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Techno-functional, Nutritional and Sensorial Qualities of Raw, Brined and Dried Mushrooms (*Pleurotus ostreatus*) Produced on Oil Palm By- Products in Benin

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Authors' contributions

This work was carried out in collaboration among all authors. The author UPT designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. The author ZY is the student who had undergone the data collection and bibliographical review for discussion. The authors UPT and CDG managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Edible mushrooms consumed in Benin include a diversity of species including oyster mushrooms (*Pleurotus ostreatus*). This Oyster mushroom production is increasing in the South of the country. The study aims to evaluate their techno-functional, nutritional and sensory properties in order to optimize their exploitation in food technology and gastronomy. Therefore, 900g of *Pleurotus ostreatus* were produced on Oil Palm By- Products and divided into three lots of 300g for the study. Lot 1 was used to evaluate the techno-functional and nutritional parameters of fresh mushrooms. Lot 2 was brined while lot 3 was dried. Samples from all three lots were collected and used to study the variability in sensory quality by treatment. The study shows that *Pleurotus ostreatus* mushrooms produced in Benin have several technological-functional and nutritional benefits that can be used for food security. The luminance values (L*), red index (a*) and yellow index (b*) for fresh oyster mushrooms were respectively 74.6, 2.78 and 26.35. The hue value and the chroma value of the raw mushrooms were respectively of 5.98 and 26.49. The pH of fresh oyster mushrooms was 6.35. The water holding capacity was 11.85% and the technological yield was 88.15%. Nutritionally, the dry matter, fat, ash and protein content of the *Pleurotus ostreatus* were 9.8%, 2.6%, 6.7%, and 14.78% respectively. About sensorial quality, fresh and brined mushrooms were better appreciated than dried mushrooms. Overall, *Pleurotus ostreatus* mushrooms produced in palm residues have several techno-functional and nutritional assets and may be promoted for food and nutritional security.

Keywords: Benin; mushrooms; nutrients; palm by-products; sensorial profile; processing traits.

1. INTRODUCTION

Mushrooms are widely exploited by African rural populations mainly as food [1,2] and/or as a source of income [3,4]. They contribute significantly to household food security, especially in rural West Africa [5,6]. More than 200 species of mushrooms have long been used as functional foods worldwide [7], but only 35 species have been grown commercially [8,9]. They are a rich source of nutrients, especially protein, minerals and vitamins B, C and D [10]. Mushrooms contain 20-35% of protein (dry weight), are low in fat and contain the nine essential amino acids [11]. Mushrooms are delicacies appreciated for their characteristic texture and pleasant flavor. They have received particular attention from food and pharmaceutical researchers because of their bioactive components [12,13]. These biomolecules, such as phenolic compounds, terpenes, steroids and polysaccharides, have many biological activities [14]. Mushrooms can have health benefits due to a multitude of compounds with not only antifungal activity [15], antigenoxicity [16], antioxidant [17], antiproliferative [18], anti-carcinogenic [19], antihyperlipidemic [20], anti-hypertensive and anti-nociceptive, but also for their immunostimulation properties [21], hypocholesterolemia [22]. They are also capable of reducing stress and are good for diabetic patients [23]. Mushrooms are generally low in saturated fat, rich in fiber and protein, and can reduce harmful blood cholesterol and act as appetite suppressants [24]. Mushrooms of the genus Pleurotus occupy the second place on the world market of mushrooms and whose production of the species *P. ostreatus* is increasing in Benin.

The Pleurotus spp. of the basidiomycete class belongs to a group known as 'white rot mushroomsi' [25], as they produce white mycelium and are generally grown on non-comcomposted lignocellulosic substrates [26] in which various species of Pleurotus are commercially cultivated and have considerable economic value, including *P. ostreatus* (oyster mushrooms), *P. eryngii* (royal oyster or Cardoncello), *P. pulmonarius* (phoenix mushroom), *P. djamor* (pink oyster), *P. sajor-caju* (Indian oyster), *P. cystidiosus* (abalone oyster), *P. citrinopieatus* (golden oyster) and *P. cornucopiae* [27-29].

To enhance the value of *P. ostreatus* mushrooms in the food chain in Benin, it is necessary to characterize their technological, nutritional and sensory properties. The objective of this study is to evaluate the techno-functional, proximate composition and sensory properties of *P. ostreatus*. Specifically, it is to: determine the pH, water holding capacity, processing yield, trichromatic colour (L*, a*, b*) of raw *Peurotus ostreatus*; evaluate the nutritional quality of raw *Peurotus ostreatus*;

Determine the variation of sensorial quality of *P. ostreatus* fresh accrding to the processing methods and brine concentrations.

