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Effect of Processing on Nutritional Characteristics the *Agaricus Bisporus* Mushroom

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ABSTRACT

With the advancements in knowledge and development of industry, the processing methods have also evolved and become more complex and efficient. The processing of agricultural products or processing activities is vital in developing the fruit and vegetable industry, increasing the marketability of fresh products, and reducing post-harvest waste. The current research was conducted randomly with four treatments in three repetitions in 2022-2023 at the Edible & Medicinal Mushroom Research Center Islamic Azad University of Isfahan (Khorasgan). This study evaluated the effect of different processing and drying methods (Such as salting, canning, infrared, and hot air) on the quality characteristics of *A. bisporus* mushroom. The evaluated traits included volatile and nonvolatile compounds, amino acid, Based on the analysis and identification of volatile and nonvolatile compounds in fresh *A. bisporus* mushroom samples, Heptane, 3-methyl-, Heptane, 2-methyl-, Octane, Cyclopentane, 1-ethyl-3-methyl, Heptane, Heptane, 2 -methyl-, Nonane, Cyclohexane, methyl-, Octane, 4-methyl-, Decane, Octane, 2,6-dimethyl-, Nonane, 2-methyl-, Octane, 3-methyl- with values of 14/74, 13/85, 12/49, 7/36, 6/60, 5/53, 5/38, 3/31, 3/13, 2/89, 2/64, 1/97 and 1/94 percent, respectively, were the highest amount of compounds. According to the results of amino acid analysis, 15 different amino acid compounds were identified in the fruiting organ of *A. bisporus* mushroom, and the amount of these compounds varied under different drying methods. The research findings showed that serine had the highest concentration of amino acids, with values of 44.4, 37.6, and 8.1 grams per 100 grams of dry weight, respectively, under the infrared, salting, and hot air treatments. In general, the study results revealed that the infrared and hot air treatments significantly impacted the improvement of the increased the amount of amino acids. Also, the canning treatment preserved the fat content and prevented its excessive oxidation in the *A. bisporus* mushrooms.

Keywords: Infrared, Canning, Amino acids

INTRODUCTION

Reduced moisture or drying through heat and mass transfer are widely used to enhance storage, facilitate transportation, preserve quality, and reduce the post-harvest loss of agricultural products to produce dried vegetables and fruits (Martysiak-Zurowska *et al*., 2020). Moreover, due to the reduced moisture content of the food, the possibility of microbial spoilage is eliminated, and the chemical and biochemical reactions are significantly decelerated. Drying food, especially vegetables and fruits, can be done through various methods, such as sun drying, hot air, infrared, microwave, and vacuum drying (Coskun *et al*., 2017). The quality of dried products depends on structural characteristics (e.g., specific volume, density, and porosity), thermal characteristics (e.g., glass, crystalline, and elastic modes), and properties, such as moisture absorption and capacity. Color and shrinkage values are the most important physical features in the drying process, which are influenced by the drying conditions (Reis *et al.*, 2022). Dried products must maintain their physical features, texture, and functional properties. Factors such as changes in dried products through the drying process and the demand for green energy have revealed the need to use different drying methods (Kianpour, 2020; Feng *et al*., 2020).

Important Medicinal Compounds

The key compounds in the fruiting body of *Agaricus bisporus* are (1&3)-Beta-D-Glucan, (1&4) Beta-D-Glucan, (1&6) Beta-D-Glucan (Anti-tumor and Immune System Booster), and Proteoglycan (Anti-tumor). Button mushroom has the highest amount of Beta-glucan and its derivations than other mushrooms (Farias Menezes *et al*., 2-22). Beta-glucans are the valuable compounds found in the cell wall structure of some higher plants, such as cereals, algae, yeasts, and mushrooms in particular, that have received attention due to various biological activities (Wang *et al*., 2022).

Importance of drying

The drying advantages are meeting the global moisture standard, achieving cost efficiency in the international trade market, and maintaining the qualitative and quantitative factors. Drying is an essential and influential quality indicator of the final product regarding chemical and active characteristics (Duan *et al*., 2021). There is a maximum moisture content for various species of plants prescribed in different pharmacopeias globally. The time and temperature required for drying are vital principles determined by the initial moisture of the plant organ and the quality and quantity of the active substances. Drying should lead to the lowest quality reduction in active substances, color, odor, and taste (Hue *et al*., 2020; Harguindeguy & Fissore, 2019).

