ブロイラーの肉色改善に対するアスタキサンチン含有赤色酵母の給与レベルと給与期間ならびにレシチンとα-トコフェロール添加の影響

誌名	日本家禽学会誌
ISSN	00290254
著者	松下, 浩一 小宮山, 恒 秋葉, 征夫 ほか5名,
巻/号	37巻6号
掲載ページ	p. 341-348
発行年月	2000年11月

Influence of Feeding Duration and Dietary Level of *Phaffia rhodozyma*, a Yeast Containing High Concentrations of Astaxanthin, with or without Supplementation of Lecithin and α-Tocopherol on Meat Color Development in Broiler Chickens

Ko-ichi MATSUSHITA[1], Hisashi KOMIYAMA[1], Yukio AKIBA[2a], Kan SATO[2], Kazuaki TAKAHASHI[2], Masaaki TOYOMIZU[2], Hiroshi TSUNEKAWA[3] and Hidenori NAGAO[3]

[1] Yamanashi Prefecture Livestock Experimental Station, Tamaho-machi 409-3812
[2] Laboratory of Animal Nutrition, Graduate School of Agricultural Science, Tohoku University, Sendai-shi 981-8555
[3] Mercian Corporation, Tokyo 104-8305, Japan

Two experiments were conducted if the meat color-modifying potential of *Phaffia rhodozyma*, a yeast containing high levels of astaxanthin (Ax), is influenced by the feeding duration and the dietary concentration and if the potential is enhanced by an addition of lecithin+α-tocopherol in broiler chickens. Experimental diets supplemented with cell wall-fractured yeast to provide 10, 20 and 30 ppm Ax were fed to 3, 5 and 7 week-old chickens for 5, 3 and 1 weeks, respectively, prior to market in Experiment 1. In Experiment 2, Phaffia yeast-supplemented diets (20 ppm Ax), which were supplemented with or without lecithin (5 g/kg diet)+α-tocopherol (0.1 g/kg diet), were fed to 5 week-old chickens for 3 weeks prior to market. Feeding of Phaffia yeast influenced neither performance of broilers nor edible meat yields, irrespective of either the feeding duration, the dietary concentration or the addition of lecithin+α-tocopherol. Concerning the color analysis of edible meats using with Minolta reflectance colorimeter, lightness (L* value) was not essentially influenced by feeding of the yeast-supplemented diets, while yellowness (b* value) was slightly increased by the yeast feeding. On the other hand, the redness (a* value) of edible meats and abdominal adipose tissues was significantly or numerically increased by feeding of the yeast-supplemented diets, in which the increase was less extent in chickens received the yeast-supplemented diet (30 ppm Ax) for 1 week prior to market than chickens received the yeast-supplemented diets (20 ppm Ax) for 3 weeks. The extent of increase in a* values of edible meats was relatively dependent on the total Ax intake. Addition of lecithin+α-tocopherol did not intensify the coloration (redness) of edible meats by the feeding of yeast-supplemented diets. These results show that cell wall-fractured Phaffia yeast containing high concentrations of Ax can be a useful source for modification of meat color and the effect is briefly due to the total Ax intake in broiler chickens.

(Jpn. Poult. Sci. ***37*** *: 341-348, 2000)*

Key words : meat color, yeast, astaxanthin, broiler chickens , meat yield

Introduction

Meat color as well as skin color is understood as the major concern of consumers

Received June 1, 2000 Accepted August 9, 2000

[a] Corresponding : Yukio AKIBA (fax : +81 (0) 22-717-8691, e-mail : akiba@bios.tohoku.ac.jp)

for selection of meats in retail shops (FLETCHER, 1999). Besides skin color was considered a major quality issue for the consumer's final evaluations in the western countries (LIPSTEIN, 1989) where most of poultry meats were purchased as the whole carcass, in Japan meat color was considered a critical quality issue for evaluation of raw meat products. Preference of consumers for so-called "Jidori", cross-breeds of native chickens, has encouraged the consumption of strong-colored or reddish fillets more than light-colored or pale meats. A survey of broiler meats in processors revealed that there were much variations in the meat color in which extremes of either dark- or light-colored meats have been identified as the negative quality (AKIBA, Unpublished data).

