REVISTA ESPAÑOLA DE FISIOLOGIA, 36, 49-52. 1980

Absorption and Fate of Canthaxanthin in Chicken

A. Alonso, M. Martín and R. Gómez

Departamento de Bioquímica
Facultad de Ciencias
Apartado 644, Bilbao (Spain)

(Received on May 9, 1979)

A. ALONSO, M. MARTIN and R. GOMEZ. *Absorption and Fate of Canthaxanthin in Chicken.* Rev. esp. Fisiol., 36, 49-52. 1980.

Male Hubbard chickens were fed on a diet supplemented with canthaxanthin. The carotenoid was chemically unmodified during its absorption of distribution.

Pigment was preferentially stored in the skin of legs. The percent distribution of carotenoid in the different organs did not vary with the administered dose or during the treatment.

Digestibility, expressed as the ratio absorbed: ingested pigment, was maximal in the first day, and then decreased. Digestibility was dependent on the animal body weight.

Canthaxanthin is often used in aviculture as a dietary additive together with other carotenoid pigments, in order to obtain the appropriate colour in fat and eggs (6). In addition, it is used in oral artificial suntanners for human consumption, as well as a food additive (3).

In previous papers we have described methods for the extraction and chromatographic separation of several carotenoids, as well as the patterns of intestinal absorption of lutein and helenene in chicken (4, 5). The aim of the present study is to investigate the absorption, digestibility and fate of the carotenoid canthaxanthin in growing chickens.

Materials and Methods

Male Hubbard chickens *(Gallus domesticus)*, 8-10 days old, were used throughout this study. The animals were fed for up to 24 days on a diet consisting of wheat and fish flours (1 : 1), which was virtually free from carotenoids (4). The birds had access to this diet plus water *ad libitum*. In addition, 2 or 6 mg of canthaxanthin were given orally every day. The pigment was administered in the form of aqueous emulsion in 5 ml water. At various times, five animals were separated, allowed to starve for 24 hours, and then sacrified. The following fractions were obtained from each chicken: Digestive tract, viscerae (kidneys, lungs, heart and liver), muscle, skin (from legs), skin (other), blood and faeces.

The different fractions were separately blended with acetone in a waring blender. Hexane and water then added up to a ratio acetone : hexane : water (5 : 2 : 3), in order to extract the carotenoids. The extracted pigments were separated on a thin layer of silica gel G, with ethyl ether : hexane (7 : 3), as solvent (5).

Canthaxanthin was identified by co-chromatography with reference samples (Roche), absorption spectra in the visible range and characterization of the sodium borohydride reduction products (1). Quantitative determination was achieved by measuring the absorbance in hexane at 475 nm, according to (2).

Analysis of the extracted pigments allowed an estimation of the amount of absorbed carotenoid (A). Pigment ingested daily (I) was 2 or 6 mg, as indicated above. Digestibility (D) was calculated as follows: $D = (A/d \times I) \times 100$, where d is the number of days after onset of treatment.

Experimental data represent mean values $\pm$ standard error of the estimated mean, for five independent experiments.

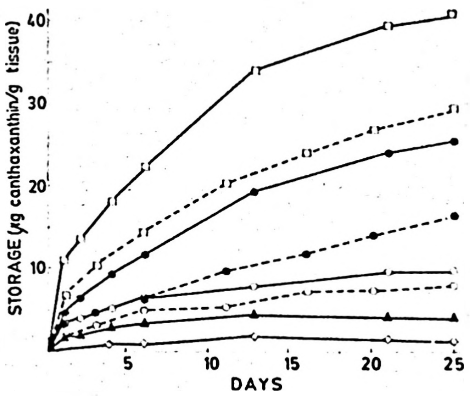

Fig. 1. *Canthaxanthin storage in various tissues during the treatment with 6 mg pigment/day (——) and 2 mg pigment/day (- - -).* (□) total; (●) skin (legs); (○) viscerae; (▲) skin (other); (◇) muscle. Points represent average values of 5 experiments. Skin (other) and muscle, do not present any diferences in both diets.

