International Journal of Food Science and Nutrition
ISSN: 2455-4898; Impact Factor: RJIF 5.14
Received: 15-05-2020; Accepted: 30-05-2020; Published: 19-06-2020
www.foodsciencejournal.com
Volume 5; Issue 3; 2020; Page No. 128-133

Development and evaluation of ready-to-reconstitute white button mushroom products using combination preservation technology

Pallavi R[1], Devaki CS[2*], OP Chauhan[3], PE Patki[4], Roopa N[5], Shekhara Naik R[6]

[1, 2, 6] Department of Food Science and Nutrition, Yuvaraja's College University of Mysore, Mysuru, Karnataka, India

[3, 4, 5] Fruits and Vegetable Technology, Defence Food Research Laboratory-Defence Research and Development Organisation, Mysuru, Karnataka, India

Abstract
In the present study, two ready-to-reconstitute (RTR) mushroom products ***viz***., mushroom butter masala and chilli garlic mushroom were developed. Mushrooms were dried in cabinet dryer and the products were prepared by permutation combination method using dried mushroom and spices. The products were packed in metalized polyester films and stored at ambient temperature conditions. The products were analyzed for nutritional composition; vitamin profile, mineral content for calcium and iron; functional parameters - polyphenols, flavonoids and anti-oxidants; quality parameters - pH, water activity, titratable acidity, free fatty acid, thiobarbituric acid test and peroxide value. During storage, functional parameters were decreased, quality parameters were increased and they were microbially safe. The biochemical and sensory qualities indicated that the mushroom product were in good condition up to three months of storage.

Keywords: mushroom, product, parameter, storage, cabinet dryer, ambient temperature

1. Introduction
Mushrooms are well known as healthy foods and dietary nutrients in all over the world, because they include rich amounts of vegetable proteins, essential amino acids, vitamins, minerals and low fat and calories (Manzi *et al*., 1999 [31]; Pedneault *et al.,* 2008) [36]. However, mushrooms are considered as a food source and they also having medicinal properties because of bioactive compounds (Chiu *et al.,* 2000 [15]; Chang and Miles, 2004) [14]. Also, edible mushrooms are useful for diseases such as hypertension and cancer (Bobek and Galbavy, 1999 [12]; Borchers *et al.,* 1999) [13]. In order to reduce the risks, people tend to try new but healthier food products. Fresh Mushroom products are highly perishable and get spoiled within 24 hours of preparation. Drying is one of the most commonly used preservative method for the preservation of foods since antiquity as it deals with the removal of moisture to avoid the microbial spoilage and other deteriorative reactions (Kroikida *et al.,* 2003) and extends the shelf life of stored food products. Dried foods with better rehydration properties are gaining worldwide demand during recent years. Now a days different types of drying treatments have been used to obtain quality dehydrated products (Maskan, 2001 [30]; Kotwaliwale *et al.,* 2007 [23]; Henriques *et al.,* 2012) [20]. Blanching is normally carried out to inhibit enzyme activity and to kill microorganisms. It also removes the air from the fruits and vegetables to prevent of colour and flavour changes during drying Fu *et al.,* (2018) [17]. Argyropoulos *et al.,* (2011) [9]. reported that drying is a majorly used preservation method to prevent the different types of spoilage including enzymatic or non-enzymatic browning and microbial growth by reducing the moisture content to a safe level of storage. Dried mushrooms are considered as precious ingredients in various food recipes or as additives in a mixture of different dried vegetable snack products. Therefore, the present study aims at the development of ready-to-reconstitute mushroom products using combination preservation technology and their effect on the stability in metalic polyester at ambient temperature (25±2).

2. Material and Methods
2.1 Materials
Good quality fresh mushroom, vegetables and spices were purchased from the local market of Mysore. All the reagents used for the study were of analytical grade.