2. MATERIALS AND METHODS

2.1 Area of Study

The study was carried out jointly within the Research Unit in Tropical Mycology and Soil-Plant-Mushroom Interactions (UR-MyTIPS), and the Unit of Quality and Safety of Agro-Products/LaRAEQ of the Faculty of Agronomy, University of Parakou in Benin. The town of Parakou (Fig. 1) is located in the Borgou Department (2º39-2°53 East Longitude and 9°6-9°21 North Latitude). This region is characterized by a Sudanese climate with alternating rainy season (May to October) and dry season (November to April). The annual rainfall is between 858 and 1400 mm, with an average of 1125 mm and the average annual temperature varies between 26 and 27°C.

In this region, there is a wide range of non-wood forest products (NWFPs) including edible wild mushrooms widely exploited by rural populations as food and as a source of income.

2.2 Methodology

2.2.1 Preparation of mushroom samples

The mushrooms used for the study belong to the genus Pleurotus and more specifically the species *P. ostreatus*. 900g of *P. ostreatus* were produced on Oil Palm By-Products and divided into three lots of 300g for the study. Lot 1 was used to evaluate the techno-functional and nutritional parameters of fresh mushrooms. Lot 2 was brined while lot 3 was dried. Samples from all three lots were collected and used for the evaluation sensory quality variation by treatment.

Mushrooms of the lot2 were brined in sterile brine of sodium chloride of 10 g/L. Preservation in brine was performed using sodium chloride solution. The brine concentrations were prepared by dissolving salt in water, boiling for 15 minutes at 99°C, cooling at 22 to 25°C, decanting and filtering. The mushrooms and brine were put into glass jars of 250 ml and sealed. They were kept in a dark place for one week at 20 to 22°C and then sensorial analyzed. The dried mushrooms of the lot3 were produced using an electric dryer at a temperature of -65°C after cutting the carpophores, washing and draining. The finished product obtained is packaged in a plastic packaging to avoid moisture.

2.2.2 Determination of water holding capacity (CRE), pH and color of fresh mushrooms

With respect to the technological quality of oyster mushrooms (*P. ostreatus*), the pH was measured in a 50 g shred of fresh oyster mushrooms (*P. ostreatus*) using a HANNA pH meter with a specialized probe. This device has been calibrated with two pH meter standards: pH = 4.1 and pH = 7.1 according to a procedure provided by the manufacturer (HANNA Instrument ®, Italy).

The water-holding capacity and the yield after cooking were also determined on fresh oyster mushrooms from the loss of juice during the cooking of the carpophore slices using bain marie at 99°C for 30 minutes. The losses of juice during cooking of the carpophore slices of fresh oyster mushrooms taken and weighed were obtained by calculating the difference in mass of the sample before and after cooking.

The colour of the fresh mushrooms was determined according to the standards of the International Lighting Committee (CIE) using a CR-410 colorimeter in the trichromatic system (CIELAB L* a* b*) after calibration of the apparatus [30,31]. The value L* or luminosity indicates the product brightness or darkness and varies from 0 (black) to 100 (white). The value of a* (chromaticity coordinate) represents an indicator of green (-) and red (+). The value of b* is an indicator of blue (-) and yellow (+). The hue values were calculated using a* and b* values according to the following formula: hue = $\tan^{-1}$(b*/a*). Chroma (C*) represents the color saturation. Chroma value was calculated according to the following formula: C* = (a*2 + b*2)1/2.

2.2.3 Assessing the nutritional quality of mushrooms

Dry matter, ash, fat and protein levels were determined according to the standard procedures recommended by AOAC [32].

