



## Quality Improvement of the Chicken Sausage with Pepper Seed (*Capsicum annuum* L.)

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### Abstract

The chicken sausages were manufactured replacing part (8%) of chicken skin with powder (1%) and oil (7%) of pepper seed (*Capsicum annuum* L.). The replacement of chicken skin with pepper seed lowered the content of total fat, saturated fatty acids, cholesterol, and sodium in chicken sausages than that of the control by reducing 13.4%, 75.0%, 42.2%, 22.6%, respectively ( $p < 0.05$ ). In addition, the pepper seed retarded lipid oxidation in chicken sausages represented by lower TBARS value than that of the control in 14 days of storage at 4 °C ( $p < 0.05$ ). Even though pepper seed hardly changed textural properties of chicken sausages except decreasing hardness, it favorably affected sensory attributes such as appearance, flavor, and overall acceptability. In conclusion, the application of pepper seed in manufacturing chicken sausages improved nutritional value and sensory properties of the products, which could be a good alternative for the people in favor of low fat and healthy products.



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### Introduction


Sausages are very popular meat products all over the world. Unfortunately, however, they contain large amounts of saturated fatty acids and cholesterol. The excessive intake of dietary fat, particularly saturated fatty acids and cholesterol, adversely affects human health and it is closely related to the risk of cardiovascular heart disease.<sup>1</sup> In general, high calorie diets- especially containing more than 30% of fat-are not recommended and considered 'unhealthy'.<sup>1,2</sup> So far, the demand for healthy meat

products has been increased,<sup>2</sup> and thus many efforts have been done to reduce saturated fat content in meat products for health benefits.<sup>3-5</sup> For instance, functional ingredients were replaced saturated fat and used to modify the texture of fat reduced meat products. Among them, hydrocolloids were beneficial in processing low-fat meat products due to the capability of hydration and gelation.<sup>3,6,7,8</sup> By the way, the reduction of fat content could deteriorate the quality of meat products because fat plays a reservoir of flavor components and contributes to the

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texture characteristics.<sup>9</sup> Since then, animal fat has been replaced with plant or marine oils to improve the nutritional profiles of meat products.<sup>4,10</sup>

On the other hand, lipid oxidation causes undesirable off-flavors and toxic compounds which raise health concerns to the people and food industry. To overcome those problems, natural herbs and spices containing antioxidant properties were used to reduce lipid oxidation of meat products during storage and prolong shelf life.<sup>5,11-15</sup> Among them, chili peppers (*Capsicum annuum* L.) are known to have great potential for human health,<sup>16,17</sup> and they are one of the most popular spices consumed worldwide. However, most of the pepper seeds has been discarded as food waste. In fact, dried chili pepper contains 25.2~25.8% of seed which could be a good food source composed of protein (15~17%), fat (25~30%), fiber (25~45%), various mineral and vitamins.<sup>18,19</sup> Besides, pepper seed oil is known rich of linoleic acid (68~72%) and oleic acid (9~11%) which has been reported health benefits against cardiovascular disease.<sup>16-19</sup> In addition, pepper seeds contain capsaicinoids, bioactive and pungent ingredients in chili pepper.<sup>16-19</sup>

Therefore, the aim of this study was to improve the sensory properties and nutritional value of chicken sausages using pepper seed (*Capsicum annuum* L.). To the point, chicken sausages were manufactured replacing part (8%) of chicken skin with pepper seed powder (1%) and pepper seed oil (7%), and analyzed the physiochemical characteristics and sensory attributes of the products during storage at 4°C.

## Materials and Methods

### Materials

Raw breast chicken meat, pepper seeds (*Capsicum annuum* L.), and all ingredients used for sausage preparation were obtained from local market. The chemicals of analytical grade were used in this study. Pepper seeds (*Capsicum annuum* L.) were ground and the powder was stored at -20° until used. Pepper seed oil was prepared by mixing dried pepper powder with olive oil with the ratio of 1:5 (w/w), filtered, and kept in a vacuum jacket.