2.2 Methods
In the present study combination preservation technology such as drying and blanching were used for development of products.

a. Development of RTR Mushroom Butter Masala

Freshly harvested button mushroom were graded, washed and halved. Those mushrooms (30.44%) were deep fried. In the other pan 100 ml of water, chopped onions (15.22%), tomato (24.35%), cinnamon stick (0.3%), javathri (0.15%) and cashewnut (2.13%) were added and cooked and make a paste out of it. To the kadai, butter (15.22%), ginger garlic (1.52%) paste were added and sauteed, grounded paste, garam masala (0.6%), chilli powder (0.6%), turmeric powder (0.3%) and coriander powder (0.6%) were added and cooked for 5 to 10 minutes on a medium flame. Fried mushrooms, salt (0.91%) and coriander leaves (1.52%) were added, mixed and cooked for two more minutes and dehydrated by using cabinet air drier at 55℃ for 24 hours. The products were packed in a metalic or metalized polyester. The products were stored at ambient temperature (25±2).

b. Development of Chilli Garlic Mushroom

Freshly harvested button mushrooms (61.91%) were graded, washed, cut into small pieces. Ginger garlic paste (2.46%), red chilli (1.9%), salt (1.23%) and sugar (1.23%) were made into paste. The oil was heated (6.19%), cumin seeds (0.2%) were added and leave it for 30 seconds. Chopped onions (12.38%) and capsicum (12.38%) were added and sauteed until golden brown. Grounded paste was added and sauteed it, until raw smell of paste was gone. Chopped mushroom pieces were added, cooked it on a medium to low heat until the mushrooms were cooked completely and dehydrated by using cabinet air drier at 55°C for 24 hours. The products were packed in metalic or metalized polyester. The products were stored at ambient temperature (25±2).

c. Drying of RTR Mushroom Butter Masala and RTR Chilli Garlic Mushroom

Mushroom butter masala and chilli garlic mushroom spread on the drying trays and dried in a cabinet drier at 55°C (M/sMACNEILL & MAGOR LIMITED, Mumbai, India). At every 30 min, the reduction in the mass content of mushroom products were recorded and the samples were dried for about 24 hour to obtain moisture content of about 20-25%.

d. Packing and Storage of Dehydrated Mushroom Products

Dried mushroom products were packed in metalised polyester (12µ) stored at ambient temperature (25±2) for shelf life evaluation.

e. Sensory Evaluation

Sensory evaluation of the-ready-re-constituted mushroom butter masala and chilli garlic mushroom were carried out by 10 semi trained panel members for grading the product in terms of colour, aroma, taste, texture and over all acceptability on a 9-point Hedonic scale, with 9 as excellent in all respects and 1 for unacceptable samples (Larmond, 1977) [26]. f. Analysis

Moisture content, ash content and free fatty acid (FFA) values in ready-to-reconstitute mushroom butter masala and chilli garlic mushroom were carried out as per the method of AOAC (2005) [6]. Carbohydrates, protein and fat contents was carried out as per the method described by AOAC (1990) [3]. Vitamin B_1, B_2, B_6, were carried out as per the method by AOAC (1995) [4]. Vit-B_3 by AOAC (1965) [1], vit-C by AOAC (1984) [2], minerals such as calcium and iron by AOAC (2016) [7]. Phenolic content and total anti-oxidants content was carried out as per the method described by Anand T *et al.,* (2018) [10]. Flavonoid content was carried out as per the method described by Blanchflower *et al.,* (2013). Thiobarbituric acid (TBA) value by Tarledgis *et al.,* (1960), total acidity and peroxide value by AOCS (1999) [5]. methods. pH was measured using microprocessor based digital pH meter (CYBER SCAN, MODEL PH 1500, EUTECH INSTRUMENTS, India). Water activity is measured by Aqualab 4TE water activity meter. Microbiological analysis was carried according to APHA (1992) [8]. method and data were transformed into logarithms of the number of colony forming units (CFU/ml).

f. Statistical Analysis

The data obtained for all the parameters and effect of storage on them was statistically analyzed through student t-test to see the critical difference at 5% level of significance using CPCS1 software.

3. Result and Discussion

The products were initially studied for nutritional composition, vitamins and minerals composition, functional components, quality parameters, sensory and microbial analysis. Storage stability studies of the products were studied by storing at ambient temperature (25±2) and analyzed periodically for functional components, quality parameters, sensory and microbial analysis.

