EFFECTS OF DIETARY RADISH GREEN AND SPINACH ON COLOR, LIPID OXIDATION AND LUTEIN ACCUMULATION IN BROILER TISSUE

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***Abstract*—this experiment was conducted to investigate the effects of dietary additive supplementation with lutein containing materials on the color, lipid oxidation and lutein accumulation in broiler tissue. To accomplish this, broilers were subjected to one of the following treatments: C, basal diet (BD); T1, BD + 2.223% spinach extraction with fermentation ethanol; T2, BD + 2% radish green powder; T3, BD + 0.61% spinach powder; T4, BD + 1.83% spinach powder. The weight gain, feed intake and feed conversion did not differ significantly among treatments. The skin of T2 and T4 showed significantly ($p<0.05$) higher CIE b^* values when compared to the other treatments. Evaluation of the color of the chicken breast meat revealed that the CIE L^* value of the control was significantly ($p<0.05$) higher than that of the other treatments, whereas T4 had a significantly ($p<0.05$) higher CIE b^* value than the other treatments. The TBARS value was lower in T1 than in the other treatments. The results of HPLC analysis revealed that the lutein peak was present only in the liver tissue of T4 and abdominal fat and muscle were not detected in any treatments. Therefore, these results suggest that supplementation of the diet with the lutein compound effectively improved lipid oxidation during storage of chicken meat**

***Index Terms*— chicken meat, meat color, lipid oxidation, lutein**

I. INTRODUCTION

Pigmentation is an important factor in consumer acceptance and perceived quality of broilers (Ouart, Bell, Jankey, Dukes & Marion, 1998). The color of poultry skin is provided by carotenoid pigments present in the diet of birds that are deposited in the skin and subcutaneous fat. Poultry use carotenoids for pigmentation, and these substances are also involved in growth metabolism and fertility (Schiedt, 1998). Some carotenoids serve as precursors for the synthesis of vitamin A (Sklan, Yosefov & Friedman, 1989; Surai & Speake, 1998), and some provide protection agaist damaging reactions in the body, acting as physiological antioxidants (Burton, 1989), and thus enhancing the immune response (Bendich, 1989; Prabhala, Garewal, Hicks, Sampliner & Waston, 1991). The effectiveness of the red xanthophyll, canthaxanthin, for pigmentation of egg yolks and broilers has been demonstrated by many researchers (Fletcher, Harms & Janky, 1978; Saylor, 1986). Canthaxanthin can significantly increase the degree of pigmentation in broilers when used in diets containing yellow carotenoids (Marusich & Bauernfeind, 1981). One of the more widely used sources of yellow pigments is the flower petals of marigolds, which contain up to 2,000 ppm of carotenoids (Tyczkowski & Hamilton, 1986).

Lutein, and its stero isomedr zeaxanthin, are members of the xanthophyll family of carotenoids. Part of what makes gthese compounds unique relative to other carotenoids in humans is their presence in specific eye tissues. Lutein and zeazanthin are highly concentrated in the macula, a small area of the retina responsible for central vision and high visual acuity, and are the only carotenoids present in this tisesue (Landrun & Bone, 2001). Such is the case in the lens, another eye tissue critical to vision, where lutein and zeaxanthin are the only casrotinodis present (Yeum, Taylor, Tang & Russell, 1995). The objective of this study was to investigate the effects of lutein compounds on color, lipid oxidation, and lutein accumulation in broiler tissue.

II. MATERIALS AND METHODS

The study was conducted using 225 1-d-old Ross broilers that were subjected to one of five treatments. Corn-soy diets were formulated to provide nutrients (Table 1). Diet inclusions provided calculated lutein levels from different lutein sources. The lutein concentrations of the five treatments were as follows; C, basal diet (BD, 4mg/ kg); T1, BD + 2 mg/kg from spinach extracted with fermentation ethanol; T2, BD + 2 mg/kg from radish green powder; T3, BD + 2 mg/kg from spinach powder; T4, BD + 6 mg/kg from spinach powder. The broilers were fed over 5 wk and then slaughtered, after which the breast muscle was obtained and aerobically packaged. The color of the meat and skin, and the concentration of lutein were then measured at postmortem 24 h. TBARS values were measured at postmortem 1, 3,

5 and 7 d.