### Preparation of Chicken Sausages

Chicken breast meat and skin were ground with a food processor (M-12s, Korea Fuji Plate, Korea)

equipped with a 6 mm and 3 mm plate (M-22, Daewoo Co., Korea) respectively for 10 min at the high speed and stored at 4°C overnight. The formulations of the sausage samples are presented in Table 1.

**Table 1: Formula of the chicken sausages**

Ingredients	Composition (%) <sup>1)</sup>	
	C	PS
Chicken breast meat	48.00 <sup>2)</sup>	48.00
Chicken skin	28.80	20.80
Pepper seed oil	0.00	7.00
Pepper seed powder	0.00	1.00
Ice	19.20	19.20
Salt	1.15	1.15
Sodium phosphate	0.29	0.29
Sugar	0.29	0.29
Monosodium glutamate	0.10	0.10
Onion	0.34	0.34
Garlic	0.19	0.19
Ginger	0.12	0.12
White pepper	0.10	0.10
Isolated soy protein	1.44	1.44

<sup>1)</sup>C: chicken sausages without pepper seed, PS: chicken sausages with pepper seed.

<sup>2)</sup>Units are %.

All ingredients were put to the ground chicken meat in silent cutter (EF-20, Crypto peerless, England) rotating at low speed for 1 min. Then, the mixture was left for 1 min and pepper seed was added before further grinding for 30 sec at high speed. The temperature was controlled below 12±3°C throughout the process. The pastes were stuffed in cellulose casing (15 mm in diameter) using stuffer and linked, and then placed in a temperature-controlled water-bath (NU-VUES-3, Food Service System, USA) kept at 100°C for 30 min. The sausages were cooled in cold water, placed in PVDC bags and stored at 5°C.

### Nutritional Analysis

The nutrient profiles on sugars, protein, fat, saturated fatty acids, trans fatty acid, cholesterol, sodium were

determined according to the guide line of Korean Food and Drug Administration (KFDA) based on American Oil Chemistry Society (AOAC, 2000) international.<sup>20</sup> All experiments were performed in triplicate and presented mean  $\pm$ SD.

#### **pH, TBARS and TVB-N**

The value of pH was measured during the storage period every 7 days for 2 weeks using digital pH meter (Precisa pH900-9050, Swiss). The sample (10 g) was grinded and mixed with distilled water (90 ml) in homogenizer (IKA, T25 Basic) at 13,000 rpm for 1min.

The thiobarbituric acid reactive substances (TBARS) content of the samples was determined by the modified method of Tarladgis *et al.*, (1960)<sup>21</sup> as described by Sallam *et al.*, (2004).<sup>22</sup>

Total volatile basic nitrogen (TVB-N) was measured following to Botta *et al.*, (1984)<sup>23</sup> by the Conway micropipette diffusion method.

#### **Microbial Analysis**

Bacterial numbers were measured every 7 days by pour plate method during storage at 4°C. The dilution was done by aseptically blending using Bagmixer (Interscience, Germany) for 1 min, 1 g of sample with 9 ml saline solution. The serial dilutions were done in triplicate with Plate Count Agar (PCA, Difco, Detroit, MI, USA) and incubated at 37°C for 48 h. Data were shown as colony forming units (CFU).

#### **Texture Measurement**

All instrumental texture analyses were performed every 7 days during the experimental period. Every sample was measured in triplicate and the values were presented as mean $\pm$ SD. Texture profile analysis (TPA) of all sausages were performed on hardness, cohesiveness, springiness, gumminess with a Texture Analyser (TA.XT plusC, Stable Micro System, UK). The samples were placed at room temperature for 1h and cut into the shape of 25 mm height x 25 mm diameter. A two cycle compression test was performed using 25kg load cell. The samples were compressed up to 50% of their original thickness with a cylindrical probe P/25. The settings were fixed: a pre-test speed of 1.0 mm/s, test speed of 5.0 mm/s, and post-test speed of 5.0 mm/s. For probe height calibration, the settings were fixed:

distance speed of 30 mm, returning speed of 10 mm/s, and contacting force of 5 g.