3.1. Nutritional Composition of RTR Mushroom Products

In the present study the nutritional components such as moisture, carbohydrates, protein, fat, ash and fibre were anlysed in RTR mushroom butter masala and RTR chilli garlic mushroom. The RTR mushroom butter masala had moisture 24.47%, carbohydrate 09.58%, protein 15.19%, fat 34.38%, fibre 10.34% and ash 06.04%. Cooking with butter showed increase in fat content. The RTR chilli garlic mushroom had moisture 21.47%, carbohydrate 28.93%, protein 16.83%, fat 07.74%, fibre 11.37% and ash 13.66%. The combination preservation technologies used in the study helped to reduce the moisture content, which in turn helps to increase the keeping quality by increasing the shelf life. As seen by some of the researchers an edible mushroom has 23.6% total carbohydrates, 37.6% total protein, 10.0% total fat, 21.2% crude fibre, 7.8% total ash contents on dry weight basis, and the moisture content was 89.4% on wet weight basis (Khan *et al.,* 2009) [21]. On wet weight basis button mushroom has the total protein 3.14g, total carbohydrate 3.23g, fat 0.17g, ash 0.85 and moisture 87.77g per 100g of sample (Poonkandi *et al.,* 2015). On dry basis, an edible mushroom has 56.8% carbohydrate, 25.0% protein, 5.7% fat and 12.5% ash contents (Demirbas, 2002 [16]; Mendil *et al.,* 2004) [32].

3.2. Mineral Content of Processed Mushroom Products

The RTR mushroom butter masala and RTR chilli garlic mushroom were analyzed for minerals such as calcium and iron and the results had calcium 21.6mg and iron 26.8mg; calcium 49.6mg and iron 25.2mg respectively per 100g of sample. Khan *et al.,* (2009) [21]. estimated the minerals such as Fe and Ca and were found to be 18.5mg and 44.0mg respectively per 100g of dry sample. Woldegiorgis *et al.,* (2015) [43]. Estimated the calcium and iron content in *Agaricus bisporus* which was found 224mg and 6.32mg respectively per 100g of dry sample. Gaur *et al.,* (2016) [7]. Estimated the minerals such as Fe and Ca by AOAC methods, which was found 46.1mg and 39.5mg respectively per 100g of dry sample.

3.3. Vitamin Content of RTR Mushroom Products

The RTR mushroom butter masala was analyzed for vitamins such as thiamine, riboflavin, niacin, pyridoxine and vitamin C. Mushroom butter masala had thiamine 2.13mg, riboflavin 1.54mg, niacin 2.87mg, pyridoxine 1.05mg and vitamin C 62.5mg per 100g of sample.

RTR chilli garlic mushroom had thiamine 1.23mg, riboflavin 0.93mg, niacin 1.84mg, pyridoxine 0.93mg and vitamin C 125mg per 100g of sample. Mattila *et al.,* (2001) estimated the vitamins such as vitamin-C, Vit-B_1, B_2, folates, niacin and vit-B_{12} in *Agaricus bisporus*. It was found 17mg, 0.6mg, 5.1mg, 450µg, 43mg and 0.8mg respectively per

100g of sample.

3.4. Storage Studies of RTR Mushroom Products

Shelf life of any product shows its potential for being stored for a definite period of time without any deteriorating effects on its quality parameters. Storage life indirectly shows the market life of the product. In the present study, two mushroom products ***viz.***, mushroom butter masala and chilli garlic mushroom were processed with multiple preservation technologies and were evaluated periodically for functional, nutritional and quality parameters. Total phenols (mg/100ml gallic acid equivalents), anti-antioxidant and total flavonoids (mg of quercetin equivalents/100g) were considered as functional parameters, vitamin C (mg/100gm) as nutritional parameter, and pH, titratable acidity, free fatty acids, peroxide value and thiobarbituric acid (TBA) value were considered as quality parameters, sensory evaluation for overall acceptability and microbiological studies were studied in the stored samples. The acceptability scores which has helped to establish the shelf life.

3.5. Functional Parameters

Total phenols (mg/100ml gallic acid equivalents), total flavonoids (mg of quercetin equivalents/100g) and anti-oxidants were considered as functional parameters. Changes during the storage period on functional parameters are presented in Table 3.

