# ELUCIDIATION OF DISCOLORATION OF MYOGLOBIN INDUCED BY ATMOSPHERIC PRESSURE PLASMA

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## I. INTRODUCTION

Recently, atmospheric pressure plasma (APP) has attracted attention as a non-thermal pasteurization technology. To date, antimicrobial effect of APP on meat has been sufficiently demonstrated. However, some studies reported that APP treatment can induce minor deterioration of meat quality, especially the color [1,4]. Fröhling et al. [1] and Kim et al. [2] proposed the green coloring effect on raw pork by APP treatment. Meat color is an important factor more than any other quality attributes because it influences the first impression and purchasing decision of meat. Consumers generally use the meat color as an indicator of freshness or wholesomeness [2]. Accordingly, it is important to maintain the fresh meat color after the treatment in order to use APP for improvement of safety and shelf-life extension for meat. We hypothesized that APP treatment affected the myoglobin in raw meat, resulting in meat discoloration because myoglobin is the most responsible factor for raw meat color [3]. Therefore, the objective of present study was to elucidate and control of APP-induced discoloration of myoglobin.

## II. MATERIALS AND METHODS

Horse skeletal muscle myoglobin, which has ferric iron ($Fe^{3+}$), was purchased from the Sigma Chemical Co. (St. Louis, MO, USA). Then, the myoglobin (60 mM) was dissolved in the 0.4 M sodium phosphate buffer (pH 6.8) with or without 0.5% sodium dithionite. Sodium dithionite, one of the strong reducing agent, was added in order to control green discoloration of myoglobin by APP. Each sample was exposed to APP for 0 and 20 min, respectively. All materials in APP device and plasma generation conditions were described in previous study [5]. The color values of the samples were measured using a colorimeter (CM-5, Konica Minolta Co., Ltd., Osaka, Japan). Ultra-violet (UV) absorption scans of the myoglobin solution were conducted using a Model X-ma 3100 spectrophotometer (Human Co., Ltd., Seoul, Korea). Nitrite concentration was measured using an ion-chromatograph (Dionex ICS-3000; Dionex Corporation, Sunnyvale, USA). Each set of data represents the mean of three replications. Statistical analysis was performed by one-way analysis of variance and significant differences were identified with the Tukey's multiple range test using SAS 9.4 software (SAS Institute Inc., USA).

## III. RESULTS AND DISCUSSION

*L**, *a**, and *b** values significantly decreased in myoglobin solution after the exposure of APP for 20 min (Table 1). Decreased *a** value describes that redness is reduced whereas greenness is induced. In the UV-absorption spectra of APP-treated myoglobin solution for 20 min, absorption peaks at 503 and 630 nm were decreased while that of 590 nm was increased (Fig. 1 (a)). Sulfmyoglobin and choleglobin, green-colored pigments derived from myoglobin, have their typical spectra which absorption maximum at 615 and 628 nm, respectively. However those maximum peaks were not observed in APP-treated myoglobin solution for 20 min. Thus, sulfmyoglobin and choleglobin might not be produced by APP treatment [3]. In order to investigate the possibility of nitrimyoglobin formation, nitrite concentration was measured and which was 146.72 mg/mL in APP-treated myoglobin for 20 min (data not shown). Nitrimyoglobin, one of the green pigments, is formed when metmyoglobin is exposed to excess nitrite and nitrous acid at pH values below 7.0 [4]. Consequently, experimental results in present study support the formation of nitrimyoglobin after APP treatment in myoglobin solution.

When myoglobin solution with 0.5% sodium dithionite was treated by APP for 20 min, *L** and *b** values were not changed whereas *a** value was increased in myoglobin solution added with 0.5% sodium dithionite

(Table 1). UV-absorption spectra were measured to elucidate the red coloration of myoglobin solution treated with 0.5% sodium dithionite and APP (Fig. 1 (b)). In myoglobin with 0.5% sodium dithionite, the absorption peak at 577 nm was shown, which is a typical spectrum of deoxymyoglobin. When 0.5% sodium dithionite was added to myoglobin solution followed by APP treatment for 20 min, absorption peaks at 548 and 579 nm were shown. This spectrum is in accordance with characteristic absorption spectrum of nitrosomyoglobin (bright red color) [3].

Table 1. Color values of myoglobin and myoglobin added with sodium dithionite after the exposure of atmospheric pressure plasma (APP)

| Treatment time (min) | Myoglobin | | | Myoglobin added with 0.5% sodium dithionite | | |
|---|---|---|---|---|---|---|
| | $L^*$ | $a^*$ | $b^*$ | $L^*$ | $a^*$ | $b^*$ |
| 0 | 79.92[a] | 9.50[a] | 30.41[a] | 73.89 | 4.56[b] | 29.32 |
| 20 | 78.48[b] | 4.86[b] | 29.58[b] | 72.85 | 11.94[a] | 33.43 |
| SEM[1)] | 0.044 | 0.113 | 0.054 | 0.244 | 0.216 | 0.742 |

[1)]Standard error of the mean (n=6).
[a-b]Values with different letters within the same column differ significantly ($P$<0.05).

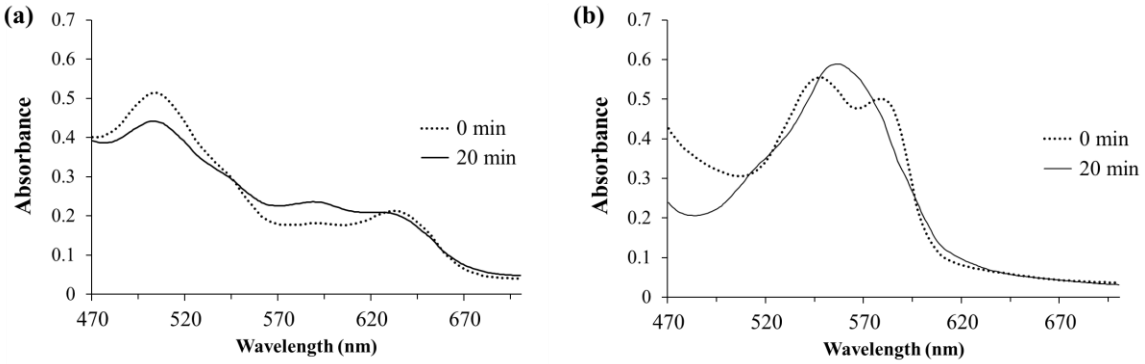


Figure 1. UV-absorption spectra of (a) myoglobin and (b) myoglobin with 0.5% sodium dithionite addition which treated with atmospheric pressure plasma (APP)

## IV. CONCLUSION

Present study reveals that the mechanism of APP-induced discoloration of myoglobin can be due to nitrimyoglobin formation. However, addition of antioxidant such as sodium dithionite can induce red color by the formation of nitrosomyoglobin.

## ACKNOWLEDGEMENTS

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