as well as low levels of fat (2.9% DW). Its predominant fatty acids are linoleic and oleic acid (654.706 and 148.168 mg/kg DW, respectively). *C. cibarius* contains the highest amount of lysine and threonine as 5.74 and 8.98 mg/g DW, respectively (Muszyńska et al., 2016a; Nyman et al., 2016). It is rich in vitamins A, E, D_2 (10.7 mg/100 g fresh weight) and vitamin B complex as well as mineral compounds, such as potassium, calcium, and phosphorus with less selenium as 67411.93, 973.17, 5126.47, and 0.61 mg/kg DW, respectively (Muszyńska et al., 2016a; Bulam et al., 2019b). In terms of sensorial properties, its meaty, umami taste is caused by flavor of 5′-GMP (0.21 mg/g DW) and monosodium glutamate-like amino acids (30.05 mg/g DW) (Muszyńska et al., 2016a), bitter amino acids and 5′-GMP+5′-IMP (Manninen et al., 2018), C_{18}-acetylenic acids including octadecadien-12-ynoic acids, and octadecadienoic acids (Mittermeier et al., 2018). Its apricot-like, cooked carrot aromatic C_8 odor compounds were detected as octanal, (*E*)-2-octenal, 3-octanone, and (*E*)-2-octen-1-ol (Aisala et al., 2019).

Main groups of its bioactive primary and secondary metabolites were determined as indole groups, phenolic acids, flavonoids, organic acids, fatty acids, amino acids and 5′-nucleotides, carbohydrates, bioelements, vitamins, carotenoids, enzymes, sterols, and tocopherols (Muszyńska et al., 2016a; Nyman et al., 2016; Bulam et al., 2019b; Panchak et al., 2020; Thu et al., 2020). Its bioactive compounds may be potentially used in dietary supplements or drugs (Muszyńska et al., 2016a). Its polysaccharides show various biological activities such as antioxidant, antitumor, antiproliferative, anticancer, immunomodulatory, immunostimulatory, chemo preventive, neuroprotective, and prebiotic properties. Furthermore, its crude extracts have cardioprotective, antioxidant, antiaging, antimicrobial, antiviral, antihyperglycemic, antihyperlipidemic, antihypertensive, anti-inflammatory, antiangiogenic, antigenotoxic, antihypoxic, cytotoxic activities and angiotensin-converting enzyme (ACE), lipoxygenase (LOX) inhibition, and wound-healing potentials (Kozarski et al., 2015; Muszyńska et al., 2016a; Nasiry et al., 2017; Nowacka-Jechalke et al., 2018; Turfan et al., 2019; Azeem et al., 2020; Badalyan & Rapior, 2020; Thu et al., 2020; Marathe et al., 2021; Uthan et al., 2021).

3. Processing Methods and Their Effects on Nutrients, Sensorial Properties, Bioactive Compounds, and Biological Activities of *C. cibarius*

Fresh *C. cibarius* has previously been processed by various techniques including cooking, immersion, drying, fermentation/pickling, freezing, and packaging with different pretreatments and storage conditions. These methods have either negative or positive effects on nutritional, sensorial and bioactive compound qualities, and biological activities of *C. cibarius* of which recent applications were indicated in Table 1. Lactic acid fermentation was one of the recent preservation methods for *C. cibarius* blanched before the process, which was applied with different strains of *Lactobacillus*. Freezing and then lyophilization applications were conducted after fermentation (Jabłońska-Ryś et al., 2016). Freeze-drying (Muszyńska et al., 2016b), vacuum drying (Šumić et al., 2017), conventional drying (Drewnowska et al., 2017; Falandysz & Drewnowska, 2017; Politowicz et al., 2017), and vacuum microwave drying (Politowicz et al., 2017) were recently studied drying methods of *C. cibarius*. In addition, drying in a universal tunnel dryer (Salihović et al., 2021), drying in a food dryer, and in the sun (Kała et al., 2021) were the other drying techniques for *C. cibarius*. Furthermore, Novakovic et al. (2019) prepared a decoction for producing of *C. cibarius* based frankfurters with a thermal treatment without smoke after freezing while Novaković et al. (2020) cooked the frozen decoction at 80°C in a smokehouse before storage at 1-4°C for 60 days. Kała et al. (2021) incubated the dried mushrooms in gastric and intestinal juices to determine the increases of bioelements, their bioaccessability, and digestibility of *C. cibarius*. In another study, citric acid application was carried out for perforated or unperforated and modified atmosphere packaged *C. cibarius* that was stored for 12 days at 0°C and 90% relative humidity after process (Ozturk et al., 2021).