Initially total phenols of mushroom butter masala and chilli garlic mushroom were 291.66mg and 358.33mg per 100gm of sample respectively. Total phenol content of mushroom butter masala and chilli garlic mushroom decreased from the level of 291.66mg to 145.73mg and 358.33 to 198.65 per 100g of mushroom products in 3 months, when stored at ambient temperature (25±2°C). Thiansilakul *et al.,* (2012) [42]. reported that the total phenols in the extracts of mushroom ranged from 14 to 21 mg/g. Senthilkumar *et al.*, (2016) [38]. reported the total phenol content was found 5.8 mg GAE/g in aqueous extract and 7.4 mg GAE/g in the methanolic extract of *A. bisporus*. (Yang and Maguer 2002) [44]. reported that, phenols such as tocopherol, found in mushrooms are known to have effective antioxidant properties.

Initially total flavonoids of RTR mushroom butter masala and chilli garlic mushroom were 73.30mg and 66.60mg per 100gm of sample respectively. Total flavonoids content of RTR mushroom butter masala and chilli garlic mushroom decreased from the level of 73.3mg to 29.63mg and 66.6mg to 22.25mg per 100g of mushroom products in 3 months, when stored at ambient temperature (25±2°C).

Initially total anti-oxidant contents of the mushroom butter masala and chilli garlic mushroom were 69.75 and 93.29% per 100g of sample respectively. Total anti-oxidant content of mushroom butter masala and chilli garlic mushroom decreased from the level of 69.75 to 44.73% and 93.29 to 52.25% per 100g of mushroom product in 3 months, when stored at ambient temperature (25±2°C). Singla *et al.*, (2009) scavenging activity of free extracts of raw mushrooms on DPPH radical were 76 per cent.

3.6. Nutritional Parameters

Vitamin C (mg/100ml) was considered as nutritional parameters. During the storage period, vitamin C content decreased from the level of 62.5 to 40.6mg per 100g and 125 to 75.2mg per 100g in RTR mushroom butter masala and chilli garlic mushroom respectively in 3 months, when stored at ambient temperature (25 ± 2°C). Vitamin C is light and heat sensitive, the concentration of vitamin C follows first order kinetics and thus storage time affects vitamin C content (Metlitsky *et al.,* 1968) [33]. Vitamin C was very less stable which reduced significantly in mushroom butter masala and chilli garlic mushroom.

3.7. Quality Parameters

The results on the changes in quality parameters during storage of processed mushroom products are given in Table 4. As shown in Table 4 it was found that there was increase in pH in RTR mushroom butter masala from 6.3 to 7.0 in third month of storage period. RTR chilli garlic mushroom from 6.4 to 7.3 in third month of storage. The increase in pH value might be attributed to the increase in volatile bases (e.g., ammonia and trimethylamine) produced by either endogenous or microbial enzymes (Manat *et al.,* 2005) [28]. Titratable acidity as expressed as % lactic acid was found to be increased in the stored RTR mushroom products. Titratable acidity of mushroom butter masala and chilli garlic mushroom increased from 0.12% to 0.21% and 0.12% to 0.19% respectively during third month of storage.

Peroxide value was increased in RTR mushroom butter masala and RTR chilli garlic mushroom. As the values shown in Table 4 indicates that, in the mushroom butter masala (0.52) the increase was more when compared to that of chilli garlic mushroom (0.34). Melton *et al.,* (1993) [34]. Reported that, there was no effect of storage condition and the type of oil on peroxide value, however by increasing storage time peroxide value increases.

As shown in Table 4, it was observed that there was increase in free fatty acid value. The value of free fatty acid was seen in higher percentage in RTR mushroom butter masala (0.16) compared to RTR chilli garlic mushroom (0.12). Pacheco-Aguilar *et al.,* (2000) [36]. reported that, lipases and phospholipases hydrolyse glycerol-fatty acid to release free fatty acids (FFA). Free fatty acids have been oxidise faster than their triacylglycerols (Labuza *et al.*, 1969 [25]; Yanishlieva-Maslarova 1985) [45] and faster than ethyl and methyl esters (Miyashita and Takagi 1986) [35]. Thus the free fatty acids exert a pro-oxidative effect. This effect is due to complex formation between hydroperoxides and carboxyl groups through a hydrogen bond, which results in an accelerated decomposition of hydroperoxides into free radicals (Miyashita and Takagi 1986) [35].

