THE IMPACT OF ADDITION OF SHIITAKE ON SHELF-LIFE STABILITY AND SENSORY OF FRANKFURTER DURING REFRIGERATED STORAGE

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Abstract – The effect of addition of shiitake levels (0, 0.4, 0.8 and 1.2%) on the quality traits such as physicochemical and microbial properties of frankfurter was studied during refrigerated storage, and its effect was also compared with those produced with 100 ppm $NaNO_2$. Our results showed that the TBARS values of frankfurters produced with shiitake were much lower than those of the control and $NaNO_2$ frankfurters in all storage days. Additionally, the addition of shiitake retarded the growth of aerobic bacteria during storage. Furthermore, the shiitake incorporation significantly (P<0.05) improved the sensory quality at day 1 storage; the higher flavor, taste and acceptability scores were given for the shiitake frankfurters than for the control and $NaNO_2$ frankfurters, probably due to its flavor enhancer and taste-active components. Finally, shiitake with its high bioactivity can be utilized to prevent lipid oxidation and microorganisms growth during storage and improve the sensory characteristics of frankfurters at day 1 storage. It is also suggested that the addition of shiitake powder to meat products is an alternative interesting way to instead of synthetic antioxidants or preservatives.

Key Words – Shiitake; Frankfurter; Antioxidant; Nitrite; Aerobic Bacteria

I. INTRODUCTION

Lipid oxidation has long been recognized as the major problems causing the negative impacts on quality and shelf-life of meat products for instance, it leads to the development of oxidative off-flavor, discoloration and deterioration of meat and meat products (1). Therefore, there is currently increasing interest in control of lipid oxidation in meat products by using the antioxidant agents from synthetic and natural sources (2,3). However, the available synthetic antioxidants have been suspected to cause toxicity problems that negatively affect consumer's health, therefore, these compounds have been restricted use in foods (4). Recently, a new trend to substitute these synthetic antioxidants with antioxidants from natural sources have been received the most attention by consumers and meat processors (2). Shiitake (*Lentinus edodes*) is the most popular and the second largest cultivated mushroom in the world (5)(Chang, 1996). The shiitake has been widely used as part of human vegetable diet and for medical purposes for thousands of years in Asian countries (5, 6). While, the shiitake has a pleasant flavor and may exert an antioxidant activity without adverse effects on their acceptability, which can be effectively incorporated into meat products, however, no attention has been paid to the use of edible mushroom as naturally functional ingredients in meat products. Therefore, the objective of this study was to investigate the impact of addition of shiitake powder on the technological quality, lipid oxidation and sensory characteristics of frankfurters during refrigerated storage.

II. MATERIALS AND METHODS

Extraction and scavenging assay

Shiitake (*Lentinus edodes*) was purchased from a local supermarket in Suwon, South Korea. Fresh pork ham and back-fat were obtained from a local commercial processor (Suwon, Korea) 24 h after slaughter. The shiitake extracts were obtained using the method of Tsai et al (7). The antioxidant activity of the shiitake extract was determined using scavenging 2,2-diphenyl-1-picrylhydrazyl (DPPH) radicals test

Frankfurter manufacture

To determine whether the shiitake exerts its antioxidant and antimicrobial activities in frankfurter, the common seasonings such as onion, garlic and pepper etc. were not added, and the smoking was also not applied. Five formulations of treatments of frankfurters; four

with different shiitake powder levels (0, 0.4, 0.8 and 1.2%) and one with 100 ppm $NaNO_2$ were prepared. Each treatment had 3 batches and each batch was prepared with 10 kg of frankfurter batter. All frankfurters in all treatments were made with the same materials and ingredients including: pork meat (50%), pork back-fat (28%), ice water (20%), phosphate (0.5%) and sodium chloride (1.5%), except the test contents which differed among these treatments. The meat batter was immediately stuffed into 28-mm diameter collagen casings (Naturin Viscofan Co, Tajonar-Navarra, Spain) using a vacuum stuffer (Model VF610, Handtmann Co, Biberach, Germany). Finally, the frankfurters were placed in a smokehouse and cooked for 10 min after the internal temperature reached 70 °C. After cooking, the cooked frankfurters were immediately soaked in cold water to cool and left to drain the water. Thereafter, the samples were placed in polyethylene/polyamide bags (3frankfurters/bag) (day 0). The bags containing samples were then simply sealed with a packaging system (Model VP-9900, Roll Pack Co.,Pyengtaek, Korea) and finally assigned into 3 different storage periods; 1, 15 and 30 days and kept at 4 °C.