#### **Sensory Evaluation**

Sensory analyses were performed by 10 panelists who were experienced and trained in sensory evaluation of foods. A 7-point hedonic scale (7 = very like; 1 = very dislike) was used for scoring the intensities of the sensory attributes such as texture, flavor, taste, appearance and overall acceptability. Samples were prepared warm and sliced to 1 cm thick and 2 cm in diameter, placed on white plates with three digit codes, and then arranged in random order and presented to the panel for evaluation. Water and crackers were provided to the panel for neutralizing the taste and rinsing the mouth between evaluations. Experiments were conducted in a properly designed room.

#### **Statistical Analysis**

All experiments were performed in triplicate. Data were presented as means and standard deviations (SD) and analyzed using PASW Statistics 17.0 (SPSS, Inc., Chicago, IL, USA). One-way analysis of variance (ANOVA) and Duncan's multiple range test were done to determine the differences of multiple samples. On the other hand, t-test was performed to compare two samples.

### **Results and Discussion**

#### **Nutrition Profiles**

The novel chicken sausages were manufactured replacing part of chicken skin with pepper seed powder and pepper seed oil. The nutrient compositions of chicken sausages are shown in Table 2. Significant differences lay in the contents of total fat, saturated fatty acids, cholesterol, carbohydrate, protein, sodium between two groups ( $p < 0.05$ ). Carbohydrate content was significantly ( $p < 0.05$ ) higher in PS due to addition of fiber rich pepper seed. Chicken skin has been used for manufacturing sausages as a source of fat and an emulsifying agent. The problems of chicken skin as a component in processed meat products are the high contents of fat and cholesterol. In this study it was observed that the replacement of chicken skin with pepper seed decreased the amount of saturated fatty acids and cholesterol in chicken sausages ( $p < 0.05$ ). In addition, the protein content of PS was slightly less than that of the control ( $p < 0.05$ ) because part

of chicken skin, rich in collagen, was replaced with pepper seed powder and oil. In our previous study,<sup>15</sup> part of pork fat was replaced with pepper seed powder and oil in manufacturing pork sausages. This study was conducted following the component and formula of the previous study except for chicken. Comparing nutritional profiles of the samples, the chicken sausages with pepper seed were lower

in calories (34.9%), total fat (50.0%), saturated fat (87.2%), cholesterol (27.1%), sodium (21.9%) than pork sausages made as control in previous study. Overall, the results clearly show that the replacement of the components - from pork to chicken and from animal fat to pepper seed - improved the nutritional profiles of the sausages.

**Table 2: Nutritional profiles of the chicken sausages**

Nutrition Facts (serving size: 100g)	Samples <sup>1)</sup>	
	C	PS
Calories(kcal)	180.72±10.30 <sup>2)A</sup>	163.64±16.41 <sup>B</sup>
Total Carbohydrates(g)	3.48±0.23 <sup>A</sup>	5.99±0.56 <sup>B</sup>
Sugar(g)	0.77±0.71	0.81±0.34
Protein(g)	16.14±0.69 <sup>A</sup>	12.78±0.33 <sup>B</sup>
Total Fat(g)	11.36±0.50 <sup>A</sup>	9.84±0.39 <sup>B</sup>
Saturated Fat(g)	3.80±0.42 <sup>A</sup>	0.95±0.21 <sup>B</sup>
Trans Fat(g)	0.11±0.03	0.00±0.09
Cholesterol(mg)	47.08±6.55 <sup>A</sup>	27.21±5.27 <sup>B</sup>
Sodium(mg)	677.60±33.11 <sup>A</sup>	524.70±54.61 <sup>B</sup>

<sup>1)</sup>C: chicken sausages without pepper seed, PS: chicken sausages with pepper seed.