Table 1. Effects of various preservation and processing methods on nutrient, sensorial, bioactive compound qualities and bioactivities of *C. cibarius*

Preservation/Processing methods	Effects on Nutrient, Sensorial and Bioactive compound qualities	Effects on Biological activities	Reference
Lactic acid fermentation (LAF), firstly washing in cold tap water of 15°C, blanching (B) in boiling water for 4 min, fermentation with *Lactobacillus plantarum* Ib, *L. casei* Lby, and *L. helveticus* K_1Lb strains at 21-22°C for 8 d, storage at 5°C for 5 w. Freezing (F) at -20°C for 24 h, and then lyophilization (LY) for 72 h.	*L. plantarum* most effectively reduced pH of fermented mushrooms (FEM). Total phenolic content (TPC), FRAP, DPPH decreased in blanched samples (BS) (1.30 mg GAE/g DW, 5.77 µmol TE/g DW, 19.72 µmol TE/g DW, respectively) compared with fresh mushrooms (FM) (1.88 mg GAE/g DW, 16.56 µmol TE/g DW, 34.08 µmol TE/g DW, respectively). LAF exerted no significant effect on TPC in FEM, compared with BS. Use of different LAF bacterial strains had no significant effect on TPC in FEM. TPC decreased when FM were fermented. Total free phenolic acid (TFPA) decreased in BS and FEM, compared with FM. The highest TFPA was observed in *L. plantarum* FEM.	B caused a significant decrease in antioxidant activities (AA) of Chanterelles (C), compared with fresh ones. LAF had no significant influence on AA measured using DPPH, in comparison with BS. C fermented by using *L. plantarum* exhibited higher AA in comparison to mushrooms fermented with other *Lactobacillus* strains.	Jabłońska-Ryś et al., 2016
Freeze-drying (FD), boiling with 80 mL of distilled water at100°C for 60 min in Soxhlet apparatus, F, FD, extraction in artificial digestive juices at37°C of 10 mL saliva/1 min; 10 mL gastric/15, 60, 120 min; and 10 mL intestinal/150 min.	Zn released from thermally processed mushrooms ranged 0.44-5.37 mg/100 g DW, while it was found as 0.37-15.02 mg/100 g DW in unprocessed samples. For C, thermal processing resulted in a slight increase in release of Zn (3.83-4.99 mg/100 g DW) compared to unprocessed C (2.69-3.75 mg/100 g DW).	ND	Muszyńska et al., 2016b
Vacuum drying (VD) at 46-74°C, 2-58 kPa for 8.34-23.01 h.	Total solids (TS) (%), a_w, rehydration power (%) changed as 72.80-91.42, 0.514-0.876, and 53.08-72.23, respectively. ΔE, *L*, TPC (mg GAE/100 g DW), IC_{50} (mg/mL) were detected as 69.95-80.35, 16.25-28.88, 240.47-358.63, and 2.0202-5.0070, respectively. TS, ΔE, TPC increased; a_w, *L*, IC_{50} decreased compared to fresh samples**.**	IC_{50} and TPC in methanolic extract of fresh C were 8.011 mg/mL, 137.93 mg GAE/100 g DW, respectively. AA increased with decrease of IC_{50} value and increase of TPC.	Šumić et al., 2017
Conventional drying (CD) at 65°C, then 105°C. Deep freezing (DF) at -20°C for 1 month, FD. B in boiling deionized or potable water for 5 or 15 min, FD. B and then Pickling (P) in vinegar marinade at room temperature for 1 month, FD.	B of FM caused decrease of Cd by around 11 to 36%, while B of deep-frozen C by around 40%. A rate of Cd decrease in C was similar when C were blanched for 5 or15 min in deionized or potable water. P of blanched ones with diluted vinegar marinade had pronounced effect on further removal of Cd. Blanched + pickled C lost an extra 37-71% of Cd. Total leaching rate of Cd from fresh or deep-frozen C was between 77 and 91% when blanched, and then pickled.	ND	Drewnowska et al., 2017

ND: not determined.