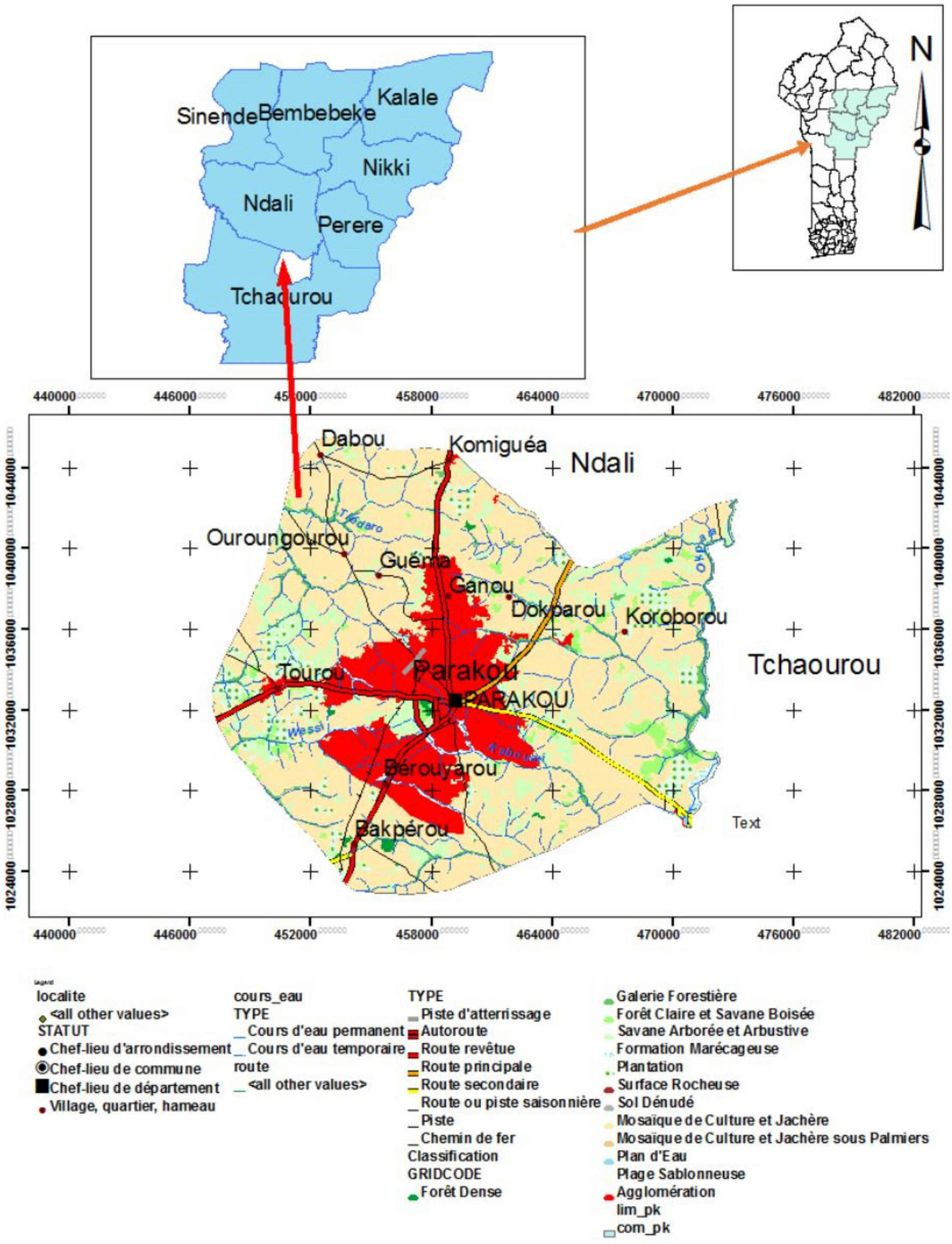

Fig. 1. Area of study

The water content was determined gravimetrically in accordance with the standard NF V 04- 401 of April 2001. For each measurement, 3 replicates were performed.

The fat content was determined in accordance with the standard NF V 04-402 of January 1968 (ISO 1443: 1973). For each measurement, 2 replicates were performed.

The total ash content was determined according to the standard NF V 04-404 of April 2001. The protein content was determined using the Kjeldahl method in accordance with the standard NF V 04-407 of September 2002, according to the following principles:

- mineralization of the test sample with H_2SO_4 in the presence of a catalyst (Kjeldahl pellet);
- Distillation of NH_4 and collection in H_3BO_3;
- Titration of the solution by a solution of HCl 1N;
- Determination of nitrogen content (TN) and calculation of protein content (TP = 6.25TN.

2.2.4 Evaluation of the sensorial attributes of raw, brined and dried oyster mushrooms

The sensorial analysis was carried out on the carpophores of raw, brined and dried oyster mushrooms according to the standard ISO 13299:2016 by a jury panels of 10 assessors selected randomly among the potential mushroom consumers. For the tasting, identical samples of pieces of *P. ostreatus* of each type (Fresh, brined vs Dried) were used as ingredients in the preparation of omelet per lot under the same conditions without seasoning. The jury members received the homologous cuts belonging to the same lot and completed a tasting scores grid (Scales ranging from 1 to 5). They assessed 4 important sensorial traits: texture, color, flavor and juiciness. For texture scoring, 1 corresponds to very hard, 2 is hard, 3 is acceptable, 4 is tender and 5 is very tender. As for juiciness, 1 corresponds to very dry, 2 to dry, 3 to acceptable, 4 to mellow and 5 to very mellow. Flavor intensity scales were very low (1), low (2), acceptable (3), strong (4) and very strong (5). For color, 1 corresponds to very unattractive, 2 to unattractive, 3 to acceptable, 4 to quite attractive and 5 to very attractive. Finally, a Global product acceptability rating from 1 to 5 was given per sample.