<sup>2)</sup>Values are mean±SD.

<sup>A,B)</sup>in the same row with different superscripts are significantly different at  $p < 0.05$ .

#### pH, TBARS, TVB-N, Microbial Analysis

The values of pH, TBA, TVB-N, microbial analysis of the chicken sausages are presented in Table 3.

The initial pH values of the control and PS were not changed significantly ( $p < 0.05$ ) for 14 days at 4°C. The effect of storage time and pepper seed was not observed on the pH of chicken sausages. It was reported that microbial growth decreased the pH of sausages during storage.<sup>10,24</sup> In this study, however, no viable microorganisms were detected during 14 days of storage at 4°C which could explain no significant changes of pH in this experiment.

TBARS value is routinely used as an index to represent lipid oxidation in meat products, and determined by mainly malondialdehyde that could contribute to the off-flavors of oxidized fat.<sup>21,25,26</sup> TBARS values were significantly increased in all samples throughout storage at 4°C ( $p < 0.05$ ). The initial TBARS values of control and PS were

0.29±0.05 and 0.28±0.02 µg MDA/ml respectively, and increased to 0.47±0.04 and 0.38±0.01 µg MDA/ml in 14 days of storage. The TBARS values of PS were significantly lower ( $p < 0.05$ ) than that of the control in 14 days of storage, representing that the pepper seed had protective effects against lipid oxidation in chicken sausages. Normally TBARS value is below 0.7-1.0 mg malonaldehyde/kg meat. When TBARS value is reaching more than 1.0 mg malonaldehyde/kg meat the off-flavor would affect sensory attributes.<sup>21,25</sup> In this study TBARS value of all samples remained adequate level for 14 days at 4°C.

The TVB-N is the products of protein decomposition related to bacterial activities during storage.<sup>23,26,27</sup> Therefore, the increased value of total volatile basic nitrogen (TVB-N) could represent the spoilage of meat products. As expected, TVB-N values of the chicken sausages were raised ( $p < 0.05$ ) with the time of storage. However, the differences of TVB-N

values between control and PS were not observed during the storage ( $p > 0.05$ ).

No viable microorganisms were observed in all samples during the storage at 4°C indicating

adequate thermal processing and sanitary conditions in the products. It is reported that as most microorganisms were vulnerable to heat they were easily destroyed by heat treatment in sausage manufacture.<sup>28,29</sup>

**Table 3: The changes of pH, TBARS, TVB-N, and TPC of the chicken sausages during storage periods**

	Samples <sup>1)</sup>	Storage days		
		0	7	14
pH	C	6.01±0.01 <sup>2)</sup>	6.00±0.00	6.00±0.01
	PS	6.01±0.00	6.01±0.00	6.00±0.00
TBARS <sup>3)</sup>	C	0.29±0.05 <sup>A</sup>	0.32±0.02 <sup>A</sup>	0.47±0.04 <sup>aB</sup>
	PS	0.28±0.02 <sup>A</sup>	0.31±0.01 <sup>A</sup>	0.38±0.01 <sup>bB</sup>
TVB-N <sup>3)</sup>	C	7.87±0.07 <sup>A</sup>	11.96±0.08 <sup>B</sup>	13.65±0.10 <sup>C</sup>
	PS	7.23±0.04 <sup>A</sup>	10.77±0.10 <sup>B</sup>	13.65±0.08 <sup>C</sup>
TPC <sup>3)</sup>	C	N.D. <sup>4)</sup>	N.D.	N.D.
	PS	N.D.	N.D.	N.D.

A-C in the same row with different superscripts are significantly different at  $p < 0.05$ .

a, b in the same column with different superscripts are significantly different at  $p < 0.05$ .

<sup>1)</sup>C: chicken sausages without pepper seed, PS: chicken sausages with pepper seed.

<sup>2)</sup>Values are mean±SD.

<sup>3)</sup>TBARS: thiobarbituric acid reactive substances, TVB-N: total volatile basic nitrogen, TPC: total plate count

<sup>4)</sup>N.D. means 'not detected'.