Table 1. *Continued*

Preservation/Processing methods	Effects on Nutrient, Sensorial and Bioactive compound qualities	Effects on Biological activities	Reference
CD at 65°C, then 105°C. DF at -20°C for 1 month, FD. B in boiling deionized or potable water for 5 or 15 min, FD. B and then P at room temperature for 1 month, FD.	B of fresh C caused leaching of Hg by app. 15%, while loss of up to 35% was observed for B of deep-frozen C. Rate of Hg leaching from C was same when blanched for 5 or15 min irrespective of deionized or potable water used. P of blanched C with diluted vinegar marinade had minor effect on removal of Hg.	ND	Falandysz & Drewnowska, 2017
CD (50, 60, 70, 80°C), FD, vacuum microwave drying (VMD) (240, 480 W), and a combination of convective pre-drying and vacuum microwave finish drying (CPD-VMFD) (50-80°C+480 or240 W).	The most abundant aromatic volatile compounds (VC) in fresh samples were 1-hexanol, 1-octen-3-ol, 2-octen-1-ol. The highest contents of VC were found after CD at 80°C (129 µg/100 g DW), CPD-VMFD at 70°C-480 or240 W (136 µg/100 g DW) and CPD-VMFD at 80°C-480 or240 W (136 µg/100 g DW). The best dehydration method according to descriptive sensory analysis and PCA were CD at 70 and 80°C.	ND	Politowicz et al., 2017
Preparing a decoction for manufacturing of frankfurters (FR), preheating a mixture of 60 or120 g dry powdered mushroom and 2 L distilled water at 80°C, cooling, F. Thermal treatment without smoke. Storage (S) of FR at 1-4°C for 60 d.	Moisture and fat of FR decreased while protein increased compared to control group (CG). During S, all treatments increased in redness. All FR decreased in lightness after 60 days. There was decrease in yellowness during S, but on 60th day, it showed a significant increase compared to 1st day after production of F. On 60th day, there was decline in pH values compared to 1st day of S. FR had higher values than CG in terms of texture of hardness and chewiness during S. C addition in FR caused positive effects on sensorial features, odor, taste, and overall quality during 1st month.	Decoction of C exhibits neutralization of ABTS radical in dose-dependent manner with high antioxidant potency. EC_{50} was around 12 mg/mL. C decoction was most effective in inhibiting growth or killing of *Candida albicans*. C addition significantly reduced formation of total aerobic mesophilic bacteria during storage. In all three groups of FR, *Salmonella* spp., *Escherichia coli*, and *Listeria monocytogenes* were not detected.	Novakovic et al., 2019
Preparing a decoction for producing of FR, preheating mixture of 60 or120g dry powdered mushroom and 2 L distilled water at 80°C for 1 h, cooling, F. Cooking at 80°C in smokehouse, cooling. S of FR at 1-4°C for 60 d.	*Boletus edulis* FR contained the highest amount of phenolics, while C and *Craterellus cornicupioides* FR contained significantly lower levels of phenolics, on each day of S. On 1st S day, Thiobarbituric acid reactive substances (TBARs) for FR were significantly lower compared with control FR. On 60th S day, TBARs for C FR was 0.07 mg MDA/kg which was higher than values of other two FR.	AA of C decoction was lower than AA of *B. edulis* decoction according to DPPH. EC_{50} was around 7.41 mg/mL. Using conjugated diene method, at concentration of 10 mg/mL, lower AA of decoction was 22.36% for C, compared to other two mushrooms.	Novaković et al., 2020
Drying (D) in a universal tunnel dryer at 70°C for 4-5 h (processed mushrooms). S by cooling at 4°C (FM).	D did not have much effect on presence of essential and non-essential amino acids. Total carbohydrate in dried mushrooms (DM) was significantly higher than in extracts of FM. Lower vitamin C content was detected in DM.	ND	Salihović et al., 2021

ND: not determined.