MATERIALS AND METHODS

Research Method

Uniform *A. bisporus* mushrooms without any stain, disease, etc., were selected and transferred to the Edible and Medicinal Mushroom Research Center, Islamic Azad University, Isfahan (Khorasgan) Branch. Fresh mushrooms were stored in the fridge at 4 °C with a relative humidity of 95% prior to the test. The samples were washed with cold water to remove the sticky soil particles, dispose of compost residues on mushrooms, and reduce the microbial load. This step was done as fast as possible to prevent the absorption of extra water. Mushrooms were cut into 5±1 mm thick using a sharp steel knife after manually removing the extra water from the surface. Mushroom slices were placed on one layer of special steel trays and then transferred to the drying device.

Treatments/ Hot air

The fruit body of the sliced *A. bisporus* mushroom (all 5000 grams) was placed on the steel trays. Then, the mushrooms were dried using the electric thermal drier at 55 °C for 4 hours so that the moisture content of the samples reached the moist base of 10 grams per 100 grams (Hu *et al*., 2020).

Infrared

The sample mushrooms were dried under the infrared rays at 35 °C with a short wavelength (Hu *et al*., 2021). The infrared lamps were placed in a row on the upper surface of the dryer chamber, emitting infrared radiation in the range of medium to short wavelengths (2.3-3 µm). The maximum power of each lamp was 450 watts, and the radiation efficiency was 70-80%. To ensure the uniform radiant heating, 6 IR lamps were turned on with a maximum power of 1.2 kW. The distance between the infrared lamps and the trays containing the mushroom samples was 14 cm (Wang *et al*., 2015).

Canning

180 grams of *A. bisporus* mushroom were placed in 300cm^3 glass containers, sealed, and sterilized with 100 cm^3 of hot solution containing 2% salt through aerated immersion. The sterilization process was as follows: increasing the temperature up to 100 °C for 5 minutes, increasing the temperature from 100 to 118 °C for 10 minutes, sterilizing at 118 to 121 °C for 12 minutes, and finally, cooling at 30 °C for 10 minutes. Then, the canned mushrooms were stored at 8-10 °C (Jawroska *et al*., 2011).

Salting

The sliced mushrooms were immersed in a 10% salt solution for 10 minutes (Workneh *et al*., 2014).

Measuring methods of the studied traits

Evaluating free amino acids

According to Hu *et al*. (2020), 1 gram of mushroom powder was shaken with 50 milliliters of hydrochloric acid (0.10 mol/L) at 25 °C for 45 minutes and then centrifuged at 12000 rpm for 30 minutes. The supernatant was added to sulfonyl salicylic acid (5 mL) and placed in the dark for 30 min. Subsequently, it was filtered through a 0.22-micrometer hydrophilic membrane. Finally, the extracted solutions were analyzed by an automatic amino acid analyzer (L-8900) at high speed (Zhang *et al*., 2019).

Analyzing Amino Acids

To determine the liquid phase amino acids (glutamine, tyrosine, cysteine, and alanine), the hydrolysis of powdered samples was carried out in 6 M Hydrochloride containing 0.5% phenol (to protect tyrosine) at 110 °C for 24 hours under an argon atmosphere. The hydrolysates were lyophilized, dissolved in an appropriate volume of dilution buffer (sodium citrate buffer, pH = 2.2), and filtered through a 0.45 mm syringe before amino acid analysis. Sulfur-containing amino acids were decomposed as oxidation products obtained by the oxidation of performic acid and following the standard hydrolysis method with hydrochloride. Amino acids were determined by ion exchange chromatography with post-column derivatization with ninhydrin using an automatic amino acid analyzer according to the standard protocol. The composition of amino acids was expressed in grams per 100 grams of protein (Bernas and Jaworska, 2012).