In RTR mushroom butter masala TBA increased to 0.71 from the initial value 0.25 and in RTR chilli garlic mushroom from 0.05 to 0.13 $mEqO_2$/gm of the samples during 3 month of storage period. Thiobarbituric acid is widely used as an indicator of degree of lipid oxidation, and the presence of TBA reactive substances is due to the second stage of auto-oxidation during which peroxides are oxidised to aldehydes and ketones (Lindsay 1991). Mushroom products showed an increase in TBA values (mg/malonaldehyde/gm) during storage.

3.8. Sensory Parameters

The sensory evaluation is a scientific discipline that measures, analyses and interprets reactions to those characteristics of food and materials as they are perceived by the senses of vision, odour, taste, touch and hearing (Sidel and Stone, 2006) []. Overall acceptability is the sum

of different quality attributes which have a bearing on consumer perception towards the acceptance or rejection of a product. The results on the changes in sensory parameters during storage of RTR mushroom products are shown in Table 5. The initial acceptability score of mushroom butter masala and chilli garlic mushroom was 8.2 and 8.6 on 9-point hedonic scale and decreased slowly with the storage period after 3 months of storage. In general, any product with the score of below 6 is on the non-acceptance. Though the product was acceptable during storage, the temperature of storage influenced the scores.

3.9. Changes in Microbial Quality

Microbial growth during storage will be depended on the preservation conditions. (Gram and Dalgaard 2002). The mushroom products samples were subjected to bacterial, yeast and mold count on every one month of interval for three months. Samples showed normally an increasing trend in bacterial count with maximum increase by the end of 3rd month. All mushroom products showed lower values of bacteria, yeast and mold with storage at 10^2 dilutions. All the samples showed no significant mold growth. The samples confined to permissible limit of microbial count of 1000/10000. The mushroom products were evaluated for its microbial quality. The microbiological analysis clearly shows the sterilized condition of the product, coliform was nil upto 3 months of storage period reflecting the safety of the product.

Table 1: Nutritional composition of RTR mushroom products per 100g of sample

Mushroom products	Moisture (%)	Carbohydrates (g)	Protein (g)	Fat (g)	Fibre (g)	Ash (g)
RTR mushroom butter masala	24.47±0.04	09.58±0.02	15.19±0.01	34.38±0.04	10.34±0.04	06.04±0.07
RTR chilli garlic mushroom	21.47±0.12	28.93±0.17	16.83±0.05	07.74±0.09	11.37±0.01	13.66±0.14

Table 2: Micronutrients content of RTR mushroom products mg/100g

Micronutrients	RTR mushroom butter masala	RTR chilli garlic mushroom
Thiamin	2.13±0.02	1.23±0.01
Riboflavin	1.54±0.06	0.93±0.05
Niacin	2.87±0.14	1.84±0.11
Pyridoxine	1.05±0.03	0.93±0.04
Vitamin C	62.5±0.17	125±0.06
Calcium	21.6±0.07	49.6±0.14
Iron	26.8±0.14	25.2±0.07

Table 3: Storage stability study of processed mushroom products on functional parameters (n=3)

Functional parameters	Period in months	RTR mushroom butter masala	RTR chilli garlic mushroom
Total phenol (mg/100ml gallic acid)	0	$291.66±0.06^a$	$358.33±0.34^a$
	1	$248.53±0.22^b$	$287.27±0.21^d$
	2	$202.21±0.34^b$	$234.76±0.17^d$
	3	$145.73±0.22^a$	$198.65±0.14^b$
Flavonoid (mg/100ml quercetin)	0	$73.30±0.12^d$	$66.60±0.04^b$
	1	$51.46±0.13^b$	$43.33±0.11^d$
	2	$38.45±0.16^b$	$35.87±0.17^a$
	3	$29.63±0.18^b$	$22.25±0.04^c$
Antioxidant (I%)	0	$69.75±0.13^c$	$93.29±0.01^a$
	1	$54.73±0.21^b$	$73.95±0.11^d$
	2	$49.72±0.13^c$	$61.21±0.16^a$
	3	$44.73±0.18^b$	$52.25±0.06^a$

Storage temperature: 25±2°C

*Note: Values with different superscripts are significant difference with initial period at the level, a: $p<0.0001$, b: $p<0.001$, c: $p<0.01$, d: $p<0.05$

Table 4: Storage stability study of processed mushroom products on quality parameters (n=3)