For the study of the effect of brine concentration on the sensory quality of brined mushrooms, 100g of fresh mushroom samples from Lot 2 were then divided into four subsamples (SC1, SC2, SC3 and SC4) and pickled in brine of 5 g/L, 7.5 g/L, 10 g/L and 12.5 g/l. respectively and then stored for a week at room temperature. The judges also assessed the tenderness, color, flavor, juiciness and overall acceptability of each type of brined mushroom.

2.3 Statistical Analysis

The data collected were analyzed with the software Statistical Analysis System [33]. The Generalized Linear Model (GLM) procedure was used for variance analysis. The proc mean procedure was used to determine standard averages and errors. The averages were compared two to two by the Student t-test.

3. RESULTS AND DISCUSSION

3.1 Techno-functional and nutritional quality of fresh mushrooms

The values of the technological and nutritional parameters of the *Pleurotus ostreatus* mushrooms obtained are reported in Tables 1 and 2 respectively.

The pH value was 6.35. The water retention capacity is 11.85%. The technological cooking Yield was 88.15%. The color of the fresh mushrooms determined according to the standards of the International Committee of Lighting (CIELAB L* a* b*) indicates that the values of brightness (L*), the index of red (a*) and the index of yellow (b*) are respectively 74.6, 2.78 and 26.35. The hue value and the chroma value were respectively of 5.98 and 26.49.

For nutritional values, the dry matter, fat, ash and protein content of *Pleurotus ostreatus* were 9.8%, 2.4%, 6.8%, and 22.6% respectively.

The results of this study show that *P. ostreatus* mushrooms are an excellent source of protein. This mushroom could thus play a crucial role in the coverage of the protein needs of the Beninese population due to the emergence and increase of its production which ensures its availability. The promotion of its mass culture will certainly increase its availability, accessibility and use for the food security of the population [34].

Table 1. Technological quality of raw *Pleurotus ostreatus*

Variables	Mean	Standard Error
pH	6.35	0.01
Water Holding Capacity (%)	11.85	0.2
Technological cooking yield (%)	88.15	0.2
L*	74.6	0.6
a*	2.78	0.2
b*	26.35	0.3
Hue (H*)	5.98	0.01
Chroma (C*)	26.49	0.2

Table 2. Nutritional quality of raw *Pleurotus ostreatus*

Variables	Mean	Standard Error
Dry matter content (g/100g of Raw matter)	9.8	0.02
Protein content (g/100g of dry matter)	22.6	0.1
Fat content (g/100g de of dry matter)	2.4	0.1
Ash content (g/100g de of dry matter)	6.8	0.02

The protein and mineral levels of the oyster mushrooms recorded herein are comparable to those of the species of *Pleurotus geesteranus* used in the study by Patil et al. [35]. Similarly to the results of these authors, *P. ostreatus* mushrooms in this study is very poor in fat. Such low lipid content have also been reported by Anno et al. [36] in *Psathyrella tuberculata* (1.78g/100 g), *Lentinus squarrosulus* (0.92 g/100 g), *Volvariella volvacea* (2.27 g/100 g), and *Auricularia polytrich* (4.55 g/100 g) in Côte d'Ivoire. However, the fat concentration obtained in this study is higher than reported by Patil et al. [35]. This difference in concentration may be related to the variety of substrates used by the authors for the mushroom production. Introducing oyster mushrooms into household diets can help reduce the risk of obesity [24].

Furthermore, the values of the technological and nutritional parameters of *Pleurotus ostreatus* mushrooms obtained in this study are comparable to those reported in the literature [24,37-39]. According to Panjikkaran et al. [40], mushrooms are a rich source of nutrients, particularly protein, minerals and vitamins B, C and D. Mushrooms are generally poor in saturated fat and rich in fiber and protein, and can reduce harmful blood cholesterol and act as appetite suppressants [24,41,42].

Water holding capacity is an important technological parameter in food quality and influences juiciness [43]. The values recorded in this study are technological indicators and show that these mushrooms can be preserved by drying or brining. Products with good water holding capacity are characterized by low weight loss during storage and processing into cooked products [30,31].