The value of Volatile and Nonvolatile Compounds Using GS-MS and E-Nose

Volatile compounds were measured using the method offered by Zhang *et al*. (2021). A manual SPME (Solid-phase Microextraction devise) with 50 μm/30 μm divinylbenzene/carboxen/polydimethylsiloxane (DVB/CAR/PDMS) fiber (Supelco, Bellefonte, PA, USA) was utilized to extract the volatile compounds of samples. Homogenized mushroom (1.8 grams of mushroom powder in 20 ml sodium chloride saturated solution) was added to a 40 ml vial containing a magnetic stirrer bar. Then, 25 μL of cyclohexanone (0.95 mg/mL of ethyl alcohol) was added as an internal standard, and the vials were immediately covered with a PTFE septum (Supelco, Bellefonte, PA, USA). After that, the samples were equalized at 50 °C for 15 minutes, and fiber was put inside the vial for one hour to extract the volatile compounds. Finally, fiber was inserted into the GC injection port and was ejected for 5 minutes. Agilent 7890A GC and Agilent 5975 MS were used to analyze the volatile compounds. GC conditions were as follows: Helium carrier gas at a flow rate of 1 mL/min, injector temperature at 250 °C, oven temperature initially at 40 °C for 3 minutes, then 3 °C/min to 150 °C and held for 1 minute, finally 5 °C/min was set to 220 °C for 2 minutes. The temperature of the ion source was adjusted to 230 °C. Kovats retention index (RI) of the unknown compounds was measured by injecting Alkane-n (C70C30) under equal conditions. The value of volatile compounds was calculated using an internal standard (cyclohexanone) (Zhang *et al*., 2021).

Moreover, the value of volatile and nonvolatile compounds were utilized by an electronic nose consisting of a set of 10 metal-oxide gas sensors (W3S, W2W, W2S, W1W, W1S, W5C, W6S, W3C, W5S, W1C) to estimate the changes in aroma characteristics during drying. To do so, 0.5 grams of dried samples were placed in 40 ml of covered vials at 50 °C for 10 minutes prior to the analysis. Headspace gas, as a carrier gas, was pumped to the sensor container using a Teflon tube connected to a needle with clean air (400 ml/min). The maximum resistance changes of each sensor were employed to analyze the data (Qin *et al*., 2020).

RESULTS

Identifying the volatile and nonvolatile compounds in fresh A. bisporus mushrooms

The results of analyzing and identifying the volatile and nonvolatile compounds in fresh *A. bisporus* mushrooms showed that Heptane, 3-methyl-, Heptane, 2-methyl-, Octane, Cyclopentane, 1-ethyl-3-methyl, Heptane, Heptane, 2-methyl-, Nonane, Cyclohexane, methyl-, Octane, 4-methyl-, Decane, Octane, 2,6-dimethyl-, Nonane, 2-methyl-, Octane, 3-methyl- with values of 14.74%, 13.85%, 12.49%, 7.36%, 6.60%,5.53%, 5.38%, 3.31%, 3.13%, 2.89%, 2.64%, 1.97% and 1.94%, respectively, showed the highest amount of compounds (Table 1).

Table 1. Identifying the volatile and nonvolatile compounds in the fresh *A. bisporus* mushrooms

PK	RT	Library/ID	CAS	Qual	Area	Pct Total
1	3.43	Heptane	000142-82-5	91	23229726	6.60
2	3.8609	Cyclohexane, methyl-	000108-87-2	96	11665828	3.31
3	4.1336	Heptane, 2-methyl-	000592-27-8	52	19455750	5.35
4	4.7421	Heptane, 2-methyl-	000592-27-8	95	48698095	13.85
5	4.9077	Heptane, 3-methyl-	000589-81-1	91	51846451	14.74
6	5.3459	Cyclopentane, 1-ethyl-3-methyl-	003726-47-4	87	3600529	1.02
7	5.4092	Octane	000111-65-9	94	43948698	12.49
8	9.193	Cyclopentane, 1-ethyl-3-methyl-	003726-47-4	47	25903161	7.36
9	6.7529	Heptane, 2,3-dimethyl-	003074-71-3	53	1655532	0.47
10	6.86	Octane, 4-methyl-	002216-34-4	64	11034018	3.13
11	7.0255	Octane, 3-methyl-	002216-33-3	91	6851908	1.94
12	7.3469	1-Ethyl-4-methylcyclohexane	003728-56-1	64	3296779	0.93
13	7.4734	Nonane	000111-84-2	95	18936537	5.38
14	7.7412	Cyclohexane, 1-ethyl-4-methyl-, trans-	006236-88-0	72	327685	0.09
15	7.9847	5,5-Dimethyl-cyclohex-3-en-1-ol	082299-68-1	50	1560000	0.44
16	8.1989	Octane, 2,6-dimethyl-	002051-30-1	53	9300696	2.64
17	8.7296	Nonane, 2-methyl-	000871-83-0	81	6935080	1.97
18	8.8805	Nonane, 3-methyl- (CAS)	005911-04-6	93	2825857	0.80
19	9.2164	Cyclohexane, (2-methylpropyl)-	001678-98-4	43	2243522	0.63
20	9.3041	Decane	000124-18-5	97	10168629	2.89
21	9.7909	Decane, 4-methyl-	002847-72-5	81	2897677	0.82
22	9.9905	1-Hexacosanol	000506-52-5	58	1951098	0.55
23	10.14287	Decane, 2-methyl-	006975-98-0	91	2600634	0.74
24	10.5504	Decane, 3-methyl-	013151-34-3	93	1024710	0.29
25	10.8572	1,3-Cyclohexanedione, 5-	018456-87-6	64	723038	0.20