Lipid oxidation

The content of thiobarbituric acid reactive substances (TBARS) was determined to evaluate the lipid oxidation level of frankfurters during storage, using the method described by Pikul et al (8).

*Microbial analysis***:** Ten gram frankfurters were taken aseptically from each batch in each treatment, transferred to sterile plastic pouches and homogenized for 1 min at room temperature with 90 mL of autoclaved 0.85% sodium chloride solution using a stomacher Lab-Blender 400 (Seward Medical, London). Serial dilutions were made in sterilized diluted solution and aerobic mesophilic bacteria were determined by spreading 1mL of appropriate dilutions onto 3M Petrifilm Aerobic Count Plate (3M Health Care., Paul, MN, USA) incubated for 48 h at 30 °C.

Sensory evaluation: Sensory evaluation of frankfurters in different treatments at 1 day storage was performed using the method as described by Deda et al (2).

Statistic analysis: The data were subjected to statistical analysis using the Statistic Analysis System (SAS) package (SAS Institute, Cary, NC, USA, 2007).

III. RESULTS AND DISCUSSION

Effect of shiitake addition on lipid oxidation

The TBARS values were affected by the shiitake addition and storage time (Table 1). Frankfurters produced with shiitake at all levels had much lower TBARS values than the control at all days examined ($P<0.05$). Noticeably, the higher the added shiitake levels the lower the TBARS values. It was also observed that the TBARS values in control and $NaNO_2$ frankfurters significantly ($P<0.05$) increased as the storage time increased, indicating that lipid oxidation was more extensive in these samples. The TBARS values of frankfurters made with 0.8 and 1.2% shiitake remained unchanged throughout the storage ($P>0.05$). When compared to the TBARS level in 100 ppm $NaNO_2$ frankfurters at all storage days, the frankfurters produced with shiitake in the cases of 0.8 and 1.2% had significantly lower TBARS values.

$NaNO_2$ has been extensively reported to have the antioxidant activity in comminuted meat products (9). However, when compared to the TBARS level in 100 ppm $NaNO_2$ frankfurters at all storage days, the frankfurters produced with shiitake in the cases of 0.8 and 1.2% had significantly lower TBARS values. The differences in oxidative stability between the shiitake and $NaNO_2$ treatments could be attributed due to the differences in their chemical structures (10). The mushroom's phenolics with their OH groups therefore could be responsible for the relatively high antioxidant activity (11).

Table 1. Thiobarituric acid reactive substances (TBARS) values of frankfurters formulated with different levels of shiitake during refrigerated storage.

Treatment	TBARS (mg MDA/kg sample)		
	1 d	15d	30 d
0% (T1:control)	1.05aC	2.40aB	2.97aA
0.4% (T2)	0.87bB	1.78bA	1.81bA
0.8% (T3)	0.61dA	0.74cA	0.84dA
1.2% (T4)	0.48dA	0.50dA	0.49eA
100 ppm (T5)	0.58cC	0.73cB	0.91cA
SEM	0.01	0.02	0.05

Values with different letters (a-e) in the same column differ significantly (P <0.05). Values with different letters (A-C) in the same row differ significantly (P <0.05). SEM: Standard error of means.

