MJoSHT
Malaysian Journal of Science, Health & Technology
[mjosht.usim.edu.my]

Article

Potential Use of Underutilised Mushroom Stems in Meat Products and Meat Analogues: A Mini Review

Sayeed Ibrahim, H. S. and Huda-Faujan, N.

Food Biotechnology Programme, Faculty of Science and Technology, Universiti Sains Islam Malaysia, Bandar Baru Nilai, 71800 Nilai, Negeri Sembilan, Malaysia.

Correspondence should be addressed to:
Huda-Faujan, N.; nurhuda@usim.edu.my

Article Info
Article history:
Received: 13 October 2022
Accepted: 18 July 2023
Published:12 September 2023

Academic Editor: Hanis Yahya
Malaysian Journal of Science, Health & Technology

MJoSHT2023, Volume 9, Issue No. 2
eISSN: 2601-0003

https://doi.org/10.33102/mjosht.v9i2.334

***Abstract*— The demand for meat has gradually increased throughout the years, and it is more widely ingested than plant products due to its sensory qualities as well as its high nutritional content, mainly protein. However, meat is low in calcium, dietary fibre, and vitamin C. Consumers' increased awareness of the possible links between nutrition and health has recently led to major dietary changes toward healthier food options. Furthermore, rising meat prices, vegetarianism, concerns about animal suffering, and sustainability issues have driven market trends toward meat alternatives from plant sources. As such, mushrooms are regarded as one of the healthier ingredients due to their nutritive, bioactive, and therapeutic values. The fibrous structure mimics the texture of meat and possesses an umami flavour, which imparts a meaty taste to the food products. Globally, Asian countries generate the highest percentage of overall mushroom production. The application of mushrooms, however, is limited to the fruiting bodies rather than the stems, which also contain high dietary fibre content. The stems are often discarded as food waste due to their tough texture. Researchers have begun to use edible mushroom waste and their by-products, especially stems, to create value-added products in a variety of sectors, such as the food industry, owing to their nutritional values and contributions to the circular economy and environmental protection. Thus, the primary intent of this review is to discuss the potential of underutilised mushroom stems in meat products.**

***Keywords*— mushroom waste; mushrooms products; meat plant-based alternative, underutilised mushroom stems; vegetarian meat**

I. INTRODUCTION

The worldwide demand for meat has been rising steadily over the years. Meat that has been considered a luxury in the past has become a staple as it can be found in almost all restaurants and kitchens across the world. Among meat categories, poultry is the most popular type of processed meat, followed by red meat, including pork and beef, accounting for 38% and 33% of the global market, respectively [1]. Meat products are often consumed more than plant products due to their sensory characteristics and high nutritional content of proteins, minerals (iron, selenium, zinc), and vitamins

(primarily B6 and B12) [2]. However, muscle foods are deficient in calcium, dietary fibre, and vitamin C [3].

In recent years, consumers have become more aware of a possible relationship between food and health, leading to changes in eating habits towards a healthier diet [3]. Additionally, an increase in meat prices, the emergence of vegetarianism [4] as well as increase in awareness pertaining to animal suffering and sustainability issues, particularly the greenhouse gas emissions from animal protein production, have shifted consumer preference towards non-meat protein sources [5] such as soybeans, legumes, wheat, oil seeds, and mushrooms. These ingredients are noticeable due to their ability to retain moisture and water during the processes of cooking, reheating, freezing, and thawing. Moreover, they are cheaper than meat and could offer nutritional and health benefits equivalent to meat [4].

In general, mushrooms are regarded as a more sustainable and healthier natural ingredient due to their nutritive, bioactive, and therapeutic values [3]. Hence, the cultivation of mushrooms is rising due to the current surge in health foods. Indeed, thirty nations generate more than 10,000 tonnes of mushrooms annually, and forty-three nations produce less than 10,000 tonnes of mushrooms, with the world's total production of nearly 10.2 million tonnes [6]. The worldwide mushroom market is anticipated to rise at a Compound Annual Growth Rate (CAGR) of 6.74% from 15.25 million tonnes in 2021 to 24.05 million tonnes in 2028 [7].

