# EFFECTS OF LOTUS (*Nelumbo nucifera*) ROOT POWDER ON THE QUALITY CHARACTERISTICS IN PORK SAUSAGE

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**Abstract –This study was conducted to evaluate the effect of lotus root powder on the lipid oxidation and other quality characteristics of emulsion-type pork sausage. Lotus root powder was applied by different levels (0, 1, 2, and 3%). The proximate composition, pH value, instrumental color, cooking yield, emulsion stability, texture, TBARS value of pork sausages were analyzed. Cooking yield and emulsion stability increased significantly as the lotus root powder addition level increased ($p$<0.05). Lipid oxidation of pork sausage was lowered significantly by the addition of lotus root powder ($p$<0.05). Therefore, the result from this study indicates that adding lotus root powder could prevent the lipid oxidation and stabilize the emulsion matrix in emulsion-type pork sausage.**

**Key Words – meat product, pork sausage, lipid oxidation, lotus root powder, antioxidant effect.**

## I. INTRODUCTION

Pork sausage, which is one of the classic meat products, has been consumed all over the world. In general, sausage contains high fat content such as 20-30% pork back fat which is not only crucial constituent for flavor, juiciness and tenderness but also a source of essential fatty acids [1]. However, fat is prone to oxidation and lipid rancidity causes a decrease in consumer acceptability. Therefore, antioxidants are used for delay lipid oxidation process and enhancing an oxidative stability in the sausages. Synthetic antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxy-anisole (BHA) have been used in the meat products, however, needs for natural antioxidant substances are growing due to the toxic safety problem of synthetic antioxidants [2].

Lotus (*Nelumbo nucifera*) is an aquatic plant which cultivated in the eastern Asia, such as Republic of Korea. Its rhizome (lotus root) is consumed as vegetables and recognized traditional herbal medicine. Lotus root contains various biological active substances such as flavonoids (kaempferol, quercetin, and isoquercetin), polyphenolic compounds, and oligomeric procyanidines, which possesses anti-inflammatory and antioxidant activities [3, 4].

Besides, lotus root also have abundant dietary fiber which is consisted of carbohydrate polymers and non-carbohydrate components. Dietary fiber, not only helps to lower the risk of coronary heart diseases, diabetes, obesity and gastrointestinal diseases [5]. Dietary fiber is used for improvement of texture and cooking yield in meat products because it increases the water and fat binding properties [6].

Despite of these beneficial properties of lotus root, there is very few studies on the application of lotus root to meat products. Therefore, the purpose of this study was to evaluate the lipid oxidation stability and other quality characteristics of emulsion-type pork sausage with lotus root powder.

## II. MATERIALS AND METHODS

### 2.1. *Preparation of lotus root powder and manufacture of pork sausage*

Lotus root powder was obtained from a local market. Fresh pork hams and back fats were purchased from local retailer, 48 h postmortem. All subcutaneous and intramuscular fat and visible connective tissues were removed from the fresh ham muscles. The formulation of pork sausages with different level of lotus root powder is presented in Table 1. The pork ham and back fat were grinded through a 3 mm plate. And grounded pork ham and back fat, lotus root powder, ice, nitrite pickling salt (NPS), phosphate, spices and ascorbic acid were emulsified in a silent cutter (Nr-963009, Scharfen, Witten, Germany). Emulsified meat batter was stuffed into collagen casings using a stuffer. Then the samples were heated at 75°C for

30 min in a water bath. The cooked sausages were then cooled and stored at 4°C until analysis.

2.2. *Proximate composition*

Compositional properties of the pork sausages were determined using AOAC methods [7].

2.3. *pH measurement*

The pH values of the pork sausages were determined in a homogenate prepared with 5 g of sample and distilled water (20 ml), using a pH meter (Model 340, Mettler-Toledo GmbH, Schwerzenbach, Switzerland). All determinations were performed in triplicate.

2.4. *Instrumental color evaluations*

The color of the pork sausages were measured by the CIE LAB system using a color meter (Minolta Chroma meter CR-210, Japan; illuminate C, calibrated with white plate, L*=+97.83, a*=-0.43, b*=+1.98). Lightness (CIE L*), redness (CIE a*), and yellowness (CIE b*) values were recorded.