Results and Discussion

Experiments performed on untreated chickens revealed the absence of canthaxanthin in all fractions. However, small amounts of lutein, helenene, zeaxanthine, etcetera, were found as residues from the standard farm diet.

In the treated animals, these yellow pigments were found in the same trace amounts. In addition, only canthaxanthin was detected. On the other hand, the amount of absorbed plus excreted canthaxanthin represented nearly the total ingested carotenoid. The data support the idea that canthaxanthin is not chemically modified during the intestinal absorption, blood transport or storage. Most of the ingested pigment was excreted in faeces. The amount of canthaxanthin in the digestive tract could not be measured accurately, as varying amounts of the carotenoid adhered to the intestinal mucosa. The levels of canthaxanthin in blood remained essentially constant throughout the experiments, at 0.5 ± 0.05 µg/ml.

Figure 1 shows the storage of canthaxanthin in various tissues during the treatment with 6 mg and 2 mg pigment/day. Very similar results were found in both cases. The total amounts of pigment stored after the 24 days of treatment were respectively 41.3 ± 1.71 µg and 29.6 ± 0.27 µg per gram wet weight tissue in the 6 mg and 2 mg diets. Carotenoid was deposited in the different tissues very rapidly at the beginning of the treatment, and then at somewhat slower rate for the remainder of the experiment. Important differences were found in the storage levels of the different organs. The highest amount of pigment was stored in the skin of the legs, where the rate of deposit was characteristically high between days 6 and 13. In this period, the storage rate was much slower in the other organs under study.

The relative distribution of canthaxanthin in the various tissue fractions was independent of time and of the amount of administered carotenoid (table I). These indicate that the various tissues have different affinities for the pigment, which

Table I. *Distribution of canthaxanthin (%) in the different tissues for both pigment doses. Data correspond to the 1st and 24th days of treatment, as well as to the mean of 7 different days.*
Mean values ± S.E.M. of 5 independent experiments.

Tissue fraction	Mole (%)		
	1st day	24th day	Mean
		canthaxanthin (2 mg/day)	
Viscerae	30.5 ± 1.16	32.3 ± 2.13	31.1 ± 1.12
Muscle	5.9 ± 0.45	5.1 ± 0.15	5.1 ± 0.60
Skin (legs)	50.3 ± 1.50	47.9 ± 2.14	50.2 ± 1.50
Skin (other)	13.7 ± 0.59	14.7 ± 1.32	13.6 ± 0.59
		canthaxanthin (6 mg/day)	
Viscerae	28.4 ± 1.12	30.6 ±0.98	28.3 ± 1.57
Muscle	4.0 ± 0.62	4.8 ± 0.34	4.5 ± 0.36
Skin (legs)	52.3 ± 2.31	51.2 ± 1.98	53.1 ± 2.48
Skin (other)	15.3 ± 0.45	13.4 ± 0.93	14.1 ± 0.83

are inherent to them and cannot be modified by the diet.

The variation of canthaxanthin digestibility with time is shown in figure 2 for both pigment doses. The variation in animal body weight is also shown. At all times, digestibility for the 2 mg diet was about twice that for the 6 mg. In both cases, digestibility was maximal the first day, and then decreased gradually. This could mean that absorption levels decrease with the increase in stored pigment. From the 2nd week on, a slight increase in digestibility was observed, which could be attributed to the concomitant increase in animal body weight.

Digestibility was also calculated for the different tissue fractions. Figure 3 repre-

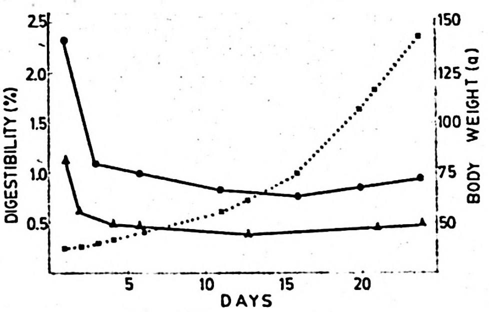

Fig. 2. *Variation of canthaxanthin digestibility (straigth line) during the treatment with 2 mg (●) and 6 mg (▲) pigment/day, and variation of chicken body weight (dotted line).* Points represent average values of 5 experiments.