3.2 Variation of Sensorial Quality of Raw, Dried and Pickled Mushrooms

Overall, the raw *P. ostreatus* and brined *P. ostreatus* were better appreciated than mushrooms dried after cooking in bain marie at 95°C for 1 hour without seasoning. The variability in tenderness, juiciness, flavor, color and overall acceptance scores is represented by the radar graph in Fig. 2.

3.3 Effect of Brine Concentration on Sensory Quality of Pickled Mushrooms

Variability in sensory quality of pickled mushrooms at 5 g/L, 7.5 g/L, 10 g/L and 12,5 g/l is recorded in Fig. 3. It is apparent that pickling of mushrooms at 10g/l had the highest scores for all sensory parameters measured followed by pickled mushrooms at 7.5 g/L, 5g/L g/l and 12.5 g/l.

Overall, it comes out from the study that raw and brined *Pleurotus ostreatus* mushrooms were more appreciated organoleptically than dried mushrooms. This preference for fresh products over processed products would be related to the fact that fresh raw materials contain the integrity of their nutrients and better preserve their flavor, taste and appetiteness after cooking. An increased concentration of 0.5 % sodium chloride led to the improvement of sensorial attributes of mushrooms. The salt protects the brined mushrooms from alteration and improves their acceptability [44].

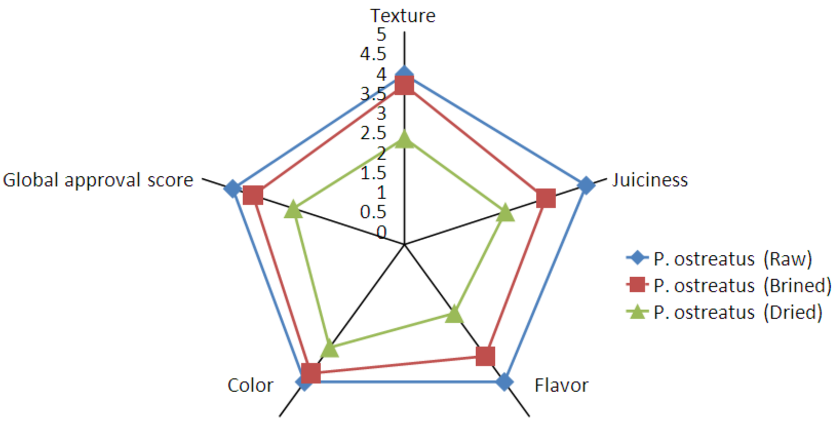

Fig. 2. Sensorial quality of raw, brined and dried mushrooms

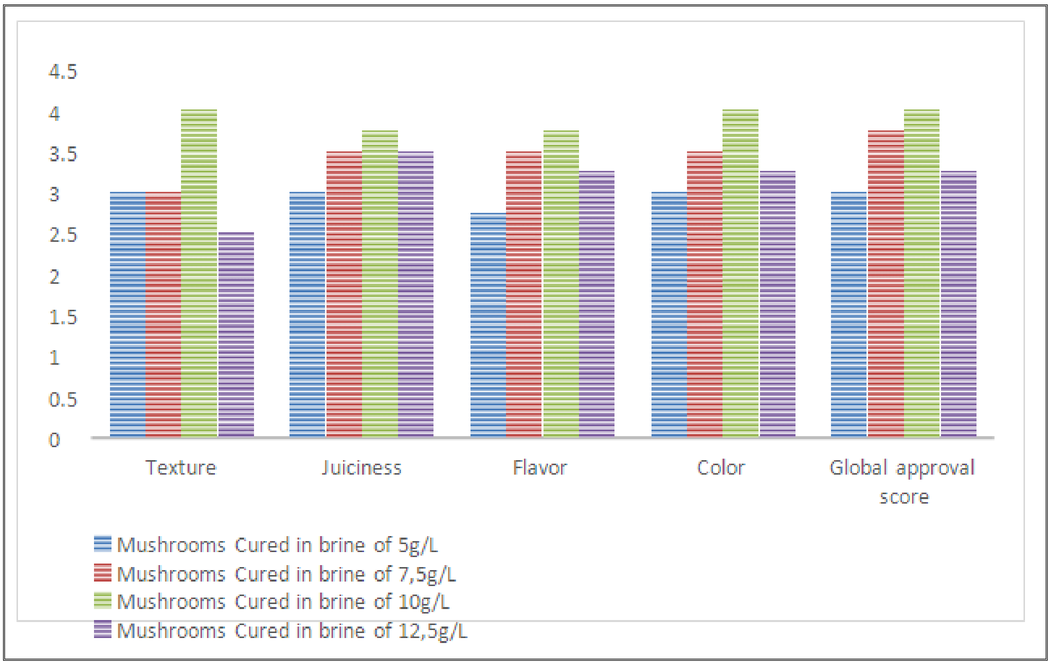

Fig. 3. Effect of brine concentration on sensory quality of brined mushrooms

The excellent processing traits of oyster mushrooms by brining or drying show that they can be used in culinary technology, particularly in pastry and egg-product industries. Kalacˇ et al. [11] reported that mushrooms received particular attention from food and pharmaceutical researchers because of their bioactive constituents [12,45,13]. These biomolecules, such as phenolic compounds, terpenes, steroids and polysaccharides, have many biological activities [14]. Mushrooms can have health benefits due to a multitude of compounds with not only antifungal activity [15], antigenoxicity [16], antioxidant [17], antiproliferative [18], anti- carcinogenic [19], antihyperlipidemic [20], anti-hypertensive and anti-nociceptive, but also for their immune-ostimulation properties [21], hypo-cholesterolemia [22]. They are also capable of reducing stress and are good for diabetic patients [23].

4. CONCLUSION

Overall, *Pleurotus ostreatus* mushrooms prduced in palm residues in Benin have several nutritional assets with protein levels comparable to those of rabbit meat. In addition, this mushroom is low in fat and rich in minerals. Its production may be promoted for food and nutritional security. The luminance values (L*), the red index (a*) and the yellow index (b*) recorded and the pH of the slightly acid oyster mushrooms confirm that *Pleurotus ostreatus* can be assimilated to white meat. The water retention capacity is 11.85% the cooking technology of 88.15% indicates that *Pleurotus ostreatus* can be well preserved by desiccation or brining. On the sensory side, the fresh brined Oyster mushrooms better preserve their flavor and taste during cooking. It would also be interesting to continue the current work by determining the fatty acid composition of *Pleurotus ostreatus*.