Table 1. *Continued*

Preservation/Processing methods	Effects on Nutrient, Sensorial and Bioactive compound qualities	Effects on Biological activities	Reference
F, drying in a food dryer (DFD), drying in the sun (DS) and LY. Incubation in gastric juice (pepsin, NaCl, HCl) for 15 or 60 min, and in intestinal juice ($NaHCO_3$, pancreatin, bile salts) for 150 min.	Fresh samples were a more valuable source of bioelements except Fe than frozen C. LY and DS were more advantageous than other methods in terms of increases of bioelements (Mg, Zn, Fe, Cu), their bioaccessibility (BA), and digestibility of mushrooms in *in vitro*-simulated gastrointestinal digestion system. BA of Mg and Zn was the highest, at almost 100%.	ND	Kała et al., 2021
Citric acid (CA) application, perforated or unperforated, modified atmosphere packaging (MAP) (17 and 23 µm film thickness). S at 0°C and 90% relative humidity for 12 d.	MAP significantly reduced weight loss and decay compared to control. During S, significant increases were observed in protein, ash, dry matter, vitamin C, and TPC. At end of S, citric acid+23 µm thick non-perforated low-density polyethylene [LDPE (CANP23)] treatment for the highest protein; control and distilled water+23 µm thick non-perforated LDPE (NP23) for the highest vit C; citric acid+17 µm thick perforated LDPE (CAP17) for the highest TPC were determined.	During S period, significant increases was observed in AA. At end of S, NP23 for the highest AA was determined.	Ozturk et al., 2021

ND: not determined.

4. Conclusions

Both traditional and novel preservation and processing methods have recently been applied to extend shelf life and improve nutritional, bioactivity, and commercial values of *C. cibarius*. Among these applications, cooking with/without smoke, fermentation, pickling, freezing, various drying techniques, citric acid immersion, and modified atmosphere packaging can be recommended to utilize for post-harvest preservation of fresh *C. cibarius* due to enhancing amounts of its dry matter, ash, protein, vitamin C, and bioelement contents. Furthermore, it was indicated that these methods increased total phenolic contents, aromatic volatile compounds, sensorial features, Δ*E* values, removal of heavy metals, releasing of bioelements, and antioxidant, antimicrobial activities of *C. cibarius* and *C. cibarius* decoction added functional foods. However, some preserving and processing methods including blanching, lactic acid fermentation, vacuum, and hot air drying had some disadvantages on nutrient, phytochemical, sensorial qualities, and bioactivities of *C. cibarius* such as decreasing in its total phenolic, total free phenolic acid, vitamin C contents, *L* values, and antioxidant activities. Further studies should be conducted to preserve and advance food quality of *C. cibarius* for off season scientific, industrial, and household utilization.

Declaration of competing interest

The authors declare no conflict of interest.

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References

Aisala, H., Sola, J., Hopia, A., Linderborg, K. M., & Sandell, M. (2019). Odor-contributing volatile compounds of wild edible Nordic mushrooms analyzed with HS–SPME–GC–MS and HS–SPME–GC–O/FID. *Food Chemistry*, *283*, 566-578. https://doi.org/10.1016/j.foodchem.2019.01.053

Azeem, U., Hakeem, K. R., & Ali, M. (2020). Commercialization and conservation. Fungi for Human Health(pp. 97-106). Switzerland: Springer. https://doi.org/10.1007/978-3-030-58756-7_8

Badalyan, S. M., & Rapior, S. (2020). Perspectives of biomedical application of macrofungi. *Current Trends in Biomedical Engineering & Biosciences, 19*, 556024. http://doi.org/10.19080/CTBEB.2020.19.556024

Bulam, S., Üstün, N. Ş., and Pekşen, A. (2018a). The most popular edible wild mushrooms in Vezirköprü District of Samsun Province. *Turkish Journal of Agriculture - Food Science and Technology*, *6*, 189-194. https://doi.org/10.24925/turjaf.v6i2.189-194.1547

Bulam, S., Üstün, N. Ş., & Pekşen, A. (2018b). Mushroom foreign trade of Turkey in the last decade. International Congress on Engineering and Life Science (ICELIS 2018), Kastamonu, Turkey.