FRONING (1995) reviewed the many live bird production factors associated with poultry meat color. Practical development of dietary manipulation of meat color might be a current concerns of animal scientists in terms of satisfying market preferences. We previously showed that feeding of red-pigmented yeast, *Phaffia rhodozyma,* which contains high concentrations of astaxanthin (Ax), a carotenoid, intensified the redness of broiler meats, in particular the redness of breast fillets (AKIBA *et al.,* 2000 a). It was the first to show that the meat color, in particular the redness, of both breast and thigh portions could be manipulated by feeding chickens with a natural feedstuff containing carotenoids.

In a viewpoint to promoting practically the use of Phaffia yeast for meat color modification, either to shorten the feeding duration of the yeast, to lower the dietary inclusion levels or to enhance the pigmenting potency might be explored. Lecithin, a phospholipid, which is essential for absorption and transport through blood circulation of lipid-soluble substances (BRODY, 1994) and α-tocopherol, an antioxidant, can be anticipated to encourage the meat color-modifying effects of Ax. Therefore, we report here the influence of feeding duration and dietary level of Phaffia yeast and the effects of an addition of lecithin + α-tocopherol on meat color development in broiler chickens.

Materials and Methods

Birds and diets

Female broiler day-old chicks obtained from a commercial hatchery were reared on floor in a window-less house and provided with water and commercial diets *ad libitum* prior to commencing to each experiment. Throughout the experiments, they were fed on a commercial starter diet (ME 3150 kcal/kg, CP 22.0%) for 3 weeks from 1 day of age and a finisher diet (ME 3150 kcal/kg, CP 18.0%) for subsequent 5 weeks as the basal diets up to market. Yellow corn, soybean meal, fish meal and yellow grease were the major ingredients in both diets. Chickens had free access to experimental feed and water at all times.

Experiment 1

One hundred and twenty-four female broiler chicks (Cobb) were assigned at random to 4 groups of 31 birds each. One group was fed on a diet with no supplementation of Phaffia yeast as the control. For the 3 remaining groups, the yeast-supplemented diets containing 10, 20 and 30 ppm Ax were fed for 5, 3 and 1 weeks, respectively, prior to the slaughtering (8 weeks of age).

Experiment 2

Four hundred and eight female broiler chickens (Cobb) aged 5 weeks were assigned at random to 3 groups of 136, with 4 replicates of 34 birds each, and fed on diets with or without Phaffia yeast for 3 weeks up to market. The yeast-supplemented diets containing 20 ppm Ax was added with or without lecithin (5 g/kg diet)+α-tocopherol (0.1 g/kg diet).

Cell wall-fractured Phaffia yeast and additives

The yeasts, *Phaffia rhodozyma,* fermented in a jar, was freeze-dried at room temperature and mechanically ground into fine powder, cooled to room temperature as quickly as possible, and air-dried. The chemical composition of the cell wall-fractured yeast has been described by us in a previous paper (AKIBA *et al.,* 2000 b). The total carotenoid and Ax concentrations of the yeast used for present experiments were 3,595 and 2,405 ppm, respectively. Thus the yeast was supplemented at 0.42, 0.83 and 1.25% in the basal diet so as to give concentrations of 10, 20 and 30 ppm Ax in diets.

Lecithin (phosphatidyl choline) and α-tocopherol acetate were obtained from Wako Pure Chemical Co. (Osaka, Japan).

Measurements

The body weights and feed consumption of chickens were recorded every week. At the end of each experiment, all birds were bled by cutting the carotid artery. Feather removal was accomplished in a commercial free action picker, after subscalding at approximately 60℃. Head and shank were removed and the remaining carcasses were chilled for 24 h prior to separation of edible meats and tissues. Breast meat (Pectoralis superficialis) and sasami (Pectoralis profundus), thigh muscles, wing, liver and abdominal pad were dissected and weighed. The percentage yield of edible meats (sum of breast, sasami and thigh meats) was calculated on the basis of carcass weight.

Analysis

The color of each sample was determined using a Minolta reflectance colorimeter (Minolta Chroma Meter CR-200b, Minolta Corp., Japan) and are reported according to the CIE system values of lightness (L*), redness (a*), and yellowness (b*). In order to accomplish uniformly the determination of meat color, colorimetry was performed at the fixed portion of breast, sasami, thigh meats (Satorius and Semitendinosus), abdominal fat pad and breast skin, respectively, throughout each experiment.

Statistical analysis

All results are expressed as means±SD. In each experiment, a SAS application package was used for statistical calculations (SAS, 1982). Data were analyzed by ANOVA using a general linear models procedure followed by Duncan's multiple range test. Statements of statistical significance were based on $P<0.05$.