Mushrooms are becoming more common ingredients in muscle food due to their fibrous structure mimics the texture of meat analogues [3]. Meat analogous, also known as a meat alternative, meat substitute, faux meat, mock meat, or imitation meat, is defined as food structurally similar to meat but different in composition. It demonstrates the aesthetic qualities of certain types of meat, mainly the texture, flavour, appearance, and chemical properties [4]. In addition, mushrooms provide a unique taste and umami flavour due to the presence of sodium salts of free amino acids (glutamic amino acids and aspartic amino acids) as well as 5'-nucleotides. As a result, it gives foods a meaty taste, which consumers favourably accept [3], thereby driving animal protein replacement with mushrooms in meat products [8-9]. The application of mushrooms, however, is limited to the fruiting bodies rather than the stems, which are often discarded due to their tough texture. This leads to problems in agro-industrial waste management [10]. In China, the mushroom business generated over 100,000 tonnes of stems per year, and it was assumed that the volume was similarly higher in other developed nations. These leftovers mainly go to landfills or are used as compost [11].

Recently, plant-based waste materials have gained popularity as functional food components in meat products because of their high dietary fibre content and bioactive compounds such as vitamins, minerals, and polyphenols. These dietary fibres and phenolic compounds combine to form antioxidant dietary fibres, which can be used as dietary supplements to improve gastrointestinal health or as technical ingredients to inhibit lipid oxidation in foods, increasing the food products' shelf-life [12]. Over the years, several food products have been developed using mushroom stems, reducing the amount of meat present. This substitution fits with the growing need for a shift from an animal-protein diet to a plant-based diet, which encourages the reduction of animal products (Flexitarian approach), avoiding meat products (vegetarian), or avoiding animal products altogether (vegan) [3]. Adding mushroom stem waste powder positively affects the cooking yield and nutritional composition, especially dietary fibre content [12]. In this regard, researchers have begun to use edible mushroom stems and waste to create value-added food products due to the good compatibility of mushrooms with meat products.

II. BACKGROUND OF MUSHROOM

A mushroom is a fleshy, spore-bearing fruiting body of a fungus that is recognised by a stem (stipe), cap (pileus), and gills (lamellae) [13]. Mushrooms have been consumed since antiquity and recognised by many civilisations, including the Greeks, Romans, and Chinese culture, due to their unique flavour and therapeutic properties [14], nutritional content, and healing properties [15]. Mushrooms were widely used for culinary purposes by the upper class during the previous era [16]. In addition, mushrooms have a peculiarly pleasant savoury taste, which is known as umami due to the presence of sodium salts of free amino acids such as glutamic and aspartic amino acids and 5-nucleotides, which makes them a popular choice in food [3]. Currently, mushrooms are consumed in households all over the world as they possess a unique texture and desirable taste [16] that are compatible with meat and fish products [3].

Mushrooms can be classified into three categories: edible, medicinal, and wild. It is believed that there are at least 12,000 mushroom species worldwide, with around 2000 of them ideal for edible and/or medicinal use [3]. Globally, Asian countries generate the highest percentage of overall mushroom production (74.64%) [17]. In 2011, China was reported to be the world's largest mushroom producer, along with the United States, Italy, The Netherlands, and Poland [18]. The most cultivated edible mushroom species are *Pleurotus ostreatus*, *Lentinula edodes*, *Agaricus bisporus*, *Flammulina velutipes*, and *Auricularia auricular*. Meanwhile, *Ganoderma lucidum*, *Cordyceps sinensis*, and *Poria cocos* are the most harvested medicinal mushrooms [15]. The most important factors influencing the production of grown edible mushrooms are temperature, humidity, fresh air, and compact material. In general, mushroom production is more sustainable than meat products, hence causing less damage to the environment [3].

III. NUTRITIONAL PROPERTIES OF MUSHROOM

Mushrooms are known for their nutritional richness and have been applied in various products such as patties [8], bread [19], muffins [20], pasta [21], snacks [22], soup [23], cookies [24-25], and biscuits [26]. Mushrooms are high-quality protein source as they contain all nine amino acids essential for humans [27]. Mushrooms contain about four times the protein content of tomatoes and carrots, six times that of oranges, and twelve times that of apples [3]. However, the amount of crude protein of mushrooms is mainly differ and affected by development stage, and species [28].