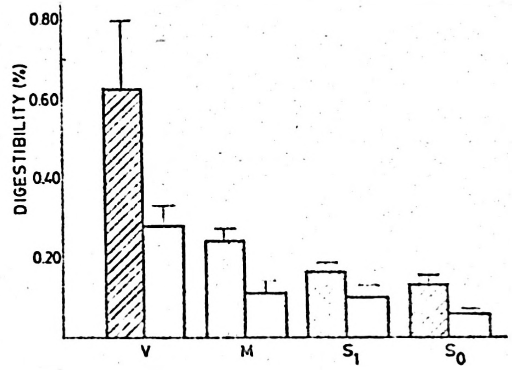

Fig. 3. *Average values of canthaxanthin digestibility in various tissue fractions during treatment with 6 mg (open bars) and 2 mg (filled bars) carotenoid/day.*
V, viscerae; M, muscle; Sl, skin (legs); So, skin (other). Bars denote mean values of 5 experiments and S.E.M.

sents the average canthaxanthin digestibility in the different tissue fractions, for both diets. It can be seen that, especially in the case of leg skin and other pigment-accumulating tissues, the digestibility was significantly higher (about twice) in the 2 mg than in the 6 mg diet.

The data presented here could be applied for optimal pigmentation in chickens. The results in figure 1 prove that by using higher doses of canthaxanthin, despite lower digestibility (fig. 2), the same storage levels are reached at much earlier stages, without affecting the pigment distribution (table I). Maximal pigmentation could then be achieved by administering small doses over a short period of time. Moreover, according to the data presented in figure 2, three independent factors appear to enhance digestibility. These are: low pigment doses, early stages of treatment and period of increase of body weight. A compromise has to be reached with respect to the carotenoid dose between digestibility and storage levels. It is apparent, then, that rapid and efficient pigmentation will be achieved by administering relatively high doses of canthaxanthin for short periods of time, when rapid weight gain is taking place.

Resumen

Se estudia en pollos Hubbard machos la absorción y almacenamiento de cantaxantina, para lo cual se alimentan con una dieta rica en dicho producto.

Se determina que la cantaxantina no se modifica químicamente durante su absorción o distribución. El almacenamiento del pigmento se realiza preferentemente en la piel de las patas y la distribución porcentual del carotenoide en los diferentes órganos no varía con la dosis administrada a lo largo del tratamiento.

Se comprueba también que la digestibilidad (cociente pigmento absorbido: pigmento ingerido) es máxima el primer día, luego decrece y depende en gran manera del peso del animal.

Acknowledgement

The authors are grateful to Prof. J. M. Macarulla for his helpful advice throughout this work.

References

1. ALONSO, A.: «Studies on orally administered artificial suntanners». M. Sc. Thesis, University of Bilbao (Spain), 1977.
2. DAVIES, B. H.: In «Chemistry and Biochemistry of Plant Pigments» (T. W. Goodwin, ed.). Academic Press, London, 1965, p. 489.
3. FAO-WHO: In «Evaluation of certain food additives». *Technical Report* n.° 557. World Health Organization Press. Geneva, 1974.
4. GÓMEZ, R., ALONSO, A. and MARTÍN, M.: *Rev esp. Fisiol.*, 34, 257-260, 1978.
5. GÓMEZ, R., GOÑI, F. M. and MACARULLA, J. M.: *Rev. esp. Fisiol.*, 34, 253-256, 1978.
6. MARUSICH, W. L. and BAUERNFEIND, J. C.: *J. Poultry Sci.*, 49, 1555-1557, 1970.