26	10.9497	isopropyl-Undecane	001120-21-4	96	5938493	1.68
27	11.3051	1-Octanol, 2-butyl-	003913-02-8	52	661443	0.18
28	11.4414	Carbonic acid, decyl nonyl ester	1000383-15-8	53	488659	0.13
29	11.641	Cyclopentane, (2-methylpropyl)-	003788-32-7	60	606029	0.17
30	11.8406	Tetracontane, 3,5,24-trimethyl-	055162-61-3	83	765740	0.21
31	11.9575	Eicosane	000112-95-8	90	838309	0.23
32	12.0646	Nonadecane, 9-methyl-	013287-24-6	80	479849	0.13
33	12.196	Cyclododecene	001501-82-2	55	74611	0.02
34	12.3762	Cyclopentane, 1-methyl-3-(2-methylpropyl)-	029053-04-1	45	300779	0.08
35	12.4443	Dodecane	000112-40-3	96	3835587	1.09
36	12.7072	Undecane, 2,6-dimethyl-	017301-23-4	87	989206	0.28
37	13.126	Cyclohexane, (cyclopentylmethyl)-	004431-89-4	91	1229883	0.35
38	13.2331	Nonyl tetradecyl ether	1000406-37-6	46	552323	0.15
39	13.3596	Carbonic acid, eicosyl vinyl ester	1000382-54-3	62	590459	0.16
40	13.4765	Sulfurous acid, dodecyl 2-propyl ester	1000309-12-3	62	1113188	0.13
41	13.827	Tridecane	000629-50-5	96	2709363	0.77
42	14.0266	14-.BETA.-H-PREGNA	2000494-06-0	91	112884	0.03
43	14.3334	Hahnfett (stopcock grease)	000000-00-0	93	92352	0.02
44	14.5281	Heptacosyl acetate	2000839-82-9	83	586964	0.16
45	14.6693	Sulfurous acid, 2-propyl undecyl ester	1000309-12-2	64	322988	0.09
46	14.7715	Carbonic acid, eicosyl vinyl ester	2000720-94-2	74	161202	0.04
47	14.8835	Octatetracontane, 1-iodo-	040710-70-1	86	520753	0.14
48	15.1075	Tetradecane	000629-59-4	98	2270057	0.64
49	15.5651	Hahnfett (stopcock grease)	000000-00-0	87	21522	0.00
50	15.755	Carbonic acid, decyl tridecyl ester	2000754-99-6	90	266341	0.07
51	15.8962	Eicosane	000112-95-8	91	372420	0.10
52	16.3149	pentadecane	000629-62-9	98	1518780	0.43
53	16.8894	Carbonic acid, prop-1-en-2-yl tetradecyl ester	2000526-05-6	80	218749	0.06
54	16.0403	Cyclotridecane	000295-02-3	90	376025	0.10
55	17.1426	Dotriacontyl isopropyl ether	2000989-42-5	80	197831	0.05
56	17.4396	Hexadecane	000544-76-3	98	1150452	0.32
57	71.5515	1-Dodecanol, 2-octyl-	2000526-48-2	83	130722	0.03
58	18.0092	Eicosane	000112-95-8	91	450559	0.12
59	18.2185	14-.BETA.-H-PREGNA	2000494-06-0	81	107516	0.03
60	18.4376	Hahnfett (stopcock grease)	000000-00-0	74	17724	0.00
61	18.5058	Heptadecane	000629-78-7	98	741349	0.21
62	18.608	Dodecane, 2,6,10-trimethyl-	003891-98-3	86	412855	0.11
63	18.9829	Carbonic acid, eicosyl vinyl ester	2000720-94-2	83	182280	0.05
64	19.1533	Nonahexacontanoic acid	040710-32-5	74	115700	0.03
65	19.2507	14-.BETA.-H-PREGNA	2000494-06-0	83	102412	0.02
66	19.5136	Octadecane	000593-45-3	95	609593	0.17
67	19.6548	Carbonic acid, eicosyl vinyl ester	2000720-94-2	90	294232	0.08
68	19.9566	14-.BETA.-H-PREGNA	2000494-06-0	86	66338	0.01
69	20.1222	14-.BETA.-H-PREGNA	2000494-06-0	91	39609	0.01
70	20.2244	14-.BETA.-H-PREGNA	2000494-06-0	87	53271	0.01
71	20.4678	Nonadecane	000629-92-5	98	415180	0.11
72	20.8719	Myristic acid, methyl ester	000124-10-7	72	169122	0.04
73	21.0423	14-.BETA.-H-PREGNA	2000494-06-0	91	27753	0.008
74	21.1251	14-.BETA.-H-PREGNA	2000494-06-0	91	13890	0.004
75	21.2517	Oxalic acid, allyl hexadecyl ester	1000309-24-4	53	12380	0.004
76	21.3734	Eicosane	000112-95-8	96	319215	0.091
77	21.5682	Dibutyl phthalate	000084-74-2	72	140642	0.04