Mushrooms are high in indigestible carbohydrates, which contribute to a low glycemic index as well as contain high mannitol making them apt for diabetic patients. Both caps and stems are also high in dietary fibre due to the presence of non-starch polysaccharides (predominantly composed of insoluble dietary fibre and glucans) which may help prevent hypertension and hypercholesterolemia and be beneficial in weight control. Moreover, they are an excellent source of polysaccharides (α-glucan, β-glucan chitin, mannans, galactans, and xylans), minerals (copper, iron, manganese, zinc, phosphorus and potassium), vitamins (B1, B2, B12, C, D, E, folate, and niacin), and unsaturated fatty acids primarily linoleic acid [3].

Since mushrooms are plant-based source foods, thus, they are cholesterol-free and contain low amounts of sodium [29]. For example, the fruiting bodies of *Agaricus* sp. contain 396 mg sodium/kg (n=14) [30] compared to processed meats containing 7 to 39 g sodium chloride/kg [31]. Mushrooms are also gluten-free [29] and a rich source of bioactive compounds such as phenolics and flavonoids that could be vital to human health in lowering the risk of diseases such as oral health and cancer [18]. In addition, mushrooms act as an immune system enhancer, antibacterial, and cholesterol-lowering agents. Consumers consume almost 5 kg of mushrooms per person per year on average, which is projected due to consumer awareness of a healthy diet [32].

IV. POTENTIAL APPLICATION OF MUSHROOMS IN MEAT PRODUCTS

Mushrooms are a source of healthy food and are recognised as superior nutritional supplements. They are being used directly in food as well as raw materials in the formulation of novel functional foods development due to their taste, aroma, and inherent texture-modifying functional properties, which have been found to positively affect the appearance, flavour, overall acceptance, and shelf-life of food products, especially in meat products. Various meat products have been developed using mushrooms as functional bioactive components to improve the nutritional content and potential health benefits. Adding mushrooms to processed meats may help lower the salt levels of the products, providing more nutritional and health advantages to consumers. Mushrooms have been successfully added in many formulations of meat products [3], such as chicken sausage [33], chicken frankfurter [34], pork frankfurter [35], emulsion-type sausage [36], Cantonese sausage [37], chicken burger [38], chicken patties [8], pork patty [39], and beef burger [40]. Indeed, the incorporation of mushrooms influences the cooking characteristics, physicochemical properties, and nutritional composition of the meat products.

IV. APPLICATION OF MUSHROOM STEMS IN MEAT PRODUCTS OR MEAT ANALOGUE

Consumers ingest meat products for their sensory properties and essential nutritional components [2]. It is anticipated that booming population, education, urbanisation, industrialisation, and affluence will result in a 72% increase in meat consumption by 2030. It is forecasted that worldwide meat production will more than double from 229 million tonnes in 1999/01 to 465 million tonnes in 2050 [41]. However, the reputation of meat products has recently been impacted due to high levels of saturated fatty acids, cholesterol, salt, and synthetic additives, which are frequently linked to a variety of diseases such as diabetes, obesity, cardiovascular disease, and cancer. The suggestion to restrict the intake of red meat and processed meat has influenced the consumer's perception of meat products. As a result, meat is replaced with various plants, including co-products and by-products, with the added benefit of dietary fibre, which is not common in meat products [2].

The use of plant-based waste materials as a functional ingredient in meat products is gaining popularity [12,42-44]. As such, mushrooms are considered a promissory source of bioactive compounds that can be utilised to develop healthier meat products [2]. Total mushroom production in Asian countries contributes the highest percentage of total worldwide production [17]. However, the potential values of the stems or stalks were often omitted and considered as food loss, which led to challenges in agro-industrial waste management [45]. Data on the global or country-specific allocation of crop residues to mushroom production are scarce in the literature [46]. In fact, for every kg of mushrooms harvested, approximately 25% is left behind and is treated as waste, and this consists of the mushroom stems that connect the mushroom to the compost [47]. In the past few years, the agro-industrial waste from mushrooms has attracted the attention of researchers from all over the world due to the presence of bioactive compounds [45]. Recently, mushroom stems were successfully added to several meat products, and the effects of mushroom stems and their waste in meat and meat analogue products are presented in Table 1.