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sileshi GW, Tibuhwa DD, Mlambo A. Underutilized wild edible fungi and their undervalued ecosystem services in Africa. CABI Agricultural Bioscience. 2023;4(3). Available:https://doi.org/10.1186/s43170-023-00145-7
2. Fernandes T, Garrine C, Ferrão J, Bell V, Varzakas T. Mushroom Nutrition as Preventative Healthcare in Sub-Saharan Africa. Applied Sciences. 2021;11(9):4221. Available:https://doi.org/10.3390/app11094221
3. Das AK, Nanda PK, Dandapat P, Bandyopadhyay S, Gullón P, Sivaraman GK, McClements DJ, Gullón B, Lorenzo JM. Edible mushrooms as functional ingredients for development of healthier and more sustainable muscle foods: A flexitarian approach. Molecules. 2021;26, 2463.
4. Kinge TR, Goldman G, Jacobs A, Ndiritu GG, Gryzenhout M. A first checklist of macrofungi for South Africa. MycoKeys. 2020;63.
5. Lang M. Consumer acceptance of blending plant-based ingredients into traditional meat-based foods: Evidence from the meat-mushroom blend. Food Qual. Prefer. 2020;79:103758.
6. Souleymane B, Yorou NS. Diversité inter-ethniques dans la consommation des champignons sauvages de la région de N'Dali au Bénin. Tropicultura. 2015;33.
7. Kalacˇ P. A review of chemical composition and nutritional value of wild-growing and cultivated mushrooms. J. Sci. Food Agric. 2013;93:209–218.
8. Dimopoulou, M, Kolonas A, Mourtakos S, Androutsos O, Gortzi O. Nutritional composition and biological properties of sixteen edible mushroom species. Appl. Sci. 2022;12:8074.
9. Chun S, Gopal J, Muthu M. Antioxidant Activity of Mushroom Extracts/Polysaccharides-Their Antiviral Properties and Plausible AntiCOVID-19 Properties. Antioxidants. 2021;10: 1899.
10. Wang Q, Niu LL, Liu HP, Wu YR, Li MY, Jia Q. Structural characterization of a novel polysaccharide from Pleurotus citrinopileatus and its antitumor activity on H22 tumor-bearing mice. Int. J. Biol. Macromol. 2021;168:251–260.
11. Kalacˇ P. Chemical composition and nutritional value of European species of wild growing mushrooms: A review. Food Chem. 2009;113:9–16.
12. Sheu F, Chien PJ, Wang HK, Chang HH, Shyu YT. New protein PCiP from edible golden oyster mushroom (*Pleurotus citrinopileatus*) activating murine macrophages and splenocytes. J. Sci. Food Agric. 2007;87:1550–1558.
13. Mariga AM, Yang WJ, Mugambi DK, Pei F, Zhao L, Shao Y. Antiproliferative and immunostimulatory activity of a protein from Pleurotus eryngii. J. Sci. Food Agric. 2014;94: 3152–3162.
14. Marçal S, Sousa AS, Taofiq O, Antunes F, Morais AMMB, Freitas AC, Barros L, Ferreira ICFR, Pintado M. Impact of postharvest preservation methods on nutritional value and bioactive properties