Quality parameters	Period in month	RTR mushroom butter masala	RTR chilli garlic mushroom
pH	0	$6.3±0.05^c$	$6.4±0.05^c$
	1	$6.6±0.01^a$	$6.9±0.02^b$
	2	$6.8±0.03^b$	$7.1±0.01^a$
	3	$7.0±0.04^c$	$7.3±0.05^c$
Titratable acidity (% Lactic acid))	0	$0.12±0.05^b$	$0.12±0.01^a$
	1	$0.16±0.07^c$	$0.14±0.08^c$
	2	$0.19±0.08^c$	$0.17±0.03^a$
	3	$0.21±0.04^b$	$0.19±0.02^a$
Peroxide value ($MEqO_2/g$)	0	$0.32±0.01^a$	$0.24±0.04^c$
	1	$0.40±0.05^c$	$0.28±0.09^c$
	2	$0.45±0.03^c$	$0.31±0.01^a$
	3	$0.52±0.02^b$	$0.34±0.04^b$
Free fatty acid (%/g)	0	$0.07±0.01^a$	$0.05±0.08^b$
	1	$0.09±0.02^a$	$0.07±0.01^a$
	2	$0.13±0.04^b$	$0.10±0.02^c$

	3	0.16±0.05^{c}	0.12±0.04^{b}
TBA (mg/malonaldehyde/kg)	0	0.25±0.01^{a}	0.05±0.01^{a}
	1	0.42±0.04^{c}	0.08±0.05^{c}
	2	0.56±0.01^{a}	0.10±0.01^{a}
	3	0.71±0.02^{c}	0.13±0.04^{c}

Storage Temperature: 25±2°C

*Note: Values with different superscripts are significant difference with initial period at the level, a: p<0.0001, b: p<0.001, c: p<0.01, d: p<0.05

Table 5: Storage stability study of processed mushroom product on sensory score (n=25)

SL. No	Mushroom products	Period In month	Colour	Aroma	Texture	Taste	OAA
01	RTR mushroom butter masala	0	8.3±0.18^{a}	8.1±0.19^{b}	8.3±0.18^{a}	8.1±0.22^{b}	8.2±0.12^{a}
		1	7.1±0.02^{c}	7.0±0.16^{a}	7.2±0.14^{c}	6.8±0.11^{a}	7.0±0.11^{a}
		2	6.5±0.08^{c}	6.7±0.13^{a}	6.7±0.08^{c}	6.1±0.12^{a}	6.5±0.02^{c}
		3	6.0±0.06^{c}	6.3±0.12^{c}	6.2±0.09^{c}	5.8±0.11^{c}	6.1±0.01^{c}
02	RTR chilli garlic mushroom	0	8.5±0.18^{a}	8.7±0.14^{a}	8.5±0.21^{a}	8.7±0.19^{a}	8.6±0.06^{a}
		1	7.3±0.09^{c}	7.5±0.05^{c}	7.2±0.26^{a}	7.6±0.12^{c}	7.4±0.09^{a}
		2	6.5±0.18^{c}	6.7±0.17^{c}	6.5±0.11^{b}	6.7±0.19^{a}	6.6±0.14^{a}
		3	6.0±0.09^{c}	5.8±0.07^{c}	6.2±0.16^{b}	6.0±0.10^{c}	6.0±0.27^{a}

*OAA - Over all acceptability

*Note: Values with different superscripts are significant difference with initial period at the level, a: p<0.0001, b: p<0.001, c: p<0.01, d: p<0.05

4. Conclusion

The study brought two ready-to-reconstitute mushroom products using combination preservation technology ***viz***., RTR mushroom butter masala and RTR chilli garlic mushroom which were found to be highly acceptable and had good nutritional value. The biochemical and sensory qualities indicated that the mushroom products were found to be in good condition up to three months of storage at ambient temperature (25±2°C). It can be concluded that, addition of spices in mushroom products offers the preservative effect due to their antioxidant and antimicrobial properties whereas the compounds present in button mushroom ***viz***., β-glucans, catechin, and vitamin C etc, provides a synergetic effect to the products. Therefore it can be recommended that, mushroom not only increases the nutritional quality but also improves the shelf life of products at ambient temperature. Preservation technology used in the present study helped in increasing the stability of the product at ambient temperature (25±2).