In general, the addition of mushroom stems in meat products significantly increased dietary fibre [12, 42-43] and lowered saturated fat [12, 42-44], but different mushrooms affected the physical properties of meat products [12,42-44]. This depends on the muscle types incorporated with the mushroom stems (stipes or stalks). Indeed, mushroom stems contain various phytochemical compounds such as phenolics [49-50], tannins, saponins, and alkaloids [51], and this contributes to the improvement of the stability of meat products during storage [12,44]. Several phenolic compounds that were identified in mushroom stems of *Flammulina velutipes* and *Hypsizygus tessellatus* were chromogenic acid, Methyl-5-O-caffeoylquinate, Kukoamine A, and Kushenol K [52].

TABLE I. EFFECTS OF MUSHROOM STEMS IN MEAT PRODUCTS OR MEAT ANALOGUES

Type and level of mushroom stems or stipes	Type of meat or muscle food	Effects	References
Grey oyster mushroom stems (GOMS) with chickpea flour (60%, 55%, 50%, 45%)	Imitation chicken nuggets	• No significant change in pH, but significantly higher moisture retention as compared to commercial chicken nuggets. • Significantly lower in cooking loss but higher in cooking yield as compared to commercial chicken nuggets. • Higher moisture and crude fibre content but significantly lower in fat content compared to commercial chicken nuggets. • Better sensory acceptance at 55% of GOMS.	[42-43]
Enoki mushroom stems (EMS) (2%, 4%, 6%)	Goat meat nuggets	• Increase in pH and no adverse effect on the appearance or texture of the final product. • Significantly lower in cooking loss compared to control goat meat nuggets. • The emulsion stability and total phenolic content significantly improved compared to the control goat meat nugget. • Higher in moisture, ash and total dietary fibre as compared to control goat meat nugget. • No significant differences in sensory attributes. • Significantly improved shelf-life of the meat products due to the phenolic content of EMS, which can inhibit lipid oxidation during storage.	[12]
Shiitake stipes extracts (SSE) (0.3, and 0.6%)	Fermented sausages	• Did not cause defects of colour, texture, and sensory quality in SSE-based sausage compared to control fermented sausage. • Significantly improve lipid oxidation and microbial stability at 0.6% SSE.	[44]
Shiitake mushroom stalks	Vegetarian meatball	• Low in saturated fat and high in protein.	[48]

V. CONCLUSIONS

Mushrooms are widely used in various products, but the potential values of the stems, stipes or stalks are usually omitted and considered food waste, which poses a challenge in agro-industrial waste management. The underutilised mushroom stems have the potential to be incorporated into meat products as they mimic the texture of meat as well as contribute to the appealing umami flavour. Furthermore, mushroom stems possess a high nutritional value, especially fibre and phytochemical content that could be a promising ingredient to produce a value-added meat product in the current sector aligned with consumers' preferences and recent trends.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

ACKNOWLEDGEMENT

The authors acknowledge the financial provided by the Faculty of Science and Technology (FST), USIM, for conducting the previous study.

REFERENCES

[1] Cision PRNewswire, "Worldwide Demand for Meat Products Steadily Rising," FinancialNewsMedia.com, May 27, 2020, accessed March 4, 2023, https://www.prnewswire.com/news-releases/worldwide-demand-for-meat-products-steadily-rising-301065720.html.

[2] Montes, A. P., E. Rangel-Vargas, J. M. Lorenzo, L. Romero, and E. M. Santos, "Edible Mushrooms as a Novel Trend in the Development of Healthier Meat Products," Current Opinion in Food Science 37 (February 2020): 118-124, https://doi.org/10.1016/j.cofs.2020.10.004.

[3] Das, A. K., P. K. Nanda, P. Dandapat, S. Bandyopadhyay, P. Gullón, G. K. Sivaraman, D. J. McClements, B. Gullón, and J. M. Lorenzo, "Edible Mushrooms as Functional Ingredients for Development of Healthier and More Sustainable Muscle Foods: A Flexitarian Approach," Molecules 26, no. 9 (April 2021): 2463, https://doi.org/10.3390/molecules26092463.

[4] Joshi, V. K., and S. Kumar, "Meat Analogues: Plant-Based Alternatives to Meat Products - A Review," International Journal of Food Fermentation and Technology 5, no. 2 (December 2015): 107-119, http://doi.org/10.5958/2277-9396.2016.00001.5.