Bulam, S., Pekşen, A., & Üstün, N. Ş. (2019a). Yenebilir ve tıbbi mantarların gıda ürünlerinde kullanım potansiyeli. *Mantar Dergisi*, *10*, 137-151. https://doi.org/10.30708.mantar.644367

Bulam, S., Üstün, N. Ş., & Pekşen, A. (2019b). Yenebilir doğa mantarlarının bazı fiziksel ve fizikokimyasal özellikleri ile mineral madde içeriklerinin belirlenmesi. *Mantar Dergisi*, *10*, 193-203. https://doi.org/10.30708.mantar.638995

Bulam, S., Üstün, N. Ş., & Pekşen, A. (2021). Effects of different processing methods on nutrient and bioactivity properties of Chanterelle mushroom (*Cantharellus cibarius*): A review. International Online Conferences on Engineering and Natural Sciences (IOCENS'21) Abstract Book, Gümüşhane, Turkey.

Cateni, F., Gargano, M. L., Procida, G., Venturella, G., Cirlincione, F., & Ferraro, V. (2021). Mycochemicals in wild and cultivated mushrooms: nutrition and health. *Phytochemistry Reviews*, 1-45. https://doi.org/10.1007/s11101-021-09748-2

Dimitrijevic, M. V., Mitic, V. D., Jovanovic, O. P., Stankov Jovanovic, V. P., Nikolic, J. S., Petrovic, G. M., & Stojanovic, G. S. (2018). Comparative study of fatty acids profile in eleven wild mushrooms of Boletacea and Russulaceae families. *Chemistry & Biodiversity*, *15*, e1700434. https://doi.org/10.1002/cbdv.201700434

Drewnowska, M., Hanć, A., Barałkiewicz, D., & Falandysz, J. (2017). Pickling of Chanterelle *Cantharellus cibarius* mushrooms highly reduce cadmium contamination. *Environmental Science and Pollution Research, 24*, 21733-21738. https://doi.org/10.1007/s11356-017-9819-2

Falandysz, J., & Drewnowska, M. (2017). Cooking can decrease mercury contamination of a mushroom meal: *Cantharellus cibarius* and *Amanita fulva*. *Environmental Science and Pollution Research, 24*, 13352-13357. https://doi.org/10.1007/s11356-017-8933-5

Ho, L. H., Zulkifli, N. A., & Tan, T. C. (2020). Edible mushroom: Nutritional properties, potential nutraceutical values, and its utilisation in food product development. An Introduction to Mushroom (pp. 1-19). IntechOpen. http://dx.doi.org/10.5772/intechopen.91827

Jabłońska-Ryś, E., Sławińska, A., & Szwajgier, D. (2016). Effect of lactic acid fermentation on antioxidant properties and phenolic acid contents of Oyster (*Pleurotus ostreatus*) and Chanterelle (*Cantharellus cibarius*) mushrooms. *Food Science and Biotechnology, 25*, 439-444. https://doi.org/10.1007/s10068-016-0060-4

Kała, K., Krakowska, A., Zięba, P., Opoka, W., & Muszyńska, B. (2021). Effect of conservation methods on the bioaccessibility of bioelements from *in vitro*-digested edible mushrooms. *Journal of the Science of Food and Agriculture, 101*, 3481-3488. https://doi.org/10.1002/jsfa.10979

Kozarski, M., Klaus, A., Vunduk, J., Zizak, Z., Niksic, M., Jakovljevic, D., Vrvic, M. M., & Van Griensven, L. J. L. D. (2015). Nutraceutical properties of the methanolic extract of edible mushroom *Cantharellus cibarius* (Fries): Primary mechanisms. *Food & Function, 6*, 1875-1886. https://doi.org/10.1039/c5fo00312a

Lovrić, M., Da Re, R., Vidale, E., Prokofieva, I., Wong, J., Pettenella, D., Verkerk, P. J., & Mavsar, R. (2020). Nonwood forest products in Europe – A quantitative overview. Forest Policy and Economics, *116*, 102175. https://doi.org/10.1016/j.forpol.2020.102175

Lovrić, M., Da Re, R., Vidale, E., Prokofieva, I., Wong, J., Pettenella, D., Verkerk, P. J., & Mavsar, R. (2021). Collection and consumption of non-wood forest products in Europe. *Forestry: An International Journal of Forest Research, 94*, 757-770. https://doi.org/10.1093/forestry/cpab018

Manninen, H., Rotola-Pukkila, M., Aisala, H., Hopia, A., & Laaksonen, T. (2018). Free amino acids and 5′-nucleotides in Finnish forest mushrooms. *Food Chemistry, 247*, 23-28. https://doi.org/10.1016/j.foodchem.2017.12.014