Results

Experiment 1

The average feed intake, body weight at 8 week, edible meat yield, and yields of breast, sasami and thigh meats were not significantly influenced by the dietary Ax concentration and the feeding duration (Table 1). Results of meat color evaluation is presented in Table 2. The lightness (L* value) and yellowness (b* value) of the edible meats, with the exception of thigh meat (Satorius), were not modified by feeding the yeast-supplemented diets for 1 to 5 weeks. The redness (a* value) of breast meat, sasami and adipose tissue was significantly increased by feeding the yeast-supplemented diets, in which the increase was less extent in chickens received the yeast-supplemented diet (30 ppm Ax) for 1 week prior to market than the other groups

Table 1. Effect of feeding Phaffia yeast-supplemented diets for 1 to 5 weeks prior to slaughter on performance and edible meat yield in broiler chickens[1]

Treatment		Body weight at 8 week	Feed intake (8 weeks)	Edible meat yield	Breast meat	Sasami	Thigh meat
Phaffia yeast							
Dietary level (Ax, ppm)	Feeding (Weeks)	(kg)	(kg)	(% of carcass wt)	Pectoralis superficialis (g)	Pectoralis profundus (g)	(g)
Control	—	3.33±0.17	7.10	44.2±1.7	624±57	123±13	626±43
10	5	3.36±0.15	7.07	44.1±1.8	639±62	121±11	619±36
20	3	3.55±0.15	7.22	44.5±1.2	649±57	127±10	643±34
30	1	3.44±0.14	7.07	44.7±1.4	641±40	123±13	623±41

[1] Values for body weight and edible meat production represent mean±SD with 20 observations. Values for feed intake represent mean values.

Table 2. Effect of feeding Phaffia yeast for 1 to 5 weeks prior to slaughter on meat color in broiler chickens[1]

Treatment		Pectoralis		Satorius	Semitendinosus	Abdominal
Phaffia yeast						
Dietary level (Ax, ppm)	Feeding (Weeks)	superficialis (Breast meat)	profundus (Sasami)	(Thigh meat)	(Thigh meat)	adipose tissue
Lightness (L* value)						
Control	—	46.6±2.2	42.9±2.1	43.8±2.0	47.9±2.1	70.0±1.9[a]
10	5	46.2±1.9	42.1±1.7	43.5±1.9	48.7±1.8	67.3±1.9[b]
20	3	45.6±1.4	41.8±2.1	42.6±1.7	47.2±2.1	68.2±1.8[b]
30	1	46.0±1.7	42.0±1.8	44.5±1.8	48.4±1.1	69.6±1.8[ab]
Redness (a* value)						
Control	—	0.4±0.9[b]	0.5±1.1[b]	7.5±1.6	13.2±1.6	−0.2±2.1[b]
10	5	1.6±1.2[a]	1.9±0.7[a]	8.8±1.7	14.4±1.7	2.1±1.9[a]
20	3	1.8±1.1[a]	2.3±1.2[a]	8.6±1.3	14.4±1.7	2.6±1.2[a]
30	1	1.5±1.4[a]	1.5±1.1[ab]	7.8±2.0	13.8±1.7	1.5±1.8[a]
Yellowness (b* value)						
Control	—	12.3±1.3	11.4±1.2	14.2±1.2[b]	18.7±3.0	21.4±3.0
10	5	14.2±2.0	12.7±1.1	16.0±2.0[a]	20.8±1.5	21.5±2.7
20	3	13.8±1.6	12.4±1.1	15.4±1.2[ab]	19.8±1.3	22.3±1.3
30	1	12.4±1.6	12.3±1.0	15.0±0.9[ab]	19.6±1.0	22.6±2.5

[1] L*, a* and b* values were determined by Chroma Meter. Mean±SD with 20 observations.
[a,b] Means with different superscripts in column are significantly different ($P<0.05$).

received the yeast-supplemented diets (10 or 20 ppm Ax) for 5 or 3 weeks, respectively. Feeding of the yeast-supplemented diets resulted in numerical increases in a* values of thigh meats (both Satorius and Semitendinosus), although this result was not statistically significant. Feeding of the yeast-supplemented diets resulted in decreases of the coefficient of variance (SD/mean value) of the a* values in all meats sampled. The lightness (L* value) of edible meats were not changed by any of treatments, while that of abdominal fat is influenced by the feeding of yeast-supplemented diet.