[5] Michel, F., C. Hartmann, and M. Siegrist, "Consumers' Associations, Perceptions and Acceptance of Meat and Plant-Based Meat Alternatives," Food Quality and Preference 87 (January 2021): 104063, https://doi.org/10.1016/j.foodqual.2020.104063.

[6] Sekino, N., and Z. Jiang, "Fuel and Material Utilisation of a Waste Shiitake (Lentinula edodes) Mushroom Bed Derived from Hardwood Chips I: Characteristics of Calorific Value in Terms of Elemental Composition and Ash Content," Journal of Wood Science 67, no. 1 (January 2021): 1-10, https://doi.org/10.1186/s10086-020-01935-7.

[7] Fortune Business Insight, "The Global Mushroom Market is Projected to Grow from 15.25 Million Tonnes in 2021 to 24.05 Million Tonnes in 2028 at a CAGR of 6.74% in Forecast Period 2021-2028," accessed May 9, 2023, https://www.fortunebusinessinsights.com/industry-reports/mushroom-market-100197, April 2022.

[8] Wan Rosli, W. I., M. A. Solihah, M. Aishah, N. A. Nik Fakurudin, and S. S. J. Mohsin, "Colour, Textural Properties, Cooking Characteristics and Fiber Content of Chicken Patty Added with Oyster Mushroom (Pleurotus sajor-caju)," International Food Research Journal 18, no. 2 (April 2011): 621-627.

[9] Park, G., S. Oh, S. Park, Y. Kim, Y. Park, Y. Kim, J. Lee, H. Lee, and J. Choi, "Physicochemical Characteristics and Storage Stability of Hybrid Beef Patty Using Shiitake Mushroom (Lentinus edodes)," Journal of Food Quality 2023, Article ID 7239709 (February 2023): 10 pages, https://doi.org/10.1155/2023/7239709.

[10] Guo, J., M. Zhang, and Z. Fang, "Valorisation of Mushroom By-Products: A Review," Journal of the Science of Food and Agriculture 102, no. 13 (April 2022): 5593-5605, https://doi.org/10.1002/jsfa.11946.

[11] Mahfuz, S., H. Song, Y. Miao, and Z. Liu, "Dietary Inclusion of Mushroom (Flammulina velutipes) Stem Waste on Growth Performance and Immune Responses in Growing Layer Hens," Journal of the Science of Food and Agriculture 99, no. 2 (January 2019): 703-710, https://doi.org/10.1002/jsfa.9236.

[12] Banerjee, D. K., A. K. Das, R. Banerjee, M. Pateiro, P. K. Nanda, Y. P. Gadekar, S. Biswas, D. J. McClements, and J. M. Lorenzo, "Application of Enoki Mushroom (Flammulina Velutipes) Stem Wastes as Functional Ingredients in Goat Meat Nuggets," Foods 9, no. 4 (April 2020): 432, https://doi.org/10.3390/foods9040432.

[13] Paul, V. "Mushroom Products." In Mushrooms of India, edited by S. Sharma, M. Singh, S. Prasad, and H. Rathore, vol. 1, 254-262. India: I, IIT Delhi, 2016.

[14] Valverde, M. E., T. Hernández-Pérez, and O. Paredes-López, "Mushrooms: Improving Human Health and Promoting Quality Life," International Journal of Microbiology 2015, Article ID 376387, 14 pages (2015), https://doi.org/10.1155/2015/376387.

[15] Ma, G., W. Yang, L. Zhao, F. Pei, D. Fang, and Q. Hu, "A Critical Review on the Health Promoting Effects of Mushrooms Nutraceuticals," Food Science and Human Wellness 7, no. 2 (June 2018): 125-133, https://doi.org/10.1016/j.fshw.2018.05.002.

[16] Samsudin, N. I. P., and N. Abdullah, "Edible Mushrooms from Malaysia: A Literature Review on Their Nutritional and Medicinal Properties," International Food Research Journal 26, no. 1 (February 2019): 11-31.

