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# Development of Products with Shiitake Mushroom: Chemical, Physical and Sensory Characterization

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**Abstract** Shiitake mushrooms are much appreciated and therefore their production has increased. However, an important quantity of by-products and residues, are also generated and which are considered as waste materials. In this way, the aim of this work was to develop new foods incorporating shiitake mushrooms that do not comply with standards for commercialization, thus providing additional sources of income for the farmers. For this, a filling with mushroom was produced for rissoles and pies, and the final products were analysed for their chemical composition, colour, texture and sensorial attributes. The results showed that the shiitake products presented an interesting chemical composition, rich in protein and minerals, and poor in salt. It was also observed that the frying operation induced more colour changes in the rissoles than the oven baking of the pies. The textural measurements indicated that the rissoles were much softer when compared to the pies, being also more cohesive and elastic. The sensory panel attributed high scores to both products (around 4.5, on a scale from 1 to 5), thus indicating that these may constitute an additional source of income to the farmers and at the same time reducing waste.

**Keywords** chemical composition, colour, compression test, puncture test, textural properties

## Introduction

Shiitake mushrooms (*Lentinula edodes*) have been used in human diet for centuries and their potential as phytochemicals has also been established. Shiitake mushroom is the second most popular edible mushroom around the world, representing around 25% of the overall mushroom production [1–4].

Shiitake mushroom includes two different parts: the main body used for human consumption, which is the cap, and the stipe, which is normally discarded due to its hard texture. Still, the stipe has improved nutritional value and levels of bioactive compounds [5, 6]. Many studies have proved that shiitake mushrooms contain essential macro and micro nutrients as well as many bioactive compounds, including polysaccharides, antioxidants, dietary fibre, ergosterol, vitamins ($B_1$, $B_2$ and C), folates, niacin and dietary minerals [2, 6–8].

Sustainability has demonstrated to be absolutely critical for the development and continuation of mankind as residents of Planet Earth. The limited availability of resources from the soil and sea allied to the diminishing biodiversity in terms of fauna and flora, has led to the urgency in developing strategies within the framework of sustainability [9].

More than ever, the world faces the consequences of environmental problems that lead to global warming and climate change; water and air pollution; soil contamination, erosion and exhaustion, among others. Food waste also contributes for these environmental issues. Particularly, in the case of mushrooms, a significant amount of stipes (by-products) and also mushrooms that are too small or with the wrong shape (not commercially acceptable) are

considered as waste materials. However, this may bring possibilities and opportunities for farmers at local scale or even the food industry to increase economic profitability by adequate usage and processing of these mushroom by-products. Furthermore, farmers are faced frequently with the fact that some products do not comply with standards for selling either to the commercialization circuits or even to the industry, for example due to small size or irregular shape, although they are perfectly good in terms of taste, composition and nutritional value. Hence, studies focused on developing new added-value foods from these discarded by-products are valuable [10–13].

The objective of this work was to develop new valued foods incorporating shiitake mushroom, as a way to utilize the products that do not comply with standards for commercialization (in terms of size or shape), thus avoiding waste, and creating added value for farmers. Also, by providing additional food experiences, the farmers that have rural tourism houses might find alternative ways to increase the guests' satisfaction.

## Material and Methods

### Cultivation and harvest of the shiitake mushrooms

The shiitake mushrooms were obtained from a local farm named *Ementa Sustentável*, which produces shiitake mushrooms in wooden logs, inside greenhouses, and using exclusively organicfarming techniques. The harvest is best when the mushroom's hat is open at 50% - 80% of its full development. The mushrooms are carefully collected so as not to damage the bark of the logs and at the same time to avoid leaving residues of the taken mushrooms. Following collection, a size classification occurs according to the categories: small, medium or large; and also according to their development status: open or closed. Then they are immediately stored in a refrigerator until they are sold or processed, never exceeding one week. Because open mushrooms are quite susceptible to a faster and more intense degradation, they are usually used for processing and transformation into alternative food products.