Experiment 2

Performance and edible meat production were not influenced by feeding for 3 weeks of Phaffia yeast-supplemented diets with or without addition of lecithin+ α-tocopherol (Table 3). Results of color evaluation of meats, adipose tissue and skin is presented in Table 4. The redness (a* value) of breast, sasami, thigh meats, adipose tissue and breast skin in chickens fed on the yeast-supplemented diets were significantly higher than those in the control group. The b* values of breast, sasami and thigh meats were significantly or numerically increased by feeding the yeast-supplemented diets. No significant changes by addition of lecithin+α-tocopherol were detected in a* values and b* values of edible meats, adipose tissue and skin determined.

Discussion

Phaffia yeast containing Ax has been commonly used to produce pink flesh in fishes (JOHNSON *et al.*, 1977). We have stated that the yeast is useful as a potent source for pigmentation of egg yolk in laying hens (AKIBA *et al.*, 2000 b, c, d). The present data experimentally substantiates our previous findings (AKIBA *et al.*, 2000 a) that the redness (a* value) of edible meats is intensified by feeding of Phaffia yeast containing high concentrations of Ax, a carotenoid, in broiler chickens and the effect is emphasized for breast and sasami meats compared to thigh meats. To date, as dietary manipulation of meat color prior to slaughtering has been poorly explored, our results definitely show that meat color, in particular the redness, of both breast and thigh portions can be manipulated in broiler chickens by supplementing a natural feedstuff containing

Table 3. Effect of feeding Phaffia yeast-supplemented diets with or without lecithin+α-tocopherol for 21 d prior to slaughter on performance and edible meat yield in broiler chickens[1]

Treatment[2]		Body weight at 8 week	Feed intake (8 weeks)	Edible meat yield	Breast meat	Sasami	Thigh meat
Phaffia yeast (Ax, ppm)	Lecithin + α-tocopherol	(kg)	(kg)	(% of carcass wt)	Pectoralis superficialis (g)	Pectoralis profundus (g)	(g)
Control	−	3.02±0.05	6.24±0.23	44.5±1.3	525±37	103± 8	576±25
20	−	3.03±0.06	6.18±0.12	44.9±1.3	531±32	109±10	584±38
20	+	3.00±0.07	6.30±0.08	43.9±1.0	516±24	104± 9	577±32

[1] Values for body weight and feed intake represent mean±SD with 4 observations. Values for edible meat production represent mean±SD with 20 observation.

[2] Lecithin and α-tocopherol were supplemented at 5 and 0.1 g/kg diet, respectively.

Table 4. Effect of feeding Phaffia yeast-supplemented diets with or without lecithin+α-tocopherol for 21 d prior to slaughter on meat color in broiler chickens[1]

Treatment[2]		Breast meat	Sasami	Thigh meats		Abdominal adipose tissue	Breast skin
Phaffia yeast (Ax, ppm)	Lecithin + α-tocopherol	Pectoralis superficialis	Pectoralis profundus	Satorius	Semi-tendinosus		
Lightness (L* value)							
Control	−	48.0±2.5	43.0±1.9[ab]	43.4±1.4	49.3±1.1[a]	68.2±0.8	70.2±2.1[a]
20	−	48.6±0.9	43.3±1.0[a]	42.3±0.9	47.6±1.1[b]	69.0±0.4	66.9±1.5[b]
20	+	47.4±1.1	41.8±0.7[b]	42.6±1.1	47.7±0.4[b]	69.8±0.9	66.6±0.2[b]
Redness (a* value)							
Control	−	0.4±0.3[b]	0.2±0.3[b]	4.0±0.2[b]	8.0±1.0[b]	−1.1±0.5[b]	−0.8±0.5[b]
20	−	2.0±1.5[a]	0.7±0.3[a]	5.2±0.7[a]	10.1±0.4[a]	0.1±0.5[a]	1.1±0.4[a]
20	+	1.5±1.0[a]	1.1±0.4[a]	5.3±0.4[a]	10.1±1.0[a]	0.1±0.5[a]	1.1±0.4[a]
Yellowness (b* value)							
Control	−	10.9±0.3[b]	8.8±0.3[b]	10.6±0.8[b]	15.5±0.9[b]	18.4±1.0	18.0±1.1
20	−	11.7±0.7[a]	9.6±0.9[a]	11.8±0.5[a]	16.3±0.8[ab]	18.2±0.7	18.9±1.1
20	+	11.7±0.7[a]	9.8±0.4[a]	11.4±0.4[ab]	17.7±0.5[a]	19.4±1.2	18.8±1.4

[1] L*, a* and b* values were determined by Chroma Meter. Mean±SD with 20 observations.
[2] Lecithin and α-tocopherol were supplemented at 5 and 0.1 g/kg diet, respectively.
[a,b] Means with different superscripts in column are significantly different ($P<0.05$).

carotenoids in the diet.