III. RESULTS AND DISCUSSION

As shown in Table 2, the skin color of the control showed a higher lightness than that of the treated groups, whereas the yellowness was higher ($p<0.05$) in T2 and T4 when compared to the other treatments. These results suggeted that the higher concentration of pigments in the diet fed to T4 influenced skin color in broilers, but that skin color was not influenced by the lutein sources and concentrations. The relation of coloring in intramuscular fat, consumption of the carotenoid pigments in green leafy forage results in yellow subcutaneous adipose tissue of cattle (Strachan, Yang & Dillon, 1993; Yang, Larsen & Tume, 1992) and such beef is unacceptable in markets of Southern Europe, where carcasses with 'white' carcass fat command a premium price (Anon, 1999; Dunne, O'Mara, Monahan & Moloney, 2004). On the other hand, the color of poultry skin is provided by carotenoid pigments present in the diet of birds that are deposited in the skin and subcutaneous fat. Poultry use carotenoids for pigmentation, and these substances are also involved in growth metabolism and fertility (Schiedt, 1998). The CIE L^* values were higher ($p<0.05$) in the control than the treatment groups, while the CIE a* values were higher ($p<0.05$) in T4 compared than in the other treatment groups. These results suggest that the meat color was correlated with meat quality during cold storage of chicken breast meat.

The TBARS values of chicken breast meat were not changed during the first five days of cold storage (Table 3). However, T1 had a lower TBARS value when compared to the other treatments at day seven. The TBARS values of T3 and T4 were lower ($p<0.05$) after first five days of storage than after seven days. However, the TBARS values of the other treatments did not differ significantly after cold storage for three days. This TBARS effect had been reported previously by Min, Kim, Kang & Lee (2003). Also, Sáyago-Ayerdi, Brenes, Viveros & Goñi (2009) suggested that dietary grape pomace concentrate can delay lipid oxidation significantly and reduced the potential risk induced by lipid oxidation products. Although the TBARS values did not differ significantly among treatments, lutein compound from spinach (T1) was lower TBARS value compared to spinach powder (T4). These results suggest that the lower TBARS value was related to the bioavailability rather than the concentration of lutein sources. Kim, Kang, Kim, Shim, Shin & Kim (2007) founded that bioavailability of lutein affected to lutein sources *in vitro* using caco-2 human intestinal cells.

The results of the HPLC analysis (Table 4; Fig. 1) revealed that the amount of accumulated lutein was extremely small in broiler tissues (liver, abdominal fat and muscle), while the lutein peak was only clearly observed in liver tissue of T4. According to the previously study (Tyczkowski & Hamilton, 1986), dietary carotenoids are absorbed in different sections of the intestine; whereas zeaxanthin is mainly absorbed in the ileum, the absorption of lutein takes place in the duodenum and jejunum. Subsequent to absorption, the carotenoids are rapidly deposited in broiler tissues (subcutaneous adipose layer, breast and shank shin, and toe-web). Commonly, lutein and zeaxanthin are highly concentrated in the macula, a small area of the retina responsible for central vision and high visual acuity, and are the only carotenoids present in this tissue (Landrum & Bone, 2001). Our results showed that the lutein peak was detected only in the liver tissue of T4, whereas it was not detected in the abdominal fat. Therefore, these findings suggested that it is not easy to induce the accumulation of lutein in muscle.

IV. CONCLUSION

Overall, the results of this study suggest that the higher concentration of lutein provided by supplementation of the diet with influenced lipid oxidation during cold storage of chicken meat.

ACKNOWLEDGEMENT

This research was supported by Grant from the Korean Rural Development Administration. The authors acknowledge a graduate fellowship provided by the Rural Development Administration through the Agenda system Projects, Korea.