### Preparation of the Pies and Rissoles

For the confection of the filling, 8 cloves of garlic were peeled and chopped, and then fried in a pan with 50 mL of olive oil. Then, 800 g of mushrooms were added and left to cook for a short while, until the mushrooms released all their water, followed by300 g of chopped onions, 50 g of flour, 90 g of margarine and 50 mL of semi skimmed milk. The mixture was seasoned with parsley (8 g), salt (5 g), pepper (4 g) and nutmeg (1g) and left to cook for about 10 minutes.

For the preparation of the rissoles' dough were used 240 mL of water mixed with 15 g of margarine and 3 g of salt in a pan over medium heat, with constant stirring, until it was boiling. Then, 120 g of flour were added continuing stirring. As soon as the dough began to separate from the pan, the fire was turned off and the dough was removed from the pan with the help of a wooden spoon, placed to cool on a marble surface which was previously sprinkled with flour to avoid sticking. After cooling, the mass was kneaded until a smooth and elastic texture was obtained, and then with the aid of a roll the dough was spread until a thin layer was formed to form and fill the rissoles: small amounts of filling were placed on the dough which was then folded over the various filling portions, cutting then into the shape of half circles. These were passed on beaten egg and then on breadcrumbs, and finally they were fried in hot oil at 180 °C (Figure 1).

*Figure 1: Rissoles in deep frying (left) and finalized (right)*

For the pies dough, 150 g of flour and 30 g of margarine were weighed and kneaded together with 3 g of salt and warm water added at intervals until the dough lost its stickiness. After being well kneaded, a ball was formed with the dough, which was flipped out and covered with a cloth to stand for 1 hour. Finally, it was spread with a roll over a marble surface. Then, larger circles and smaller circles were cut for the bottom and top parts, respectively. The pies were shaped in metallic forms, with the filling put before covering with slices of dough, which were connected to the bottom dough and then brushed with egg yolk. Finally, they were baked for about 45 minutes, in an oven which had been preheated to 190 °C (Figure 2).

*Figure 2: Pies under oven cooking (left) and finalized (right)*

**Chemical analyses**

For the evaluation of the chemical composition, six units were selected from three lots of each product. The samples were grounded to guarantee uniformity and all determinations were made in triplicates following standard procedures of The Official Methods of Analysis of AOAC International (AOAC, 200). The components evaluated were moisture, ash, fat, fibre, protein and salt (chlorine).

**Evaluation of colour**

Colour was measured using a colorimeter Konica Minolta CR-400, in the Cartesian Coordinates system: L*, a* and b* (CIELab colour space). Lightness is represented by L* and varies from 0 (black), to 100 (white), while the coordinates a* and b* can have negative or positive values: a* negative is green and a* positive is red; b* negative is blue and b* positive is yellow[14]. Colour measurements were made on 10Rissoles and 10 pies, three replicates on each unit.

**Evaluation of texture**

To analyse texture was usedthe texture profile analysis (TPA) obtained through a texturometer TA-XT2 (Stable Microsystems). The test consisted of two consecutive compression cyclesseparated by 5 seconds. The probeused was a flat 75 mm diameter (P/75), and the operating conditions were the following: 30 kg force load cell; pre-test, test and post-test rates equal to 0.5 mm/s; trigger force 0.1 N. The compression distance was 3 and 5 mm, respectively for the rissoles and pies. The textural properties: hardness, resilience, springiness, cohesiveness and chewiness were by means of the following equations (see Figure 3) [15]:

$$\text{Hardness (N)} = F_1 \quad (1)$$

$$\text{Resilience (\%)} = (A_5/A_4)\text{x } 100 \quad (2)$$

$$\text{Springiness (\%)} = (T_2/T_1) \text{ x } 100 \quad (3)$$

$$\text{Cohesiveness (\%)} = (A_2/A_1) \text{ x}100 \quad (4)$$

$$\text{Chewiness (N)} = F_1 \text{ x } (T_2/T_1) \text{ x } (A_2/A_1) \quad (5)$$