Table 1. Formulations of emulsion-type pork sausages with different levels of lotus root powder

(unit, %)

| Traits | CON | LR1 | LR2 | LR3 |
|---|---|---|---|---|
| Pork meat | 60 | 60 | 60 | 60 |
| Pork back fat | 20 | 20 | 20 | 20 |
| Ice | 20 | 20 | 20 | 20 |
| Total | 100 | 100 | 100 | 100 |
| NPS[2)] | 1.2 | 1.2 | 1.2 | 1.2 |
| Phosphate[3)] | 0.1 | 0.1 | 0.1 | 0.1 |
| Sugar | 0.9 | 0.9 | 0.9 | 0.9 |
| Pepper | 0.1 | 0.1 | 0.1 | 0.1 |
| Onion powder | 0.3 | 0.3 | 0.3 | 0.3 |
| Garlic powder | 0.3 | 0.3 | 0.3 | 0.3 |
| Ginger powder | 0.2 | 0.2 | 0.2 | 0.2 |
| Ascorbic acid | 0.05 | 0.05 | 0.05 | 0.05 |
| Lotus root powder | - | 1 | 2 | 3 |

[1)] NPS:nitrite pickling salt(salt:nitrite=99.4:0.6)
[2)] Phosphate : sodium tri-polyphosphate

2.5. *Cooking loss*

The meat batters were stuffed into the casing (initial weight) and after heat processing at 75°C for 30 min, cooked samples were cooled to room temperature at 21°C for 3 h. After cooling, the cooked sausages were weighed and the cooking loss was calculated as following equation: Cooking loss (%) = [{weight of sausage before cooking (g)}-{weight of sausage after cooking (g)}/weight of sausage before cooking (g)] × 100

2.6. *Emulsion stability*

The emulsion stability of meat batters was determined using a method by Bloukas and Honikel [8] with some modification. At the middle of a 15 mesh sieve, pre-weighed graduated glass tubes were filled with batter. The glass tubes were closed and heated for 30 min in a water bath to a core temperature of 75±1ºC. Then glass tubes were cooled to facilitate the separation of the fat and water layers. The fluid water and fat were measured in milliliters and calculated as percentages of the original weight of the batter.

2.7. *Texture profile analysis (TPA)*

The textural properties of the samples were measured using a spherical probe (5 diameter), attached to a texture analyser. Data were collected and analyzed in terms of hardness (kg), cohesiveness, springiness, gumminess (kg), and chewiness (kg).

2.8. *Thiobarbituric acid reactive substances (TBARS) value*

Lipid oxidation was assessed by the TBARS method of Tarladgis *et al*. [9] with minor modifications. Absorbances were measured using a UV/VIS spectrophotometer at 538 nm against a blank prepared with 5 mL distilled water and 5 mL TBA reagent. TBARS values were expressed as mg malondialdehyde (MDA)/kg samples.

2.9. *Statistical analysis*

An analysis of variance (ANOVA) was performed on all the variables measured using the general linear model (GLM) procedure of SPSS 18.0 software (SPSS Inc., Chicago, IL, USA). Duncan's multiple range tests ($p$<0.05) was used to determine differences between treatment means.

## III. RESULTS AND DISCUSSION

There was no significant effects on the proximate composition of pork sausages according to the addition of lotus root powder ($p$>0.05). The moisture content of the sausages ranged from

59.82 to 61.15%, and the protein content was within 11.19-12.87%. The fat content was determined in 20.27-23.70%, and the ash content of the samples was in 1.94-2.04%.

Table 2. Effects of lotus root powder addition on pH and instrumental color (CIE L*-, a*-, and b*-values) of pork sausages

| Traits | CON[1)] | LR1 | LR2 | LR3 |
|---|---|---|---|---|
| pH | 6.04± 0.03$^{A}$ | 5.96± 0.04$^{B}$ | 5.95± 0.12$^{B}$ | 5.92± 0.04$^{B}$ |
| L*-value | 70.01± 1.12$^{A}$ | 68.82± 0.99$^{B}$ | 67.62± 1.20$^{C}$ | 67.00± 0.67$^{C}$ |
| a*-value | 8.14± 0.40$^{A}$ | 6.84± 0.23$^{B}$ | 6.28± 0.30$^{C}$ | 6.44± 0.65$^{C}$ |
| b*-value | 8.74± 0.78$^{A}$ | 8.11± 0.46$^{B}$ | 8.42± 0.31$^{AB}$ | 8.64± 0.44$^{A}$ |

All values are mean ± SD of the three replicates.
[1)]CON, contains 0% lotus root powder; LR1, contains 1% lotus root powder; LR2, contains 2% lotus root powder; LR3, contains 3% lotus root powder.
[A-C]Means sharing different letters in the same row are significantly different ($p$<0.05).

The pH values and instrumental color (CIE L*-, a*-, and b*-values) of the pork sausages are shown in Table 3. The pH decreased significantly by the addition of the lotus root powder ($p$<0.05). The decrease of pH was considered as an effect of the pH of lotus root powder (5.89±0.01). The lightness (L*-value) and the redness (a*-value) of the pork sausages were decreased significantly as they containing more lotus root powder ($p$<0.05). The inherent color of the lotus root powder may affect the lightness and redness of the pork sausages. In accordance with this result, Jung *et al*. [10] reported that adding lotus root powder decreased lightness and redness in cooked pork patties ($p$>0.05).