[17] Rosmiza, M. Z., W. P. Davies, C. R. Rosniza-Aznie, M. J. Jabil, and M. Mazdi, "Prospects for Increasing Commercial Mushroom Production in Malaysia: Challenges and Opportunities," Mediterranean Journal of Science Social 7, no. 1 S1 (January 2016): 406-415, https://doi.org/10.5901/mjss.2016.v7n1s1p406.

[18] Feeney, M. J., J. Dwyer, C. M. Hasler-Lewis, J. A. Milner, M. Noakes, S. Rowe, M. Wach, R. B. Beelman, J. Caldwell, M. T. Cantorna, and L. A. Castlebury, "Mushrooms and Health Summit Proceedings," The Journal of Nutrition 144, no. 7 (July 2014): 1128S-1136S, https://doi.org/10.3945/jn.114.190728.

[19] Okafor, J. N. C., G. I. Okafor, A. U. Ozumba, and G. N. Elemo, "Quality Characteristics of Bread Made from Wheat and Nigerian Oyster Mushroom (Pleurotus plumonarius) Powder," Pakistan Journal of Nutrition 11, no. 1 (2012): 5-10, https://doi.org/10.3923/pjn.2012.5.10.

[20] Olawuyi, I. F., and W. Y. Lee, "Quality and Antioxidant Properties of Functional Rice Muffins Enriched with Shiitake Mushroom and Carrot Pomace," International Journal of Food Science & Technology 54, no. 7 (March 2019): 2321-2328, https://doi.org/10.1111/ijfs.14155.

[21] Lu, X., M. A. Brennan, L. Serventi, S. Mason, and C. S. Brennan, "How the Inclusion of Mushroom Powder Can Affect the Physicochemical Characteristics of Pasta," International Journal of Food Science & Technology 51, no. 11 (October 2016): 2433-2439, https://doi.org/10.1111/ijfs.13246.

[22] Lu, X., M. A. Brennan, L. Serventi, S. Mason, and C. S. Brennan, "Enrichment of Extruded Snack Products with Co-products from Chestnut Mushroom (Agrocybe aegerita) Production: Interactions Between Dietary Fiber, Physicochemical Characteristics, and Glycemic Load," Journal of Agricultural and Food Chemistry 60, no. 17 (March 2012): 4396-4401, https://doi.org/10.1021/jf3008635.

[23] Hiranpradith, V., N. Therdthai, and A. Soontrunnarudrungsri, "Effect of Steaming and Microwave Heating on Taste of Clear Soup with Split-Gill Mushroom Powder," Foods 12, no. 8 (April 2023): 1685 (18 pages), https://doi.org/10.3390/foods12081685.

[24] Ogidi, C. O., A. O. Ogunlade, R. S. Bodunde, and O. M. Aladejana, "Evaluation of Nutrient Contents and Antioxidant Activity of Wheat Cookies Fortified with Mushroom (Termitomyces robustus) and Edible Insects," Journal of Culinary Science & Technology, pp. 1-19 (February 2023), https://doi.org/10.1080/15428052.2023.2181253.

[25] Borokini, F. B., L. Lajide, F. Gbenga-Fabusiwa, and M. Oloye-Quadri, "Assessment of Nutritional and Sensory Qualities of Whole Grains Cookies Formulated from Vegetables and Mushrooms," Caliphate Journal of Science and Technology 5, no. 1 (January 2023), https://doi.org/10.4314/cajost.v5i1.10.

[26] Prodhan, U. K., K. M. M. R. Linkon, M. F. Al-Amin, and M. J. Alam, "Development and Quality Evaluation of Mushroom (Pleurotus sajor-caju) Enriched Biscuits," Emirates Journal of Food and Agriculture 27, no. 8 (July 2015): 542-547, https://doi.org/10.9755/ejfa.2015.04.082.

[27] Ayimbila, F., and S. Keawsompong, "Nutritional Quality and Biological Application of Mushroom Protein as a Novel Protein Alternative," Current Nutrition Reports 12, no. 2 (April 2023): 290-307, https://doi.org/10.1007/s13668-023-00468-x.

[28] Kumar, H., K. Bhardwaj, R. Sharma, E. Nepovimova, N. Cruz-Martins, D. S. Dhanjal, R. Singh, C. Chopra, R. Verma, K. A. Abd-Elsalam, A. Tapwal, K. Musilek, D. Kumar, and K. Kuča, "Potential Usage of Edible Mushrooms and Their Residues to Retrieve Valuable Supplies for Industrial Applications," Journal of Fungi 7, no. 6 (May 2021): 427 (17 pages), https://doi.org/10.3390/jof7060427.