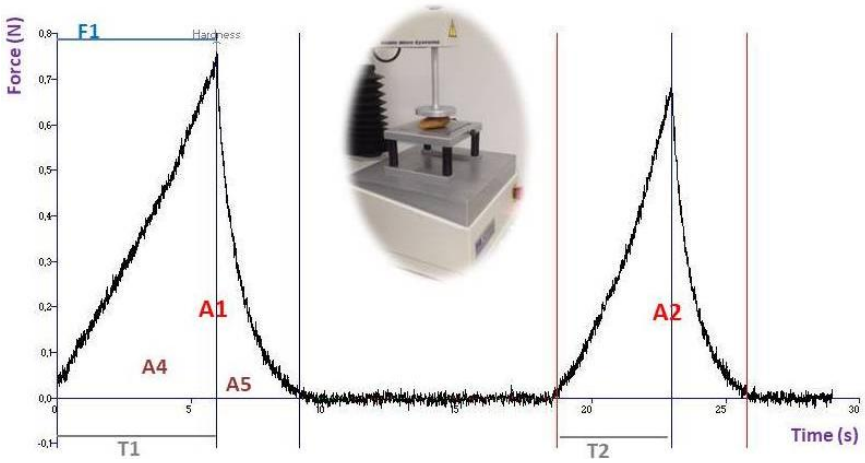



*Figure 3: Example of a texture profile analysis obtained for the rissoles*

For all textural evaluations 10units of each product were used, and one measurement was performed in each unit. The results were processed using Exponent software TEE from Stable Micro Systems.

**Sensory analysis**

Sensorial analysis consisted in tests for descriptive sensory profile, and was performed by a non-trained panel of 25 judges, who had some previous experience in sensory evaluations. The samples were presented to the panelists whole, over an odour-free white dish. Deionised water and unsalted crackers were provided for palate rising in-between the samples. The sensory attributes were evaluated for the dough and for the filling. For the dough were evaluated appearance (colour, uniformity), aroma (pleasantness), taste (salt, pleasantness), texture (hardness, crunchiness, thickness) and global appreciation. For the filling were evaluated appearance (colour, uniformity), aroma (pleasantness), taste (salt, curry, mushroom, pleasantness), texture (moist, creaminess, uniformity) and global appreciation. Finally, an overall assessment of the wholeproducts was undertaken. All attributes were scored on a scale varying from 1 (the lowest intensity of the attribute) to 5 (the highest intensity).

**Results and Discussion**

**Chemical composition**

Table 1 shows the mean values and corresponding standard deviation for the chemical components analysed in the shiitake products. The moisture content was lower for the pies, 34.53%, when compared with the rissoles, being this mostly due to the dough, which is much more dehydrated in the case of the pies due to oven processing. The protein content was similar for both products, between 4 and 5%, which might be due to the shiitake mushroom, which has approximately 3% protein [16].Mushrooms in general present low fat and cholesterol contents, being therefore considered as interesting sources of protein, with demonstrated biological effects, such as antitumor, antiviral, antimicrobial, antioxidative and immunomodulatory activities [17].

**Table 1:** Results of the chemical analyses made to the rissoles and pies filled with shiitake mushroom

| Property (unit) | Rissoles | Pies |
|---|---|---|
| Moisture (%) | 52.46±0.36 | 34.53±0.22 |
| Ash (%) | 2.15±0.19 | 1.78±0.03 |
| Fat (%) | 10.72±0.12 | 16.78±0.93 |
| Fibre (%) | 0.95±0.22 | 1.63±0.24 |
| Protein (%) | 4.87±0.19 | 4.43±0.13 |
| Salt (%) | 1.23±0.03 | 0.89±0.03 |

The presence of fat would be expected, having in mind that the dough for both products incorporates margarine. The value for the rissoles is lower, 10.72%, when compared to pies, 16.78%, because the amount of margarine incorporated into the pies dough was double of that in the rissoles' dough. The frying operation to which the rissoles were submitted did not seem to contribute much to the increase in the fat content, which means that the oil incorporation was low, due to a correct frying process and the high frying temperature. The kinetics of oil absorption is determined by multiple factors, including the oil quality, frying temperature, frying time, possible pre-treatments and finally the composition of the food product. In recent years there has been an interest in minimizing oil absorption during frying, by modification of the applied techniques as well as monitoring of frying temperature and oil degradation [18].