In a view point to promoting the dietary supplementation of Phaffia yeast for the meat color modification, shortening the feeding duration and/or lowering the supplementing levels might be anticipated. In Experiment 1 in which dietary Ax level and the feeding duration prior to slaughter were manipulated, total Ax intake during the experimental duration averaged 53, 70 and 36 mg/bird in groups fed for 5 weeks the diet containing 10 ppm Ax, for 3 weeks the diet containing 20 ppm Ax and for 1 week the diet containing 30 ppm Ax, respectively. Whilst the redness (a* value) of edible meats and adipose tissue did not significantly differ among the yeast-supplemented groups, the intensity of redness was numerically in the following order ; highest in the group fed for 3 weeks the 20 ppm Ax-supplemented diet, followed by the group fed for 5 weeks the diet with 10 ppm Ax and the lowest in the group fed for 1 week the diet with 30 ppm Ax. This order paralleled to the average values of total Ax intake, suggesting that the intensity of a* value of the edible meats is, at least, more dependent on the Ax intake of chickens than either the feeding duration or the dietary concentration of Ax, per se. Akiba *et al.* (2000 a) noted that trans-Ax was detected at 0.1–0.3 μg/g in the edible meats of chickens fed Phaffia yeast at different concentrations for 3 weeks and the concentration rose in proportion to the dietary Ax concentrations, thereby total Ax intake.

Lecithin, a phospholipid, is considered essential for absorption and transport through blood circulation of lipids and lipid-soluble substances (Brody, 1994). Whilst supplementation of Phaffia yeast containing Ax with lecithin can be anticipated to encourage the absorption and/or transport of Ax, the supplementation did not increase a* values in the edible meats. In addition, supplementation of α-tocopherol was not effective in improving the coloration of edible meats although α-tocopherol, an antioxidant, was expected to protect Ax from the degradation and metabolism of Ax in tissues. FRIGG *et al.* (1992) reported that supplementation of α-tocopherol to layers' diet did not affect yolk color and yolk concentrations of carotenoids ; lutein, zeaxanthin and canthaxanthin, in laying hens. Further exploitation of scientific procedures to improve the meat color-modifying potential of Phaffia yeast will be needed.

Current data shows that meat color, in particular the redness, is modulated by dietary supplementation of Phaffia yeast containing high concentrations of Ax. No detrimental effects on growth performance and edible meat yields were observed in broiler chickens fed on the Phaffia yeast-supplemented diets. Relatively small variations of a* values were shown in edible meats of the yeast-supplemented chickens, as shown in the smaller SD/mean values. The modification of meat color by supplementing Phaffia yeast, hence, may meet the preference of consumers that dislike much variations of meat color.

Acknowledgment

The authors thank Yoko TAKAHASHI and Shigeru KONASHI for technical assistance.

References

AKIBA, Y., K. SATO, K. TAKAHASHI, K. MATSUSHITA, H. KOMIYAMA, H. TSUNEKAWA and H. NAGAO (2000 a) Meat color modification in broiler chickens by feeding yeast Phaffia rhodozyma containing high concentrations of astaxanthin. Journal of Applied Poultry Research, (accepted for publication)

AKIBA, Y., K. SATO, K. TAKAHASHI, Y. TAKAHASHI, A. FURUKI, S. KONASHI, H. NISHIDA, H. TSUNEKAWA, Y. HAYASAKA and H. NAGAO (2000 b) Pigmentation of egg yolk with yeast Phaffia rhodozyma containing high concentration of astaxanthin in laying hens fed on a low-carotenoid diet. Japanese Poultry Science, **37** : 77-85. 2000.

AKIBA, Y., K. SATO, K. TAKAHASHI, M. TOYOMIZU, Y. TAKAHASHI, H. TSUNEKAWA, Y. HAYASAKA and H. NAGAO (2000 c) Improved pigmentation of egg yolk by feeding of yeast Phaffia rhodozyma containing high concentration of astaxanthin in laying hens. Japanese Poultry Science, **37** : 162-170. 2000.