### Texture

In Table 4, the texture profiles of chicken sausages are presented. The values for hardness of each sample were not significantly changed during storage for 14 days at 4°C. However, the addition of pepper seed reduced the hardness of chicken sausages ( $p < 0.05$ ). The pepper seed added chicken sausages were higher than the control group in cohesiveness scores but the differences showed no significance ( $p > 0.05$ ).

Previous studies reported that protein and fat content in sausage formulation contributed increasing hardness to the final product.<sup>6,28,30</sup> In this study, chicken skin was used in manufacturing chicken sausages as a source of fat and emulsifier. Pepper seed was substituted chicken skin rich of protein and fat in sample group. A major protein of chicken skin is collagen which could improve texture as an

emulsifying and gelling agent like myosin in meat emulsion. It is assumed that the lower amount of protein and fat in PS might affect the texture characteristics of PS.

### Sensory Evaluation

The scores of sensory attributes are shown in Table 5. The 10 panelists tested the texture, flavor, taste, appearance, and overall acceptability of chicken sausages. The addition of pepper seed had no significant effect on the texture ( $p > 0.05$ ). However, the samples added pepper seed were evaluated significantly higher than the controls in the sensory attribute of flavor, taste, appearance, overall acceptability ( $p < 0.05$ ). Kim *et al.*, (2013) also observed similar results in which pepper seed replaced part of pork fat in manufacturing pork sausages. Previously, Shin *et al.*, (2011),<sup>5</sup> and Na *et al.*, (2012)<sup>11</sup> also reported that natural plant

extracts enhanced sensory qualities of sausages. On the other hand, some researchers reported that meat products formulated by substituting animal fat with plant oil adversely affected sensory properties, in particular textural properties.<sup>28,31,32</sup>

**Table 4: The changes of textural characteristics of the chicken sausages during storage periods**

days	0		7		14	
	C <sup>1)</sup>	PS <sup>1)</sup>	C	PS	C	PS
Hardness (kg)	1907±68 <sup>A</sup>	1805±25 <sup>B</sup>	1884±11 <sup>A</sup>	1784±27 <sup>B</sup>	1895±37.0 <sup>A</sup>	1800±33.5 <sup>B</sup>
Cohesiveness (%)	54.4±4.5	58.7±3.1	54.2±3.9	57.9±5.1	54.6±4.8	58.0±7.0
Springiness (mm)	90.1±8.7	88.9±7.2	89.9±4.8	88.0±7.2	89.4±8.1	88.4±6.7
Gumminess (kg)	685.1±22.3	686.8±39.5	680.9±22.5	678.6±57.2	680.4±33.1	676.5±28.7

<sup>1)</sup>C: chicken sausages without pepper seed, PS: chicken sausages with pepper seed.

<sup>2)</sup>Values are mean±SD.

<sup>A,B</sup>in the same row with different superscripts are significantly different at  $p < 0.05$ .

**Table 5: Sensory characteristics of the chicken sausages**

Samples <sup>1)</sup>	texture	flavor	taste	appearance	overall acceptability
C	6.34±0.11	6.05±0.23 <sup>a</sup>	5.78±0.22 <sup>a</sup>	5.90±0.17 <sup>a</sup>	5.83±0.28 <sup>a</sup>
PS	6.29±0.17	6.30±0.31 <sup>b</sup>	6.62±0.19 <sup>b</sup>	6.65±0.30 <sup>b</sup>	6.67±0.07 <sup>b</sup>

<sup>1)</sup>C: chicken sausages without pepper seed, PS: chicken sausages with pepper seed.

<sup>2)</sup>Values are mean±SD.

<sup>a, b</sup> in the same column with different superscripts are significantly different at  $p < 0.05$ .