The fibre content was found low, between 0.95% and 1.63%, and the ash content varied from 1.78% to 2.15%, for the pies and rissoles, respectively, referring to minerals that remained after degradation of all organic matter and including dietary minerals. The salt content was also lower for the pies, 0.89%, as compared to the rissoles. Although people in general find more tasty products with more incorporated salt, this has been related with many health problems, particularly regarding heart health and kidney functions [19–21].

**Colour**

Figure 4 shows the results for the colour coordinates in the developed products, taken as individual samples and also calculated as averages of the 10 samples analysed, to investigate the degree of uniformity of the products. The results reveal that for all colour coordinates (L*, a* and b*) there was some variation between the sample of the same product, being this variability more intense for the coordinate a*, which refers to the intensity of the red colouration. This could be explained having in mind that both the frying oven baking operations induce important changes in colour, especially towards browning, which may not be totally uniform[22, 23].

The results in Figure 4 also indicate that the rissoles are darker, L* = 44.12 against 54.64, and with a more intense brown coloration, resulting in higher values for redness, a* = 9.86 against 2.40, and also yellowness, b* = 34.40 against 27.14.

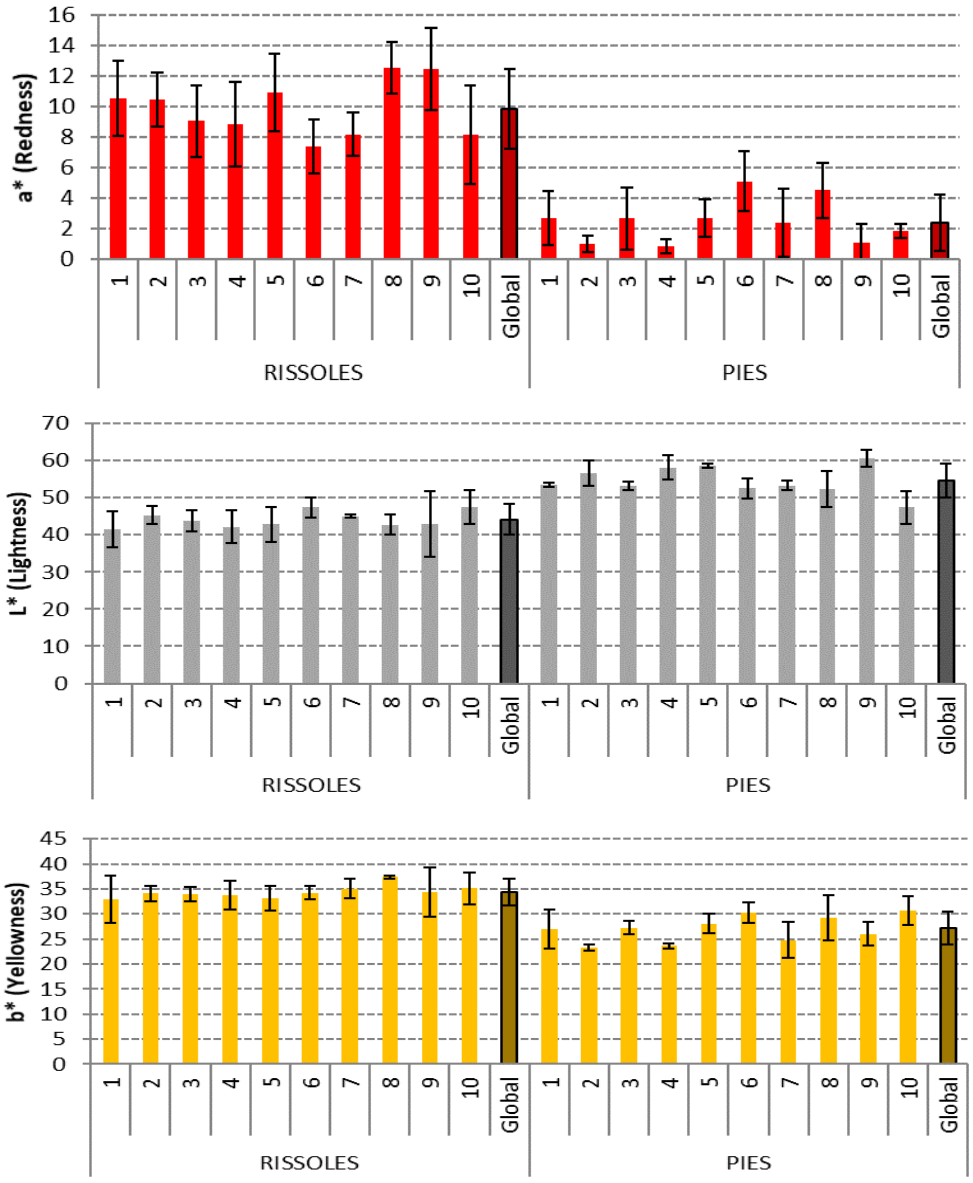
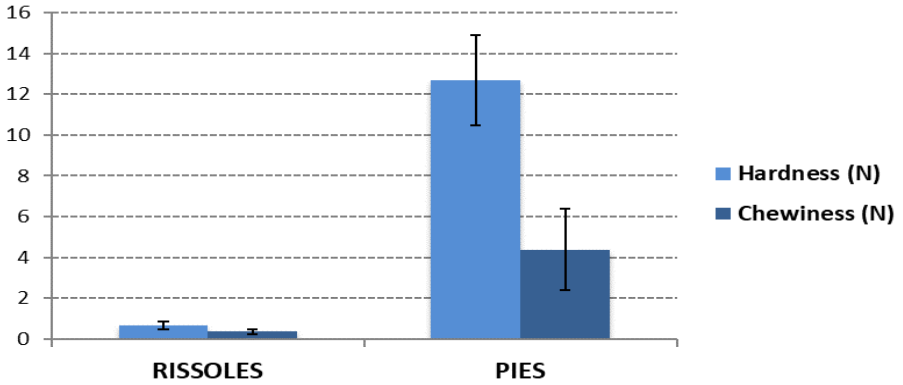



*Figure 4: Colour coordinates for the rissoles and pies separated by sample and calculated as a whole*