5. References

1. AOAC. Official methods of analysis of the association of Agricultural chemists, 10th edition, 1965, 660-663.
2. AOAC. Official methods of analysis, 14th edn. (S. Williams, ed), 1984, 844-846.
3. AOAC. Official methods of analysis, 18th edn. Association of Official Analytical Chemists, Washington, 1990.
4. AOAC. Official methods of analysis 961.15. Association of Official Analytical Chemists, Washington, 1995.
5. AOCS. Official methods and recommended practices of American Oil Chemists Society, 5th edn. A.O.C.S, Champaign, 1999.
6. AOAC. Official methods of analysis, 18th edn. Association of Official Analytical Chemists, Washington, 2005.
7. AOAC. J. of AOAC International, 2016.
8. APHA. Recommended methods for the microbial examination of foods. Broadway: Am Public Health Assoc. 1992; 19:181-188.
9. Argyropoulos D, Heindl A, Muller J. Assessment of convection, hot-air combined with microwave vacuum and freeze-drying methods for mushrooms with regard to product quality. Int J Food Sci and Technol. 2011; 46:333-42.
10. Anand T, Jalaram Reddy K, Ramya S, Farhath Khanum. Optimisation of conditions for nanoencapsulation of bacoside rich extracts by RSM technique and it's characterisation. J Open access text, 2018, 4. 10.15761/FNN.1000162.
11. Bahorun T, Grinier B, Trotin F, Brunet G, Pin T. Oxygen species scavenging activity of phenolic extracts from Hawthorn fresh plant organs and pharmaceutical preparations. Arzneimittel-Forschung. 1996; 46(11):1086-1089. PMid:8955870.
12. Bobek P, Galbavy S. Hypocholesterolemic and antiatherogenic effect of oyster mushroom (Pleurotus ostreatus) in rabbits. Food/Nahrung, 1999; 43(5):339-342.
13. Borchers AT, Stern JS, Hackman RM, Keen CL, Gershwin ME. Mushrooms, Tumors, and Immunity. Proceedings of the Society for Experimental Biology and Medicine. 1999; 221:281-293.
14. Chang ST, Miles PG. The nutritional attributes of edible mushrooms. In: Chang ST, Miles, PG. (eds), Mushrooms: cultivation, nutritional value, medicinal effect, and environmental impact, 2nd edn. CRC Press, Boca Raton, 2004, 27-37.
15. Chiu SW, Law SC, Ching ML, Cheung KW, Chen MJ. Themes for mushroom exploitation in the 21st century: sustainability, waste management, and conservation. Journal of General and Applied Microbiology. 2000; 46:269-282.
16. Demirbas A. Metal ion uptake by mushrooms from natural and artificially enriched soils. Food Chemistry. 2002; 8:89-93.
17. Fu Q, Chen SJ, Hu Z, Xie H. Effect of hot water blanching pretreatment on drying characteristics and product qualities for the novel integrated freeze drying of apple slices. Journal of food quality, 2018, 1-12.
18. Gaur T, Rao PB, Kushwaha KPS. Nutritional and anti-nutritional components of some selected edible mushroom species. Indian journal of natural products