Marathe, S. J., Hamzi, W., Bashein, A. M., Deska, J., Seppänen-Laakso, T., Singhal R. S., & Shamekh, S. (2021). Anti-angiogenic effect of *Cantharellus cibarius* extracts, its correlation with lipoxygenase inhibition, and role of the bioactives therein. *Nutrition and Cancer*, 1-11. https://doi.org/10.1080/01635581.2021.1909739

Marçal, S., Sousa, A., S., Taofiq, O., Antunes, F., Morais, A. M. M. B., Freitas, A. C., Barros, L., Ferreira, I. C. F. R., & Pintado, M. (2021). Impact of postharvest preservation methods on nutritional value and bioactive properties of mushrooms. *Trends in Food Science & Technology, 110*, 418-431. https://doi.org/10.1016/j.tifs.2021.02.007

Mittermeier, V. K., Dunkel, A., & Hofmann, T. (2018). Discovery of taste modulating octadecadien-12-ynoic acids in Golden Chanterelles (*Cantharellus cibarius*). *Food Chemistry, 269*, 53-62. https://doi.org/10.1016/j.foodchem.2018.06.123

Muszyńska, B., Kała, K., Firlej, A., & Sułkowska-Ziaja, K. (2016a). *Cantharellus cibarius* - Culinary-medicinal mushroom content and biological activity. *Acta Poloniae Pharmaceutica - Drug Research, 73*, 589-598.

Muszyńska, B., Zając, M., Kała, K., Rojowski, J. & Opoka, W. (2016b). Thermal processing can affect zinc availability in some edible mushrooms. *LWT - Food Science and Technology, 69*, 424-429. http://dx.doi.org/10.1016/j.lwt.2016.01.078

Nasiry, D., Khalatbary, A. R., & Ebrahimzadeh, M. A. (2017). Anti-inflammatory and wound-healing potential of Golden Chanterelle mushroom, *Cantharellus cibarius* (Agaricomycetes). *International Journal of Medicinal Mushrooms, 19*, 893-903. https://doi.org/10.1615/IntJMedMushrooms.2017024674

Niego, A. G., Rapior, S., Thongklang, N., Raspé, O., Jaidee, W., Lumyong, S., & Hyde, K. D. (2021). Macrofungi as a nutraceutical source: Promising bioactive compounds and market value. *Journal of Fungi, 7*, 397. https://doi.org/10.3390/jof7050397

Novakovic, S., Djekic, I., Klaus, A., Vunduk, J., Djordjevic, V., Tomović, V., Šojić, B., Kocić-Tanackov, S., Lorenzo, J. M., Barba, F. J., &

Tomasevic, I. (2019). The effect of *Cantharellus cibarius* addition on quality characteristics of frankfurter during refrigerated storage. *Foods, 8*, 635. https://doi.org/10.3390/foods8120635

Novaković, S., Đekic, I., Klaus, A., Vunduk, J., Đorđević, V., Tomović, V., Šojić, B., Koćić-Tanackov, S., & Tomašević, I. (2020). Antioxidant activity of mushrooms *in vitro* and in frankfurters. *Meat Technology, 61*, 62-69. https://doi.org/10.18485/meattech.2020.61.1.5

Nowacka-Jechalke, N., Nowak, R., Juda, M., Malm, A., Lemieszek, M., Rzeski, W., & Kaczyński, Z. (2018). New biological activity of the polysaccharide fraction from *Cantharellus cibarius* and its structural characterization. *Food Chemistry, 268*, 355-361. https://doi.org/10.1016/j.foodchem.2018.06.106

Nyman, A. A. T., Aachmann, F. L., Rise, F., Ballance, S., & Samuelsen, A. B. C. (2016). Structural characterization of a branched (1 → 6)-α-mannan and β-glucans isolated from the fruiting bodies of *Cantharellus cibarius*. *Carbohydrate Polymers, 146*, 197-207. http://dx.doi.org/10.1016/j.carbpol.2016.03.052

Ozturk, B., Havsut, E., & Yildiz, K. (2021). Delaying the postharvest quality modifications of *Cantharellus cibarius* mushroom by applying citric acid and modified atmosphere packaging. *LWT - Food Science and Technology, 138*, 110639. https://doi.org/10.1016/j.lwt.2020.110639