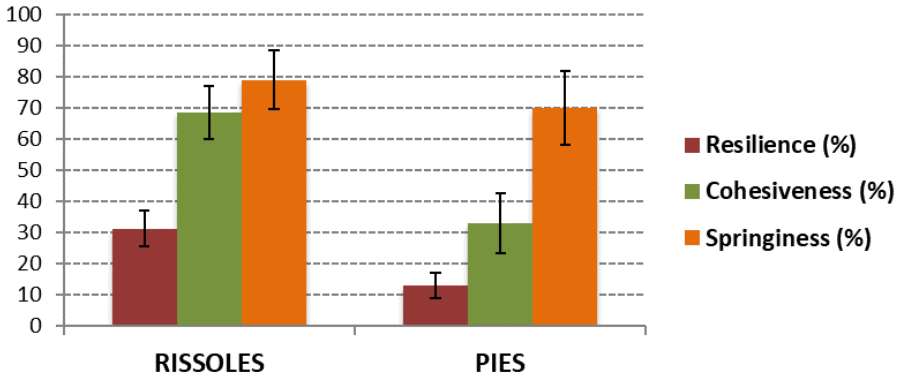


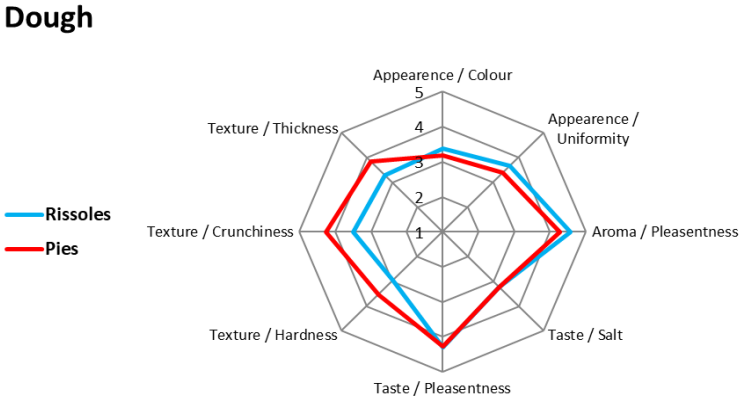

*Figure 5: Textural properties of the products determined as average of TPAs performed on 10 samples*

**Sensorial characteristics**

Figure 6 presents the sensorial characteristics of the filling and dough used in the rissoles and pies. The attribute least scored was salt, both in the dough and in the filling, indicating that the amount of salt added was low, as recommended for health purposes. Nevertheless, it was confirmed that the tasters do not quite appreciate the reduction in salt. The dough of the pies got higher scores for hardness, crunchiness and thickness, which is corroborated with the instrumental evaluations, made for texture. The dough of the rissoles received higher scores for uniformity, colour and aroma. The aroma score may be owing to the frying operations, since fried foods are much valued in general in terms of flavour. Regarding colour, the measurement made also indicated that the rissoles were darker and with more intense colours. Regarding the dough, it was most valued for taste, with scores of 4.31 and 4.27, respectively for rissoles and pies.

Since the filling used in both products was the same, it was expected that the results of the sensory evaluation would be similar, as verified in Figure 6. The attributes more valued in the filling were pleasantness of aroma, pleasantness of taste and creaminess, with values higher than 4, on a scale of up to 5 points.

The average score for overall assessment of the whole rissoles was 4.35 points and for the pies was just very slightly higher, 4.50 points (Figure 7). This indicates that both products were highly appreciated by the panellists, with average scores relatively close to the highest value of the scale considered for evaluation (from 1 to 5 points). The results also indicate that the dough and the filling were similarly scored, i.e., the panellist valued both parts equally.



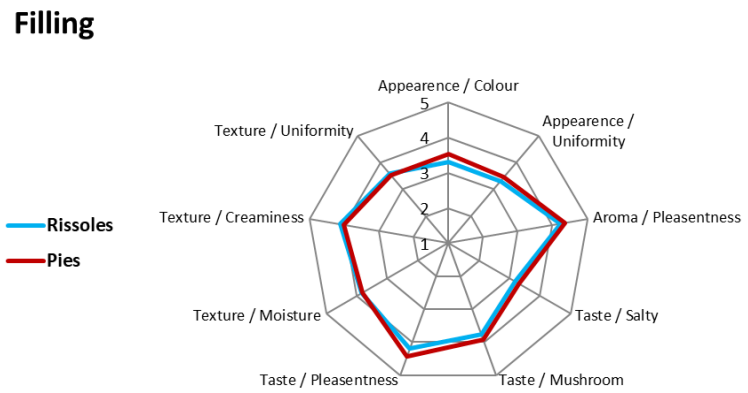



*Figure 6: Sensorial characteristics of the dough and filling of the rissoles and samosas*