and resources. 2016; 7(2):155-161.
19. Gram L, Dalgaard P. Fish spoilage bacteria-Problems and solutions. Curr Opin Biotechnol. 2002; 13(3):262-266.
20. Henriques F, Guine RPF, Barroca MJ. Influence of drying treatment on physical properties of pumpkin. Croatian. J Food Tech Biotech. 2012; 7:53-58.
21. Khan MA, Khan LA, Tania MdSHM, Uddin MdN. Investigation on the Nutritional composition of common edible and medicinal mushrooms cultivated in Bangladesh. Bangladesh J mushroom. 2009; 3(1):21-28.
22. Kaul TN. Biology and conservation of mushrooms, 2001, 117-145.
23. Kotwaliwale N, Bakane P, Verma A. Changes in textural and optical properties of oyster mushroom during hot air drying. J Food Engg. 2007; 78:1207-1211.
24. Krokida MK, Karathanos VT, Maroulis ZB Kouris DM. Drying kinetics of some vegetables. J Food Engg. 2003; 59:391-403.
25. Labuza TP, Tsuyuki H, Karel M. Kinetics in linoleate oxidation in model systems. J Am Oil Chem Soc. 1969; 46:409-416.
26. Larmond E. Laboratory methods for the sensory evaluation of foods. Canada Department of Agriculture publicationOttawa, Canada, 1977, 1637.
27. Lindsay RC. Flavour of fish. In: 8th World Congress of Food Science and Technology. Toronto. 1991.
28. Manat C, Soottawat B, Wonnop V, Cameron F. Changes of pigments and colour in sardine (Sardinella gibbosa) and mackerel (Rastrelliger kanagurta) muscle during iced storage. Food Chem. 2005; 93:607-617.
29. Mattila P, Nen PSV, Konko K, Aro H, Jalava T. Basic composition and amino acid contents of mushrooms cultivated in Finland. J of agriculture and food chemistry. 2002; 50(22):6419-6422.
30. Maskan M. Drying, shrinkage and rehydration characteristics of kiwi fruits during hot air and microwave drying. J Food Engg. 2001; 48:177-182.
31. Manzi P, Gambelli L, Marconi S, Vivanti V, Pizzoferrato L. Nutrients in edible mushrooms: an inter-species comparative study. Food Chemistry. 1999; 65:477-482.
32. Mendil D, Uluozlu OD, Hasdemir E, Caglar A. Determination of trace elements on some wild edible mushroom samples from Kastamonu, Turkey. Food Chemistry. 2004; 88:281-285.
33. Metlitsky LV, Korableva NP, Shalinova RT. Industrial testing of gamma exposure of potatoes for the preservation of sprouting. Konserv, Ovoshchesush. Prom. 1968; 1(23):45-56.
34. Melton SL, Trigiano MK, Penfield MP, Yang R. Potato chips fried in canola and/or cottonseed oil maintain high quality. J Food Sci. 1993; 58(5):1079-1083.
35. Miyashita K, Takagi T. Study on the oxidative rate and prooxidant activity of free fatty acids. J Am Oil Chem Soc. 1986; 63:1380-1384.
36. Pacheco-Aguilar R, Lugo-Sanchez ME, Robles-Burgueno MR. Postmortem biochemical and functional characteristic of Monterey sardine muscle stored at 0 °C. J Food Sci. 65: 40-47. Pedneault K, Angers P, Gosselin A, Tweddell RJ. 2008. Fatty acid profiles of polar and neutral lipids of ten species of higher basidiomycetes indigenous to eastern Canada. Mycological Research. 2000; 112:1428-1434.
37. Poongkodi GK, Priya GPH, Priya GPH. Nutrient contents of edible mushrooms. *Agaricus bisporus and Pleurotus ostreatus*. International journal of modern chemistry and applied science. 2015; 2(2):78-86.
38. Senthilkumar V, Sathishkumar G, Shivarama krishnan S, Sujatha K, Razia M. Development and shelf life evaluation of tomato mushroom mixed ketchup. Journal of food science and technology. 2016; 53(5):2236-2243.
39. Sidel JL, Stone H. Sensory Science: Methodology. In: Hui YH (ed) Handbook of food science, technology & engineering, Vol I, CRC Press Taylor & Francis, USA, 2006.
40. Singla R, Ganguli A, Ghosh M. Antioxidant activities and polyphenolic properties of raw and osmotically dehydrated mushroom *(Agaricus bisporus)*. Journal of food properties. 2009; 13:1290-1299.
41. Tarladgis BG, Watts BM, Younathan MT. A distillation method for the quantitative determination of malonaldehyde in rancid foods. J Am Oil Chem Soc. 1960; 37:44-48.
42. Thiansilakul Y, Benjakul S, Eric W, Grunwald EW, Richards MP. Retardation of myoglobin and haemoglobin-mediated lipid oxidation in washed bighead carp by phenolic compounds. Food Chem. 2012; 134:789-796.
43. Woldegiorgis AZ, Abate D, Haki GD, Ziegaler GR. Major, minor and toxic minerals and Antinutrients composition in edible mushrooms collected from Ethiopia. J of food processing and technology. 2015; 6(430):2157-7110.
44. Yang DC, Maguer ML. Mass transfer kinetics of osmotic dehydration of mushrooms. J Food Process Preser. 2002; 16(3):215-231.
45. Yanishlieva-Maslarova NV. Differences in the kinetics and mechanism of autoxidation of stearic acid and tristearin. Grasay Aceites. 1985; 36:115-119.