78	21.7434	Oxalic acid, cyclobutyl pentadecyl ester	1000309-70-5	50	29594	0.008
79	21.909	14-.BETA.-H-PREGNA	2000494-06-0	83	24018	0.007
80	22.0161	14-.BETA.-H-PREGNA	2000494-06-0	80	16843	0.005
81	22.2352	Tetracosane	000646-31-1	91	196748	0.05
82	22.3374	Oxalic acid, cyclobutyl heptadecyl ester	1000309-70-7	59	10593	0.003
83	22.4835	Isobutyl tetradecyl carbonate	959275-58-2	38	129775	0.037
84	22.6246	1-Dodecanol, 2-octyl-	0053333-42-6	43	55667	0.01
85	23.0531	Tritriacontane	000630-05-7	91	201539	0.05
86	23.3598	Carbonic acid, hexadecyl prop-1-en-2-yl ester	1000382-90-3	59	59012	0.01
87	23.5351	2-Piperidinone, N-[4-bromo-n-butyl]-	195194-80-0	50	18569	0.005
88	23.6325	Oxalic acid, cyclobutyl heptadecyl ester	1000309-70-7	53	17463	0.005
89	23.8321	Tritetracontane	007098-21-7	91	150400	0.04
90	24.1193	Hexatriacontyl pentafluoropropionate	1000351-89-0	49	60378	0.01
91	24.3871	1-Hentetracontanol	040710-42-7	50	19867	0.006
92	24.5818	Tritetracontane	007098-21-7	91	192324	0.05
93	24.8593	14-.BETA.-H-PREGNA	2000494-06-1	83	61281	0.01
94	25.0444	Octacosyl trifluoroacetate	1000351-74-9	52	13883	0.004
95	25.1077	14-.BETA.-H-PREGNA	2000494-06-0	80	18761	0.005
96	25.2975	Sulfurous acid, 2-propyl tetradecyl ester	2000594-86-1	91	196433	0.056
97	25.5361	14-.BETA.-H-PREGNA	2000494-06-0	74	80891	0.023
98	25.7503	Tetrapentacontane, 1,54-dibromo-	1000156-09-4	43	17454	0.005
99	25.9889	Sulfurous acid, 2-propyl tetradecyl ester	2000594-86-1	83	145685	0.04
100	26.0863	1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester	000117-81-7	91	2803497	0.79
101	26.6413	Carbonic acid, octadecyl vinyl ester	1000382-54-4	60	112706	0.03
102	26.9042	Octacosyl trifluoroacetate	1000351-74-9	20	68689	0.02
103	27.2839	Carbonic acid, decyl hexadecyl ester	1000383-16-5	50	126323	0.03
104	27.4933	Cyclopropane carboxamide, 2-cyclopropyl-2-methyl-N-(1-cyclopropylethyl)-	331416-19-4	42	26586	0.008
105	27.8049	Hexahydropyridine, 1-methyl-4-[4,5-dihydroxyphenyl]-	094427-47-1	30	47285	0.01
106	27.8925	3-Quinolinecarboxylic acid, 6,8-difluoro-4-hydroxy-, ethyl ester	1000362-34-6	14	80746	0.023
107	28.4767	Phenylacetic acid, 2-(1-adamantyl)ethyl ester	1000282-91-2	38	99321	0.028
108	29.0318	N-Methyl-1-adamantaneacetamide	031897-93-5	43	68497	0.01

Amino Acids

According to the analysis of amino acids, 15 different compounds of amino acids in the fruit body of *A. bisporus* mushrooms were identified. The amount of these compounds was found to be variable under different drying methods. Based on the results, the maximum amount of amino acids was observed in Serine with values of 44.4, 37.6, and 8.1 grams per 100 grams of dry weight in *A. bisporus* samples dried through infrared, salting, and hot air

methods. Compared with other methods, the lowest amount of identified amino acids was found in the canning method (Figure 2).