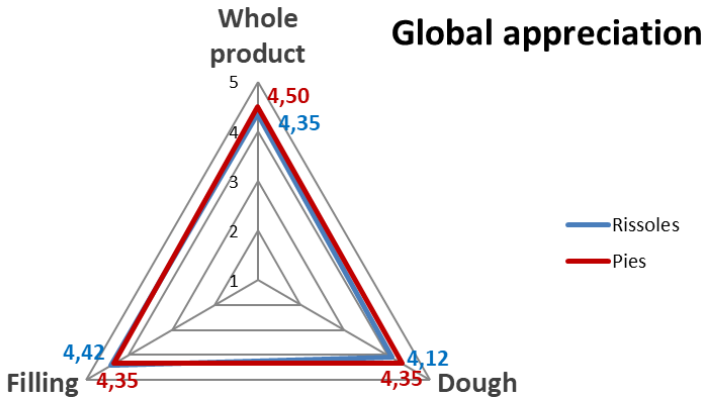



*Figure 7: Global scores for the dough, filling and whole products*

## Conclusions

The present work showed that the chemical composition of the shiitake products developed was balanced, being particularly rich in protein and dietary minerals, and relatively poor in salt. Regarding the colour evaluations, it was observed that the rissoles were more influenced by processing, frying, when compared to the pies, oven baked. In terms of texture, the rissoles were much softer when compared to the pies, being also more cohesive and elastic. Sensory analysis allowed concluding that both, the dough and the filling, as well as the whole products were highly scored, thus indicating that they were appreciated by the panel lists. This is very important because it proved that using the low valued residues and by-products from the shiitake production can be used to produce added value foods, while also contributing for a reduction in waste management needs.

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## References

1. Bisen, P.S., Baghel, R.K., Sanodiya, B.S., Thakur, G.S.& Prasad, G.B.K.S. (2010) *Lentinus edodes*: a macrofungus with pharmacological activities. *Current Medicinal Chemistry*, 17: 2419–2430.
2. Jiang, T., Luo, Z. & Ying, T. (2015) Fumigation with essential oils improves sensory quality and enhanced antioxidant ability of shiitake mushroom (*Lentinus edodes*). *Food Chemistry*, 172: 692–698.
3. Jiang, T., Wang, Q., Xu, S., Jahangir, M.M. & Ying, T. (2010) Structure and composition changes in the cell wall in relation to texture of shiitake mushrooms (*Lentinula edodes*) stored in modified atmosphere packaging. *Journal of the Science of Food and Agriculture*, 90: 742–749.