Panchak, L. V., Ya Antonyuk, L., Zyn, A. R., & Antonyuk, V. (2020). Extractive substances of fruit body Golden Chanterelle (*Cantharellus cibarius* Fr.) and Hedgehog mushroom (*Hydnum repandum* Fr.). Emirates *Journal of Food and Agriculture, 32*, 826-834. https://doi.org/10.9755/ejfa.2020.v32.i11.2195

Pekşen, A., Bulam, S., & Üstün, N. Ş. (2016). Edible wild mushrooms sold in Giresun local markets. 1st International Mediterranean Science and Engineering Congress (IMSEC 2016), Adana, Turkey.

Pekşen, A., & Kaplan, M. (2017). Ordu ilinin ekonomik öneme sahip yenilebilen doğa mantarları. *Akademik Ziraat Dergisi, 6*, 335-342.

Politowicz, J., Lech, K., Sánchez-Rodríguez, L., Szumny, A., & Carbonell-Barrachina, Á. A. (2017). Volatile composition and sensory profile of *Cantharellus cibarius* Fr. as affected by drying method. *Journal of the Science of Food and Agriculture, 97*, 5223-5232. https://doi.org/10.1002/jsfa.8406

Ramteke, A. Y., Nayak, A., Sagar, A., Kesari, S. K., & Ramteke, P. W. (2020). Recent advances in mushrooms preservation. *International Journal of Chemical Studies, 8*, 2376-2381. e-ISSN: 2321-4902

Salihović, M., Pazalja, M., Huremović, M., Ajanović, A., & Tahirović, I. (2021). Chemical ingredients of fresh and dry wild mushrooms from Bosnia and Herzegovina. *Asian Journal of Pharmaceutical Research and Health Care, 13*, 1-9. https://doi.org/10.18311/ajprhc/2021/27646

Šumić, Z., Tepić, A., Vidović, S., Vakula, A., Vladić, J., & Pavlić, B. (2017). Process optimization of Chanterelle (*Cantharellus cibarius*) mushrooms vacuum drying. *Journal of Food Processing and Preservation, 41*, e12822. https://doi.org/10.1111/jfpp.12822

Thakur, M. P. (2018). Advances in post-harvest technology and value additions of edible mushrooms. *Indian Phytopathology, 71*, 303-315. https://doi.org/10.1007/s42360-018-0060-9

Thu, Z. M., Myo, K. K., Aung, H. T., Clericuzio, M., Armijos, C., & Vidari, G. (2020). Bioactive phytochemical constituents of wild edible mushrooms from Southeast Asia. *Molecules, 25*, 1972. https://doi.org/10.3390/molecules25081972

Turfan, N., Ayan, S., Akın, Ş. S., & Akın, E. (2019). Nutritional and antioxidant variability of some wild and cultivated edible mushrooms from Kastamonu rural areas. *Turkish Journal of Agriculture - Food Science and Technology, 7*, 11-16. https://doi.org/10.24925/turjaf.v7isp3.11-16.3094

Uthan, E. T., Senturk, H., Uyanoglu, M., & Yamaç, M. (2021). First report on the *in vivo* prebiotic, biochemical, and histological effects of crude polysaccharide fraction of Golden Chantharelle mushroom, *Cantharellus cibarius* (Agaricomycetes). *International Journal of Medicinal Mushrooms, 23*, 67-77. https://doi.org/10.1615/IntJMedMushrooms.2021038233

Üstün, N. Ş., Bulam, S., & Pekşen, A. (2018). The use of mushrooms and their extracts and compounds in functional foods and nutraceuticals. 1. International Technological Sciences and Design Symposium (ITESDES 2018), Giresun, Turkey.

Xue, Z., Hao, J., Yu, W., & Kou, X. (2017). Effects of processing and storage preservation technologies on nutritional quality and biological activities of edible fungi: A review. *Journal of Food Process Engineering, 40*, e12437. https://doi.org/10.1111/jfpe.12437

Zhang, K., Pu, Y. Y., & Sun, D. W. (2018). Recent advances in quality preservation of postharvest mushrooms (*Agaricus bisporus*): A review. *Trends in Food Science & Technology, 78*, 72-82. https://doi.org/10.1016/j.tifs.2018.05.012