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Table 1. Experimental design

Treatments	Additive ratio (%)	Concentration of lutein (mg/kg)
Basal diet feed (C)	0	4
Lutein extract (T1)	2.223	6
Radish green powder (T2)	2	6
Spinach powder (T3)	0.61	6
Spinach powder (T4)	1.83	10

Table 2. Effects of supplementation with lutein containing materials on CIE color of breast meat and skin in broiler

Treatments*	Skin color			Meat color		
	L*	a*	b*	L*	a*	b*
C	78.1^{a}	4.18^{ab}	18.7^{b}	51.7^{c}	2.38^{ab}	5.21^{b}
T1	74^{b}	4.2^{ab}	12.8^{c}	57.7^{ab}	1.79^{bc}	5.59^{b}
T2	76.1^{ab}	5.18^{a}	23.3^{a}	56.5^{ab}	2.89^{a}	6.02^{b}
T3	74^{b}	5.39^{a}	17^{b}	58.1^{a}	2.83^{a}	5.49^{b}
T4	74.9^{b}	2.91^{b}	23.5^{a}	56^{b}	1.69^{c}	8.24^{a}
SEM	0.38	0.26	0.65	0.35	0.11	0.22

*C; basal diet (BD), T1; BD + 2.223% spinach extraction, T2; BD + 2% radish green powder, T3; BD + 0.61% spinach powder, T4; BD + 1.83% spinach powder.
$^{a-c}$Means with different superscripts within a row differ significantly (p<0.05).

Table 3. Effects of supplementation with lutein containing materials on TBARS of during cold storage of chicken breast meat

Treatments*	Storage days				SEM
	1	3	5	7	
C	0.23^{b}	0.33^{a}	0.33^{a}	0.38^{ABa}	0.01
T1	0.21^{b}	0.32^{a}	0.31^{a}	0.35^{Ba}	0.01
T2	0.19^{b}	0.36^{a}	0.35^{a}	0.41^{ABa}	0.01
T3	0.22^{c}	0.32^{b}	0.32^{b}	0.42^{ABa}	0.01
T4	0.21^{c}	0.37^{b}	0.38^{b}	0.43^{Aa}	0.01
SEM	0.01	0.01	0.01	0.01	

*C; basal diet (BD), T1; BD + 2.223% spinach extraction, T2; BD + 2% radish green powder, T3; BD + 0.61% spinach powder, T4; BD + 1.83% spinach powder.
$^{A-B}$Means with different superscripts within a column differ significantly (p<0.05).
$^{a-c}$Means with different superscripts within a row differ significantly (p<0.05).

Table 4. Concentrations (μg/g) of lutein in broiler tissues

Treatments*	Liver	Abdominal fat	Muscle
C	ND	ND	ND
T1	ND	ND	ND
T2	ND	ND	ND
T3	ND	ND	ND
T4	1.36±0.038	ND	ND

*C; basal diet (BD), T1; BD + 2.223% spinach extraction, T2; BD + 2% radish green powder, T3; BD + 0.61% spinach powder, T4; BD + 1.83% spinach powder.
ND; not detected.

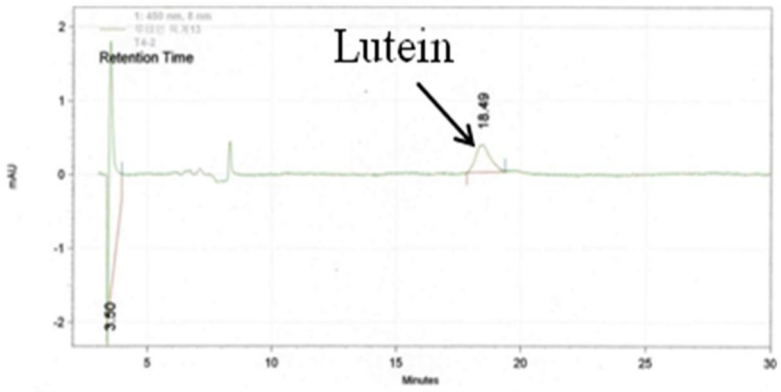

Fig. 1. Chromatogram of lutein in liver tissue of broiler.