4. Royse, D.J. (2014) A global perspective on the high five: *Agaricus, Pleurotus, Lentinula, Auricularia & Flammulina*. Proceedings of 8th International Conference on Mushroom Biology and Mushroom Products (ICMBMP8), New Delhi, India, 19-22 November 2014. Volume I & II. 1–6.
5. Yu, Z., Ming, G., Kaiping, W., Zhixiang, C., Liquan, D., Jingyu, L. & Fang, Z. (2010) Structure, chain conformation and antitumor activity of a novel polysaccharide from *Lentinus edodes*. *Fitoterapia*, 81: 1163–1170.
6. Zhang, N., Chen, H., Zhang, Y., Ma, L. & Xu X. (2013) Comparative studies on chemical parameters and antioxidant properties of stipes and caps of shiitake mushroom as affected by different drying methods. *Journal of the Science of Food and Agriculture*, 93: 3107–3113.
7. Mattila, P., Suonpää, K. & Piironen, V. (2000) Functional properties of edible mushrooms. *Nutrition*, 16: 694–696.
8. Reis, F.S., Martins, A., Barros, L. & Ferreira, I.C.F.R. (2012) Antioxidant properties and phenolic profile of the most widely appreciated cultivated mushrooms: a comparative study between in vivo and in vitro samples. *Food and Chemical Toxicology*, 50: 1201–1207.
9. Tuncer, M. (2018) A Theoretical Research on Sustainable Tourism in Aksaray. *Journal of Tourism and Gastronomy Studies*, 6: 444–450.
10. Martins, N. & Ferreira, I.C.F.R. (2017) Wastes and by-products: Upcoming sources of carotenoids for biotechnological purposes and health-related applications. *Trends in Food Science & Technology*, 62: 33–48.
11. Mirabella, N., Castellani, V. & Sala, S. (2014) Current options for the valorization of food manufacturing waste: a review. *Journal of Cleaner Production*, 65: 28–41.
12. Özdemir, G. & Güçer, E. (2018) Food Waste Management within Sustainability Perspective: A Study on Five Star Chain Hotels. *Journal of Tourism and Gastronomy Studies*, 6: 280–299.
13. Van Ba, H., Seo, H.-W., Cho, S.-H., Kim, Y.-S., Kim, J.-H., Ham, J.-S., Park, B.-Y. & Pil-Nam, S. (2017) Effects of extraction methods of shiitake by-products on their antioxidant and antimicrobial activities in fermented sausages during storage. Food Control, 79: 109–118.
14. Gonçalves, C., Guiné, R.P.F., Gonçalves, F. & Costa, D. (2017) Influence of production and conservation conditions on some physical and chemical properties of blueberries. *Agricultural Engineering International: CIGR Journal*, 19: 170–176.
15. Correia, P., Guiné, R., Correia, A.C., Gonçalves, F., Brito, M. & Ribeiro, J. (2017) Physical, chemical and sensory properties of kiwi as influenced by drying conditions. *Agricultural Engineering International*, 19: 203–212.
16. Tian, Y., Zhao, Y., Huang, J., Zeng, H. & Zheng, B. (2016) Effects of different drying methods on the product quality and volatile compounds of whole shiitake mushrooms. *Food Chemistry*, 197: 714–722.
17. Xu, X., Yan, H., Chen, J. & Zhang, X. (2011) Bioactive proteins from mushrooms. *Biotechnology Advances*, 29: 667–674.
18. Kurek, M., Ščetar, M. & Galić, K. (2017) Edible coatings minimize fat uptake in deep fat fried products: A review. *Food Hydrocolloids*, 71: 225–235.
19. DiNicolantonio, J.J., Chatterjee, S. & O'Keefe, J.H. (2016) Dietary Salt Restriction in Heart Failure: Where Is the Evidence? *Progress in Cardiovascular Diseases*, 58: 401–406.
20. Mishra, S., Ingole, S. & Jain, R. (2018) Salt sensitivity and its implication in clinical practice. *Indian Heart Journal*, 70: 556-564.
21. Yano, Y. (2018) Salt and Blood Pressure. In: Vasan, R.S. and Sawyer, D.B. (eds.) Encyclopedia of Cardiovascular Research and Medicine. pp. 345–350. Elsevier, Oxford.
22. Tian, J., Chen, S., Shi, J., Chen, J., Liu, D., Cai, Y., Ogawa, Y.& Ye, X. (2017) Microstructure and digestibility of potato strips produced by conventional frying and air-frying: An in vitro study. *Food Structure*, 14: 30–35.

23. Santos, C.S.P., Molina-Garcia, L., Cunha, S.C. & Casal, S. (2018) Fried potatoes: Impact of prolonged frying in monounsaturated oils. *Food Chemistry*, 243: 192–201.
24. Cruz, A.C., Guiné, R.P.F. & Gonçalves, J.C. (2015) Drying Kinetics and Product Quality for Convective Drying of Apples (cvs. Golden Delicious and Granny Smith). *International Journal of Fruit Science*, 15: 54–78.
25. Guiné, R.P.F., Almeida, I.C., Correia, A.C. & Gonçalves, F.J. (2015) Evaluation of the physical, chemical and sensory properties of raisins produced from grapes of the cultivar Crimson. *Journal of Food Measurement and Characterization*, 9: 337–346.
26. Guiné, R.P.F., Henriques, F. & Barroca, M.J. (2014) Influence of drying treatments on the physical and chemical properties of cucumber. *Journal of Food Measurement and Characterization*, 8: 195–206.
27. Thussu, S. & Datta, A.K. (2012) Texture prediction during deep frying: A mechanistic approach. *Journal of Food Engineering*, 108: 111–121.
28. Rahimi, J., Adewale, P., Ngadi, M., Agyare, K. & Koehler, B. (02017) Changes in the textural and thermal properties of batter coated fried potato strips during post frying holding. *Food and Bioproducts Processing*, 102: 136–143.