## Conclusion

The qualities of chicken sausages were successfully improved with the addition of pepper seed. The replacement of chicken skin with pepper seed decreased the content of total fat, saturated fatty acids and cholesterol in chicken sausages ( $p < 0.05$ ). The addition of the pepper seed retarded lipid oxidation in chicken sausages, which was represented by lower TBARS values of PS than that of the control in 14 days of storage at 4°C ( $p < 0.05$ ). Texture profiles were not affected by pepper seed except for the hardness. On the contrary sensory characteristics were significantly improved in flavor, taste, appearance, overall acceptability ( $p < 0.05$ ). These results demonstrated that the application of pepper seed in manufacturing chicken sausage was

desirable for improving the sensory properties and nutritional value of the products.

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## Conflict of Interest

The author declares no conflict of interest.

## References

1. Ebbeling C.B., Pawlak D.B., Ludwig D.S. Childhood obesity: public-health crisis, common sense cure. *Lancet*. 2002; 360: 473-482.
2. Jeon H.R., Jae M.K. Consumer consciousness toward well-being and well-being oriented consumer behaviors according to the dietary life-focused on purchasing, using, and disposal behavior of married women. *Korean Assn Human Econ*. 2007; 16(5): 957-967.
3. Lin K.W., Mei M.Y. Influences of gums, soy protein isolate, and heating temperatures on reduced-fat meat batters in a model system. *J Food Sci*. 2000; 65(1): 48-52.
4. Bolger Z., Brunton N.P., Monahan F. J. Impact of inclusion of flaxseed oil (pre-emulsified or encapsulated) on the physical characteristics of chicken sausages. *J Food Eng*. 2018; 230: 39-48.
5. Shin J.H., Kang M.J., Kim R.J., Sung N.J. The quality characteristics of sausage with added black garlic extracts. *Korean J Food Cookery Sci*. 2011; 27(6): 701-711.
6. Candogan K., Kolsarici N. Storage stability of low-fat beef frankfurters formulated with carrageenan or carrageenan with pectin. *Meat Sci*. 2003; 64(2): 207-214.
7. Pak J.I., Seo T.S., Jang A.R. Effect of dried yam extracts on sausage quality during cold storage. *Korean J Food Sci An*. 2012; 32(6): 820-827.
8. Shin S.R., Chin K.B. Evaluation of rheological properties of pork myofibrillar protein with tapioca starch and its utilization to the pork model sausages. *Korean J Food Sci. An*. 2012; 32(3): 323-329.
9. Calkins C.R., Hodgen J.M. A fresh look at meat flavor. *Meat Sci*. 2007; 77: 63-80.
10. Andres S.C., Zaritzky N.E., Califano A.N. Innovations in the development of healthier chicken sausages formulated with different lipid sources. *Poult Sci*. 2009; 88: 1755-1764.
11. Na Y.R., Joo N.M. Processing optimization and antioxidant activity of sausage prepared with tomato powder. *Korean J Food Cookery Sci*. 2012; 28(2):195-206.
12. Fernández-Lopez J., Zhi N., Aleson-Carbonell L., Pérez-Alvarez J.A., Kuri V. Antioxidant and antibacterial activities of natural extracts: Application in beef meatballs. *Meat Sci*. 2005; 69(3): 371-380.
13. Georgantelis I., Ambrosiadis P., Katikou, G., Blekas S.A., Georgakis T. Effect of rosemary extract, chitosan and  $\alpha$ -tocopherol on microbiological parameters and lipid oxidation of fresh pork sausages stored at 4°C. *Meat Sci*. 2007; 76: 172-181.
14. Falowo A.B., Fayemi P.O., Muchenje V. Natural antioxidants against lipid-protein oxidative deterioration in meat and meat products: A review. *Food Res. Int*. 2014; 64: 171-181.
15. Kim H.A., Kim B.C., Kim Y. K. Quality characteristics of the sausages added with pepper seed powder and pepper seed oil. *Korean J Food Cookery Sci*. 2013; 29: 283-289.
16. Arnnok P., Ruangviriyachai C., Mahachai R., Techawongstien S., Chanthai S. Determination of total phenolics and anthocyanin contents in the pericarp of hot chilli pepper (*Capsicum annum* L.). *Int Food Res J*. 2012; 19(1): 235-243.
17. Sim K.H., Han Y.S. The antimutagenic and antioxidant effects of red pepper and red pepper pericarp (*Capsicum annum* L.). *J Food Sci Nutr*. 2007; 12:273-278.
18. Yoon H.S., Kwon J.H., Bae M.J., Hwang J.H. Studies on the development of food resources from waste seeds. Chemical composition of red pepper seed. *Korean J Food Nutr*. 1983; 12: 49-50.
19. Ku K.H., Choi E.J., Park J.B. Chemical component analysis of red pepper (*Capsicum annum* L.) seeds with various cultivars. *J Korean Soc Food Sci Nutr*. 2008; 37(8):1084-1089.
20. AOAC. Official methods of analysis of AOAC International. 17<sup>th</sup> edition. Method. 950.46.991.36. Association of Analytical Chemists. Gaithersberg, MD. U.S.A. 2000.
21. Tarladgis B.G., Watts B.M., Younathan M.T., Dugan L. Jr. A distillation method for the