[29] Singh, M. "Mushrooms for Nutrition and Entrepreneurship." In Vegetables for Nutrition and Entrepreneurship, edited by B. Singh and P. Kalia, 361-387. Singapore: Springer Nature Singapore, 2023.

[30] Vetter, J. "Data on Sodium Content of Common Edible Mushrooms," Food Chemistry 81, no. 4 (June 2003): 589-593, https://doi.org/10.1016/S0308-8146(02)00501-0.

[31] Inguglia, E. S., Z. Zhang, B. K. Tiwari, J. P. Kerry, and C. M. Burgess, "Salt Reduction Strategies in Processed Meat Products – A Review," Trends in Food Science & Technology 59 (January 2017): 70-78, https://doi.org/10.1016/j.tifs.2016.10.016.

[32] Predanócyová, K., J. Árvay, and M. Šnirc, "Exploring Consumer Behavior and Preferences Towards Edible Mushrooms in Slovakia," Foods 12, no. 3 (January 2023): 657 (18 pages), https://doi.org/10.3390/foods12030657.

[33] Jo, K., J. Lee, and S. Jung, "Quality Characteristics of Low-Salt Chicken Sausage Supplemented with a Winter Mushroom Powder," Korean Journal of Food Science of Animal Resource 38, no. 4 (August 2018): 768-779, https://doi.org/10.5851/kosfa.2018.e15.

[34] Wan Rosli, W. I., M. S. Nor Maihiza, and M. Raushan, "The Ability of Oyster Mushroom in Improving Nutritional Composition, β-Glucan and Textural Properties of Chicken Frankfurter," International Food Research Journal 22, no. 1 (February 2015): 311-317.

[35] Pil-Nam, S., K. M. Park, G. H. Kang, S. H. Cho, B. Y. Park, and Van-Ba, "The Impact of Addition of Shiitake on Quality Characteristics of Frankfurter During Refrigerated Storage," LWT-Food Science and Technology 62, no. 1 (June 2015): 62-68, https://doi.org/10.1016/j.lwt.2015.01.032.

[36] Choe, J., J. Lee, K. Jo, C. Jo, M. Song, and S. Jung, "Application of Winter Mushroom Powder as an Alternative to Phosphates in Emulsion-Type Sausages," Meat Science 143 (September 2018): 114-118, https://doi.org/10.1016/j.meatsci.2018.04.038.

[37] Wang, X., P. Zhou, J. Cheng, Z. Chen, and X. Liu, "Use of Straw Mushrooms (Volvariella volvacea) for the Enhancement of Physicochemical, Nutritional and Sensory Profiles of Cantonese Sausages," Meat Science 146 (December 2018): 18–25, https://doi.org/10.1016/j.meatsci.2018.07.033.

[38] Dosh, K. S., N. N. Tawfiq, and S. H. Jabbar, "Preparation of Modified Chicken Burger by Partial Replacement of Chicken Meat with Powdered Oyster Mushroom and Study Its Physical and Sensory Properties," Iraqi Journal of Agricultural Science 74, no. 7 (Special Issue, 2016): 138-143, https://doi.org/10.1111/jfpp.12178.

[39] Ma, M. H., J. Y. Heo, C. Lee, Y. M. Lo, and B. Moon, "Quality and Sensory Characterization of White Jelly Mushroom (Tremella fuciformis) as a Meat Substitute in Pork Patty Formulation," Journal of Food Processing and Preservation 38, no. 3 (August 2014): 1018-1023, https://doi.org/10.1111/jfpp.12178.

[40] Patinho, I., E. Saldaña, M. M. Selani, A. C. de Camargo, T. C. Merlo, B. S. Menegali, A. P. de Souza Silva, and C. J. Contreras- Castillo, "Use of Agaricus bisporus Mushroom in Beef Burgers: Antioxidant, Flavor Enhancer and Fat Replacing Potential," Food Production, Processing and Nutrition 1, no. 7 (December 2019): 1-5, https://doi.org/10.1186/s43014-019-0006-3.