of mushrooms. Trends Food Sci. Technol. 2021;110, 418–431.
15. Ye YY, Wang HX, Ng TB. First chromatographic isolation of an antifungal thaumatin-like protein from French bean legumes and demonstration of its antifungal activity. Biochemical and Biophysical Research Communications 1999;263:130 – 4.
16. Wang JC, Hu SH, Liang ZC, Lee MY. Antigenotoxicity of extracts from Pleurotus citrinopileatus. J. Sci. Food Agric. 2005;85:770–778.
17. Roupas P, Keogh J, Noakes M, Margetts C, Taylor P. The role of edible mushrooms in health: evaluation of the evidence. J. Funct. Foods. 2012;4:687–709.
18. Stilinovic N, Capo I, Vukmirovic S, Raskovic A, Tomas A, Popovic M, Sabo A. Chemical composition, nutritional profile and in vivo antioxidant properties of the cultivated mushroom Coprinus comatus. Royal Soc. Open Sci. 2020;7:200900.
19. Wong JH, Ng TB, Chan HHL, Liu Q, Man GCW, Zhang CZ, et al. Mushroom extracts and compounds with suppressive action on breast cancer: Evidence from studies using cultured cancer cells, tumor-bearing animals, and clinical trials. Appl. Microbiol. Biotechnol. 2020;104: 4675–4703.
20. Spim SRV, Castanho N, Pistila AMH, Jozala AF, Oliveira Junior JM, Grotto D. Lentinula edodes mushroom as an ingredient to enhance the nutritional and functional properties of cereal bars. J. Food Sci. Technol. 2021 58:1349–1357.
21. Vaz JA, Barros L, Martins A, Santos-Buelga C, Vasconcelos MH, Ferreira ICFR. Chemical composition of wild edible mushrooms and antioxidant properties of their water soluble polysaccharidic and ethanolic fractions. Food Chem. 2011;126:610–616.
22. Han EH, Hwang YP, Kim HG, Choi JH, Im Yang JH. Inhibitory effect of Pleurotus eryngii extracts on the activities of allergic mediators in antigen-stimulated mast cells. Food Chem. Toxicol. 2011;49:1416–1425.
23. Akata I, Ergonul B, Kalyoncu F. Chemical compositions and antioxidant activities of 16 wild edible mushroom species grown in Anatolia. Int. J. Pharmacol. 2012;8:134–138.
24. Sheng Y, Zhao C, Zheng S, Mei X, Huang K, Wang G, He X. Anti-obesity and hypolipidemic effect of water extract from Pleurotus citrinopileatus in C57BL/6J mice. Food Sci. Nutr. 2019;7: 1295–1301.
25. Tsujiyama S, Ueno H. Performance of wood-rotting fungi-based enzymes on enzymic saccharification of rice straw. J. Sci. Food Agric. 2013;93:2841–2848.
26. Savoie JM, Salmones D, Mata G. Hydrogen peroxide concentration measured in cultivation substrates during growth and fruiting of the mushrooms. Agaricus bisporus and Pleurotus spp. J. Sci. Food Agric. 2007;87:1337–1344.
27. Pérez-Martínez AS, Acevedo-Padilla SA, Bibbins-Martínez M, Galván-Alonso J, Sergio Rosales-Mendoza A. perspective on the use of Pleurotus for the development of convenient fungi-made oral subunit vaccines. Vaccine. 2015;33(1):25-33.
DOI: 10.1016/j.vaccine.2014.10.059.
28. Knop D, Yarden O, Hadar Y. The ligninolytic peroxidases in the genus Pleurotus: divergence in activities, expression, and potential applications. Appl. Microbiol. Biotechnol. 2015;99:1025–1038.
29. Zhang X, Wang L, Ma F, Yang J, Su M. Effects of arbuscular mycorrhizal fungi inoculation on carbon and nitrogen distribution and grain yield and nutritional quality in rice (*Oryza sativa* L.) J. Sci. Food Agric; 2016.
30. Tougan PU, Dahouda M, Ahounou GS, Salifou CFA, Kpodekon MT, Mensah GA, Kossou DNF, Amenou C, Kogbeto CE, Thewis A, Youssao IAK. Effect of breeding mode, type of muscle and slaughter age on technological meat quality of local poultry population of Gallus gallus species of Benin. International Journal of Biosciences. 2013;3(6): 1-17.
31. Tougan PU, Bonou AG, Gbaguidi T, Koutinhouin GB, Ahounou S, Salifou Ch, Zannou MS, Mensah GA, Beckers Y, Everaert N, Théwis A, Youssao AKI. Influence of Feed Withdrawal Length on Carcass Traits and Technological Quality of Indigenous Chicken Meat Reared Under Traditional System in Benin. J. World Poult. Res. 2016;6(2):48-58.
32. Association of Official Analytical Chemists – AOAC. Official methods of analysis of the Association of Official Analytical Chemists 17th Ed. Gaithersburg: AOAC; 2000.