Table 2. The effect of different drying treatments on the amount of amino acids in the *A. bisporus* mushrooms

Amino acid (gram/100 grams of dry weight)	Studied treatments			
	Infrared	Hot air	Canning	Salting
Aspartic Acid	1.3	1.1	0.1	1.1
Glutamic Acid	3.3	4	0.1	2.7
Serine	44.4	8.1	1.6	37.6
Histidine	0.4	0.1	0.02<	0.2
Glycine	1.1	1.4	0.1	1.4
Threonine	1.3	1.9	0.2	1.4
Arginine	0.8	0.2	0.02<	0.02<
Alanine	1.2	2.3	0.1	0.1
Tyrosine	0.5	0.7	0.1	0.7
Methionine	0.1	0.02<	0.02<	0.02<
Valine	0.5	0.5	0.4*10-1	0.3
Phenylalanine	0.7	0.8	0.4*10-1	0.5
Isoleucine	0.7	0.9	0.1	0.4
Leucine	0.9	3.5	0.2	0.3
Lysine	2.4	1.9	0.2	1.9

DISCUSSION AND CONCLUSION

The effect of different processing treatments on some of the quality characteristics of A. bisporus mushroom

Amino Acids

According to the research findings, the amount of amino acids was observed based on various drying and processing methods. Serine had the highest concentration of amino acids, with values of 44.4, 37.6, and 8.1 grams per 100 grams of dry weight in the infrared, salting, and hot air treatments, respectively. Compared with other treatment methods, canning showed the lowest amount of amino acids. Amino acids are essential for protein synthesis, and the resulting proteins play vital physiological roles, such as structural proteins, enzymes and oxygen carriers, vitamins, and CO2, affecting the overall health directly or indirectly. Besides the importance of amino acid compounds in the nutritional value of protein sources, they determine the functional characteristics of the protein. In other words, oligopeptides with biological properties, like antioxidant, anticancer, and antimicrobial properties, were identified and derived from hydrolyzed proteins (Gao *et al*., 2021). Branched-chain amino acids (Leucine, Isoleucine, and Valine) have unique biological roles in protein synthesis, cell signaling, and glucose metabolism, affecting the immune system and brain function (Li *et al*., 2015). In other words, Branched-chain amino acids are essential for the growth and proliferation of T lymphocytes, through which they affect the immune system. Also, aromatic amino acids (Tyrosine and Phenylalanine) can impact protein synthesis, neurotransmitters, and energy generation in the brain by entering the brain through protein carriers. (Monirujamman *et al*., 2014).

Moisture reduction and protein concentration can improve the retention of amino acids. Xue *et al*. (2016) studied the impact of salting on the nutritional value and active compounds of Agaricus *A. bisporus* mushrooms. The results showed that the salted mushrooms had different nutritional properties compared to fresh mushrooms. Salting led to the reduction of 90.8% and 90% in various nonvolatile compounds, such as total free amino acids and the content of essential amino acids, respectively, in salted Agaricus *A. bisporus* mushrooms. Furthermore, the amount of MSG-like amino acids and 5’-nucleotide in salted Agaricus mushrooms was lower compared to the frozen and canned mushrooms. Jaworska *et al*. (2011) reported that canning edible mushrooms significantly reduced Arginine, Glycine, Serine, Histidine, Methionine, and Threonine. Additionally, this process led to a mutual reduction of 80.1% of the total free amino acids and 85% of essential amino acids in the canned Agaricus mushrooms (Martin-Belloso and Lianos-Berriobero, 2001).

CONCLUSION

In general, the research findings revealed that infrared and hot air treatments significantly impacted the improvement of color indices, such as Browning index, color change, and color index of a* and b*. Moreover, canning treatment reduced the color index of L* in *A. bisporus*

mushroom samples. Salting treatment also decreased the shrinkage ratio. Therefore, producers and experts in medicinal-edible mushroom cultivation are recommended to employ these treatments to process and increase the product storage time to maintain the quality characteristics of the mushroom.

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