- quantitative determination of malonaldehyde in rancid foods. *J Am Oil Chem Soc.* 1960; 37: 44-48.
22. Sallam K.I., Ishioroshi M., Samejima K. Antioxidant and antimicrobial effects of garlic in chicken sausage. *LWT - Food Sci Tech.* 2004; 37: 849-855.
23. Botta J.R., Lauder J.T., Jewer M.A. Effect of methodology on total volatile basic nitrogen (TVB-N) determination as an index of quality of fresh atlantic cod (*Gadus morhua*). *J Food Sci.* 1984; 49(3): 734-736.
24. Kim Y.J., Hwang B.S. Effects of addition of mugwort and pine needle extracts on shelf-life in emulsified sausage during cold storage. *Korean J Anim Sci Technol.* 2011; 53(5): 461-467.
25. Witte V.C., Krause G.F., Baile M.E. A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage. *J Food Sci.* 1970; 35: 352-358.
26. Yang Q., Sun D.W., Cheng Development of simplified models for nondestructive hyperspectral imaging monitoring of TVB-N contents in cured meat during drying process. *J Food Eng.* 2017; 192: 53-60.
27. Huang L., Zhao J., Chen Q., Zhang Y. Nondestructive measurement of total volatile basic nitrogen (TVB-N) in pork meat by integrating near infrared spectroscopy, computer vision and electronic nose techniques. *Food Chem.* 2014; 45(15): 228-236.
28. Malle P., Poumeyrol M. A new chemical criterion for the quality control of fish: trimethylamine/total volatile basic nitrogen (%). *J Food Protec.* 1989; 52(6): 419-423.
29. Andrés S., García M., Zaritzky N., Califano A. Storage stability of low-fat chicken sausages. *J Food Eng.* 2006; 72(4): 311-319.
30. Hung S.C., Zayas J.F. Sensory, chemical and bacteriological stability of frankfurters containing milk proteins and corn flour. *J Food Proc Preser.* 1991; 15 (6): 413-431
31. Chang H.C., Carpenter J.A. Optimizing quality of frankfurters containing oat bran and added water. *J Food Sci.* 1997; 62: 194-197.
32. Beriain M.J., Gomez I., Petri E., Insausti K., Sarries M.V. The effects of olive oil emulsified alginate on the physico-chemical, sensory, microbial, and fatty acid profiles of low-salt, inulin-enriched sausages. *Meat Sci.* 2011; 88: 189-197
33. Asuming-Bediako N., Jaspal M.H., Hallett K., Bayntun J., Baker A., Sheard P.R. Effects of replacing pork back fat with emulsified vegetable oil on fatty acid composition and quality of UK-style sausages. *Meat Sci.* 2014; 96: 187-194.