Effect of shiitake addition on aerobic bacteria (AB)

No differences in AB number occurred between the treatments at 1 day storage, but after 15 to 30 days of storage the AB number in frankfurters produced with 0.8 and 1.2% shiitake was significantly (P<0.05) lower than those in control (Table 2). Some researchers have proven that mushrooms contain some bioactive compounds such as rutin, gallic acid and catechin which have a high antimicrobial effect (12). When compared to the AB number in 100 ppm $NaNO_2$ frankfurters at 15 and 30 days, the frankfurters made with 1.2% shiitake had similar number of AB. Storage time significantly (P<0.05) increased the number of AB in all treatments, which agrees with finding of (13). However, the rate of AB increase differed among the treatments, higher for the control whereas lower for the shiitake or 100 ppm $NaNO_2$ treatments.

Table 2. Number aerobic bacteria of frankfurters formulated with different levels of shiitake during refrigerated storage

Treatment	Aerobic bacteria count (log_{10} cfu/g)		
	1 d	15d	30 d
0% (T1:control)	0.29aC	5.52aB	6.47aA
0.4% (T2)	0.28aC	5.14aB	6.11aA
0.8% (T3)	0.24aC	4.18bB	5.52bA
1.2% (T4)	0.21aC	3.59bcB	5.08bcA
100 ppm (T5)	0.27aC	3.48cB	4.52cA
SEM	0.02	0.27	0.33

Values with different letters (a-e) in the same column differ significantly (P <0.05). Values with different letters (A-C) in the same row differ significantly (P <0.05). SEM: Standard error of means.

Effect of shiitake addition on sensory characteristics

The sensory characteristics of frankfurters evaluated at 1 day storage are presented in Table 3. Higher texture score was given for the 100 ppm $NaNO_2$ frankfurters than those for the control and shiitake frankfurters (P<0.05). This could be due to the beneficial effect of the added $NaNO_2$ content on the texture of the product (14). However, no differences among the control and shiitake frankfurters were found for the texture (P>0.05). Remarkably, the frankfurters produced with shiitake at all levels had significantly (P<0.05) higher flavor scores than control and $NaNO_2$ frankfurters. Similarly the frankfurters made with 0.8 and 1.2% shiitake had significantly (P<0.05) higher taste and acceptability scores than the control and $NaNO_2$ frankfurters. The reason making the panelists gave higher flavor and taste scores for the shiitake frankfurters could be due to the contributions of the flavor enhancers and taste active compounds that exist within the shiitake. Because, previous workers have found that mushrooms also contain considerable levels of flavor enhancer (e.g., 5'-guanosine monophosphate and lenthionine) and taste active compounds (e.g., monosodium glutamate), that contribute to the umami-like taste or palatable taste (15, 16). Some other authors have reported that the additions of grape flour powder at levels of 0.5 - 5% caused a decrease in flavor and acceptability scores (3), and incorporation of 12% tomato paste increased the off-flavor score of frankfurters (2). Thus, compared to the other natural ingredients used in previous studies as cited above, the utilization of shiitake did not cause negative effects on the flavor whereas it partly improved the taste as well as overall acceptability of the product.

Table 3. Sensory characteristics of frankfurters formulated with different levels of shiitake at day 1 storage.

Treatment	Texture	Flavor	Taste	Acceptability
0% (T1)	4.56b	3.61c	3.72b	3.78b
0.4% (T2)	4.66b	4.39b	4.33b	4.39ab
0.8% (T3)	4.0b	4.61ab	4.50a	4.61a
1.2% (T4)	4.67b	5.22a	5.17a	5.11a
100 ppm (T5)	5.44a	3.89c	3.82b	4.19b
SEM	0.21	0.33	0.17	0.22

Values with different letters (a-e) in the same column differ significantly (P <0.05). Values with different letters (A-C) in the same row differ significantly (P <0.05). SEM: Standard error of means.

IV. CONCLUSION

Lipid oxidation during storage was minimized with increased shiitake levels. Additionally, the incorporation of shiitake at all levels also reduced the number of aerobic bacteria during

storage. The frankfurters made with shiitake at levels from 0.8 to 1.2% at storage 1 day had higher flavor, taste and overall acceptability scores compared to those of the control and 100 ppm $NaNO_2$ treatments. Taken together, the shiitake is a potentially natural ingredient which can be utilized at level of 0.8% to prevent lipid oxidation and retard growth of aerobic bacteria in frankfurter during storage.