AKIBA, Y., K. SATO, K. TAKAHASHI, M. TOYOMIZU, Y. TAKAHASHI, H. TSUNEKAWA, Y. HAYASAKA and H. NAGAO (2000 d) Availability of Cell Wall-Fractured Yeast, Phaffia rhodozyma, Containing High Concentration of Astaxanthin for Egg Yolk Pigmentation. Animal Science Journal, **71** : 255-260, 2000.

BRODY, T. (1994) In Nutritional Biochemistry. Academic Press. New York.

FLETCHER, D.L. (1999) Color variation in commercially packaged broiler breast fillets. Journal of Applied Poultry Science, **8** : 67-69.

FRIGG, M., C.C. WHITEHEAD and S. WEBER (1992) Absence of effects of dietary α-tocopherol on egg yolk pigmentation. British Poultry Science, **33** : 347-353.

FRONING, G.W. (1995) Color of poultry meat. Poultry and Avian Biology Reviews, **6** : 83-93.

JOHNSON, E.A., D.E. CONKLIN and M.J. LEWIS (1977) The yeast Phaffia rhodozyma as a dietary pigment source for salmonoids and crustaceans. Journal of Fish and Research Board, Canada, **34** : 2417-2421.

LIPSTEIN B. (1989) Meat quality in broilers, with particular reference to pigmentation. In Recent Advance in Animal Nutrition (HARESIGN, W. and COLE, J.A. ed.) pp. 17-41. Butterworths. London.

Statistical Analysis System (1982) SAS User's guide : statistics (SAS Institute Inc., ed.) Cary. NC.

ブロイラーの肉色改善に対するアスタキサンチン含有赤色酵母の給与レベルと給与期間ならびにレシチンと α-トコフェロール添加の影響

松下浩一[1]・小宮山恒[1]・秋葉征夫[2]・佐藤　幹[2]・高橋和昭[2]・
豊水正昭[2]・恒川　博[3]・長尾秀則[3]

[1] 山梨県畜産試験場，山梨県玉穂町 409-3812
[2] 東北大学大学院農学研究科，仙台市青葉区 981-8555
[3] メルシャン株式会社，東京都中央区 104-8305

ブロイラーの大型化による出荷日齢の早期化に伴って，鶏肉肉色の淡泊化と肉色のバラツキが大きな問題となっている。カロチノイドの一種であるアスタキサンチン（Ax）を高濃度に含む赤色酵母を給与して肉色の改善を図るとともに，赤色酵母の添加濃度と給与期間の影響，並びにレシチンと α-トコフェロールの添加効果について検討した。試験1では，飼料中Ax濃度で10, 20, 30 ppm含むように赤色酵母を添加した飼料をそれぞれ，出荷前5週間，3週間および1週間給与し，増体成績，正肉生産量，肉色（L*値，a*値，b*値）を測定した。試験2ではAx 20 ppmを含む赤色酵母添加飼料区に加えて，さらにレシチン（5 g/kg）+ α-トコフェロール（0.1 g/kg）を添加する試験区を設け，出荷前3週間給与した。

いずれの試験でも，赤色酵母の給与期間，給与レベルおよびレシチン+ α-トコフェロール添加による増体成績，正肉歩留まり，正肉重量そして正肉の明度（L*値）の変化は認められなかった。モモ肉の赤色度（a*値）は赤色酵母給与で上昇の傾向を示したが，統計的有意差は見られなかった。一方，ムネ肉とササミのa*値は赤色酵母の給与により有意に上昇し，その上昇程度はAx 20 ppm添加飼料の3週間給与区で大きく，反対にAx 30 ppm添加飼料の1週間給与区で小さい傾向にあった。a*値上昇の順序は試験期間におけるAxの総摂取量にほぼ比例しており，赤色酵母の肉色強化効果はAxの総摂取量に依存するものと考えられた。正肉の黄色度（b*値）は赤色酵母給与でわずかに上昇する傾向が見られた。正肉の肉色（a*値およびb*値）に対するレシチン+ α-トコフェロール添加効果は認められなかった。

以上のことから，赤色酵母の給与はブロイラーの肉色，特に赤色度の改善に有効であり，その改善効果は赤色酵母中アスタキサンチンの総摂取量に依存すると考えられた。

（家禽会誌，***37***：*341-348, 2000*）

キーワード：肉色，赤色酵母，アスタキサンチン，ブロイラー，正肉歩留まり