33. SAS 9.2. SAS/STAT Copyright. User's guide, vers, 6, 4 th ed, Cary, NC, USA, SAS Inst.; 2008.
34. Dundar A, Acay H, Yildiz A. Yield performances nutritional contents of three oyster mushroom species cultivated on wheat stalk. Afr. J. Biotechnol. 2008;7(19): 3497-3501.
35. Patil SS, Ahmed SA, Telang SM, Baig MMV. The nutritional value of Pleurotus ostreatus (Jacq.:fr.) kumm cultivated on different lignocellulosic agrowastes. Innov. Rom. Food Bio- technol. 2010;7:66–76.
36. Anno HFA. Quatre champignons saprophytes comestibles du centre de la Côte d'Ivoire: étude socio-alimentaire, caractéristiques chimiques et potentialités antioxydantes. Thèse de Doctorat. Université Nangui Abrogoua, Abidjan-Côte d'Ivoire. 2017;131.
37. Drozdowski LA, Reimer RA, Temelli F, Bell RC, Vasanthan T, Thomson ABR. β-Glucan extracts inhibit the in vitro intestinal uptake of long-chain fatty acids and cholesterol and down-regulate genes involved in lipogenesis and lipid transport in rats. J. Nutr. Biochem. 2010; 21:695–701.
38. Ahmed M, Abdullah N, Ahmed KU, Bhuyan MHMB. Yield and nutritional composition of oyster mushroom strains newly introduced in Bangladesh. Pesq. Agropec. Bras. 2013;2:197–202.
39. Adebayo EA, Oloke JK. Oyster mushroom (*Pleurotus species*); A natural functional food. J. Microbiol, Biotechnol. Food Sci. 2017;7(3):254-264. DOI: 10.15414/jmbfs.2017/18.7.3.254-264.
40. Panjikkaran ST, Mathew D. An environmentally friendly and cost effective technique for the commercial cultivation of oyster mushroom [*Pleurotus florida* (Mont.) Singer] J. Sci. Food Agric. 2013;93:973–976.
41. Sande D, Oliveira GP, Moura M, Martins BA, Lima M, Takahashi JA. Edible mushrooms as a ubiquitous source of essential fatty acids. Food Res. Int. 2019;125:108524.
42. Tougan PU, Yayi-Ladekan E, Imorou-Toko I, Guidime C, Thewis A. Dietary behaviors, food accessibility, and handling practices during SARS-CoV-2 pandemic in Benin. The North African Journal of Food and Nutrition Research. Special Issue 2020;04(10):S08-S18, 2020. Available:https://doi.org/10.5281/zenodo.4266796.
43. Hocquette A, Grondin M, Bertout S, Mallié M. Les champignons des genres Acremonium, beauveria, chrysosporium, fusarium, onychocola, paecilomyces, penicillium, scedosporium et scopulariopsis responsables de hyalohyphomycoses acremonium, beauveria, chrysosporium, fusarium, onychocola, paecilomyces, penicillium, scedosporium and scopulariopsis fungi responsible for hyalohyphomycosis. Journal de Mycologie Médicale. 2005; 15 (3):136-149.
44. Lungu C, Baston O, Pricop EM. The effect of brine preservation on mushrooms. Annals. Food Science and Technology. 2015;16 (2).
Available online at www.afst.valahia.ro.
45. Michael HW, Geremew-Bultosa G, Pant LM. Nutritional contents of three edible oyster mushrooms grown on two substrates at Haramaya, Ethiopia, and sensory properties of boiled mushroom and mushroom sauce. Int. J. Food Sci. Technol. 2011;46:732–738.

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