ACKNOWLEDGEMENTS

This work was financially supported by the National Institute of Animal Science (Project NO. PJ00937401), Rural Development Administration of South Korea.

REFERENCES

1. Morrissey, P. A., Sheehy, P. J. A., Galvin, K., Kerry, J. P, & Buckley, D. J. (1998). Lipid stability in meat and meat products. *Meat Science, 49*, 73–86.
2. Deda, M. S., Bloukas, J. G., & Fista, G. A. (2007). Effect of tomato paste and nitrite level on processing and quality characteristics of frankfurters. *Meat Science, 76*,501–508.
3. Ozvural, E. B., & Vural, H. (2011). Grape seed flour is a viable ingredient to improve the nutritional profile and reduce lipid oxidation of frankfurters. *Meat Science, 88*,179–183.
4. Botterweck, A. A. M., Verhagen, H., Goldbohm, R. A., Kleinjans, J., & Brandt, P. A. (2000). Intake of butylated hydroxyanisole and butylated hydroxytoluene and stomach cancer risk: results from analyses in the Netherlands cohort study. *Food and Chemical Toxicology, 38*,599–605.
5. Chang, R. (1996). Functional properties of edible mushrooms. *Nutrition Reviews, 54*, S91–S93.
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 Science for Food and Agriculture, 93*,3107–3113.
7. Tsai, S. Y., Tsai, H. L., & Mau, J. L. (2007). Antioxidant properties of *Agaricus blazei*, *Agrocybe cylindracea*, and *Boletus edulis*. *LWT-Food Science and Technology, 40*, 1392–402.
8. Pikul, J., Leszczynski, D. E., & Kummerow, A. (1989). Evaluation of three modified TBA method for measuring lipid oxidation in chicken meat. *Journal of Agriculture and Food Chemistry, 37*, 1309-1313.
9. Morrissey, P. A., & Tichivangana, J. Z. (1985). The antioxidant activities of nitrite and nitrosylmyoglobin in cooked meats. *Meat Science, 14*,175–190.
10. Dziedric, S. Z., & Hudson, B. J. F. (1984). Phenolic acids and related compounds as antioxidants for edible oils. *Food Chemistry. 14*,45-51.
11. Choi, S. W., & Sapers, G. M. (1994). Effects of washing on polyphenols and polyphenol oxidase in commercial mushroom *(Agaricus bispoms).* *Journal of Agricultural and Food Chemistry*, *42*, 2286-2290.
12. Oyetayo, V. O, & Ariyo, O. O. (2013). Antimicrobial and antioxidant properties of *Pleurotus ostreatus* cultivated on different tropical woody substrates. *Journal of Waste Conversion Bioproducts and Biotechnology, 1*,28–32.
13. Tahmouzi, S., Razavi, S. H., Safari, M., & Emam-Djomeh, Z. (2012). Influence of beet sugar, calcium lactate, and *Staphylococcus xylosus* (with nitrate reductase activity) on the chemical, microbiological, and sensorial properties of persian uncured frankfurters. *Journal of Food Science, 10*,565-71.
14. Sebranek, J. G. (1979). Advances in the technology of nitrite use and consideration of alternatives. *Food Technology*, 33, 58–62.
15. Tseng, Y. H., & Mau, J. L. (1999). Contents of sugars, amino acids and free 5'- nucleotides in mushrooms, *Agaricus bisporus*, during post-harvest storage. *Journal of the Science of Food and Agriculture, 79*,1519–1523.
16. Cho, I. H., Choi, H. K., & Kim, Y. S. (2010). Comparison of umami-taste active components in the pileus and stripe of *T. matsutake*-mushrooms of different grades. *Food Chemistry 118*, 804–807.