[41] Steinfeld, H., P. Gerber, T. Wassenaar, V. Castel, M. Rosales, and C. J. De Haan, "Livestock's Long Shadow," FAO: Rome, Italy, pp. 1-26, Retrieved on 5th June 2023 from http://www.europarl.europa.eu/climatechange/doc/FAO%20report%20executive%20summary.pdf, 2006.

[42] Husain, H., and N. Huda-Faujan, "Quality Evaluation of Imitation Chicken Nuggets from Grey Oyster Mushroom Stems and Chickpea Flour," Malaysian Applied Biology 49, no. 3 (October 2020): 61-69, https://doi.org/10.55230/mabjournal.v49i3.1542.

[43] Husain, H., and N. Huda-Faujan, "Potential Application of Grey Oyster Mushroom Stems as Halal Meat Replacer in Imitation Chicken Nuggets," Food Research 4 (Suppl. 1) (February 2020): 179-186, https://doi.org/10.26656/fr.2017.4(S1).S18.

[44] Van Ba, H., H. W. Seo, S. H. Cho, Y. S. Kim, J. H. Kim, J. S. Ham, B. Y. Park, and S. P. Nam, "Antioxidant and Anti-Foodborne Bacteria Activities of Shiitake By-Product Extract in Fermented Sausages," Food Control 70 (December 2016): 201-209, https://doi.org/10.1016/j.foodcont.2016.05.053.

[45] Barshteyn, V., and T. Krupodorova, "Utilisation of Agro-Industrial Waste by Higher Mushrooms: Modern View and Trends," The Journal of Microbiology, Biotechnology and Food Sciences 5, no. 6 (June 2016): 563-577, https://doi.org/10.15414/jmbfs.2016.5.6.563-577.

[46] Ogbu, C. C., and S. N. Okechukwu, "Agro-Industrial Waste Management: The Circular and Bioeconomic Perspective." In Agricultural Waste - New Insights, edited by F. Ahmad and M. Sultan. Intech Open, February 2023, https://doi.org/10.5772/intechopen.109181.

[47] Fungus Chain, "Mushroom Waste Applied to the Food Sector," March 8, 2021. Retrieved on July 7, 2023, from https://funguschain.eu/news/mushroom-waste-applied-to-the-food-sector/, March 2021.

[48] Tanri, G. T., "Miana Leaves & Meatball Analogue Vegetarian Pie," Diploma Report, Indonesia: Ottimmo International, November 2022. Retrieved from http://repository.ottimmo.ac.id/820/2/GLAD-EXECUTIVE%20SUMMARY.pdf.

[49] Wu, X., W. Guan, R. Yan, J. Lei, L. Xu, and Z. Wang, "Effects of UV-C on Antioxidant Activity, Total Phenolics and Main Phenolic Compounds of the Melanin Biosynthesis Pathway in Different Tissues of Button Mushroom," Postharvest Biology and Technology 118 (August 2016): 51-58, https://doi.org/10.1016/j.postharvbio.2016.03.017.

[50] Buruleanu, L. C., C. Radulescu, A. A. Georgescu, F. A. Danet, R. L. Olteanu, C. M. Nicolescu, and I. D. Dulama, "Statistical Characterisation of the Phytochemical Characteristics of Edible Mushroom Extracts," Analytical Letters 51, no. 7 (January 2018): 1039-1059, https://doi.org/10.1080/00032719.2017.1366499.

[51] Adejonwo, O. A., B. O. Omitoyin, O. A. Ogunwole, E. K. Ajani, and S. A. Omitoyin, "Chemical Characterisation and Assessment of Two Mushroom Stalks as Prebiotics for (Burchell, 1822)," Agricultura Tropica et Subtropica 54, no. 1, pp. 104-115, https://doi.org/10.2478/ats-2021-0011.

[52] Shah, S. R., C. I. Ukaegbu, H. A. Hamid, and O. R. Alara, "Evaluation of Antioxidant and Antibacterial Activities of the Stems of Flammulina velutipes and Hypsizygus tessellatus (White and Brown Var.) Extracted with Different Solvents," Journal of Food Measurement and Characterisation 12 (April 2018): 1947-1961, https://doi.org/10.1007/s11694-018-9810-8.