Table 3. Effects of lotus root powder addition on cooking loss and emulsion stability of pork sausages

| Traits | CON[1)] | LR1 | LR2 | LR3 |
|---|---|---|---|---|
| Cooking loss | 7.26± 0.12$^{A}$ | 6.66± 0.23$^{B}$ | 6.49± 0.29$^{C}$ | 6.21± 0.08$^{D}$ |
| Fat loss | 1.40± 1.24 | 1.50± 0.50 | 0.90± 0.20 | 1.20± 0.33 |
| Water loss | 18.18± 0.97$^{A}$ | 18.09± 0.39$^{A}$ | 12.50± 0.60$^{B}$ | 10.99± 1.20$^{C}$ |

All values are mean ± SD of the three replicates.
[1)]CON, contains 0% lotus root powder; LR1, contains 1% lotus root powder; LR2, contains 2% lotus root powder; LR3, contains 3% lotus root powder.
[A-D]Means sharing different letters in the same row are significantly different ($p$<0.05).

The cooking loss and emulsion stability of the pork sausages with lotus root powder is presented in Table 3. When the adding level of lotus root powder exceeded 1%, the water loss in the pork sausages decreased significantly ($p$<0.05). It was assumed that dietary fiber in the lotus root powder helped to form a stable emulsion complex as water retention ability of the batters was improved [11]. Because the lotus root powder improved the stability of the emulsion matrix, cooking loss decreased significantly as the addition level of the lotus root powder increased ($p$<0.05).

Table 4. Effects of lotus root powder addition on texture properties of pork sausages

| Traits | CON[1)] | LR1 | LR2 | LR3 |
|---|---|---|---|---|
| Hardness (kg) | 0.54± 0.25 | 0.50± 0.18 | 0.51± 0.19 | 0.54± 0.17 |
| Cohesive-ness | 0.44± 0.02$^{A}$ | 0.43± 0.02$^{AB}$ | 0.43± 0.02$^{B}$ | 0.43± 0.01$^{B}$ |
| Springiness | 0.81± 0.05$^{B}$ | 0.81± 0.07$^{B}$ | 0.87± 0.04$^{A}$ | 0.88± 0.03$^{A}$ |
| Gummi-ness | 0.24± 0.11 | 0.21± 0.07 | 0.22± 0.08 | 0.23± 0.07 |
| Chewiness | 0.19± 0.08 | 0.18± 0.06 | 0.19± 0.07 | 0.20± 0.06 |

All values are mean ± SD of the three replicates.
[1)]CON, contains 0% lotus root powder; LR1, contains 1% lotus root powder; LR2, contains 2% lotus root powder; LR3, contains 3% lotus root powder.
[A,B]Means sharing different letters in the same row are significantly different ($p$<0.05).

Table 4 shows the results of texture profile analysis of pork sausages with lotus root powder. There were no significant changes in hardness, gumminess, and chewiness in pork sausages ($p$>0.05). It was presumed that the texture of the pork sausages did not affected significantly by the addition of lotus root powder.

Table 5. Effects of lotus root powder addition on thiobarbituric acid reactive substances (TBARS) values of pork sausages

| Traits | CON[1)] | LR1 | LR2 | LR3 |
|---|---|---|---|---|
| TBARS value | 1.14± 0.15$^{A}$ | 0.70± 0.09$^{B}$ | 0.68± 0.11$^{B}$ | 0.65± 0.19$^{B}$ |

All values are mean ± SD of the three replicates.
[1)]CON, contains 0% lotus root powder; LR1, contains 1% lotus root powder; LR2, contains 2% lotus root powder; LR3, contains 3% lotus root powder.
[A,B]Means sharing different letters in the same row are significantly different ($p$<0.05).

TBARS was measured to assess the degree of lipid oxidation in the pork sausages with lotus root

powder (Table 5). The control treatment, which containing no lotus root powder, showed the highest TBARS value among the treatments ($p$<0.05). It was assumed that the antioxidant substances in the lotus root may decreased the TBARS values of the pork sausages. In consistence with this result, Park *et al*. [12] reported the addition of the lotus root or leaf powder could be an effective method to reduce the lipid oxidation in pork patties.

## IV. CONCLUSION

The emulsion-type pork sausages with the lotus root powder showed significantly higher emulsion stability and cooking yield. Moreover, lotus root powder prevented lipid oxidation in the pork sausages. These results suggest that the lotus root powder can be used as an effective additive that improves the emulsion stability and prevents the lipid oxidation in pork sausages.

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