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Carcass yield, meat and fat color of yellow-spotted river turtles (*Podocnemis unifilis*) fed with *Mauritia flexuosa* fruit-based supplement

Rendimento de carcaça e coloração da carne e gordura de tracajá (*Podocnemis unifilis*) alimentados com suplemento à base de buriti (*Mauritia flexuosa*)

Rendimiento de la canal, color de la carne y la grasa de tortugas de río de manchas amarillas (Podocnemis unifilis) alimentadas con suplemento a base de fruta Mauritia flexuosa

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ABSTRACT
One way to increase the profitability of turtle farming is to provide even more differentiated products, for example, by adding value to the products and making them healthier for consumers. Moreover, *M. flexuosa* can be used as an alternative food for the incorporation of beneficial properties into products derived from animals that feed on this fruit. The present study aimed to evaluate the carcass yield, chemical composition, and meat and fat color of reproductive age yellow-spotted river turtle (*Podocnemis unifilis*) fed different levels of *M. flexuosa* fruit-based supplements for 30 and 50 days. Supplementation for a period of up to 50 days did not affect the carcass yield of the animals, and supplementation caused changes in the coloration patterns of the meat and fat of the animals after 30 days of supplementation.

Keywords: chelonia, animal farming, aquaculture, chelonian farming.

RESUMO
Uma das maneiras de tornar a quelonicultura mais lucrativa é fazer com que ela forneça produtos ainda mais diferenciados, por exemplo por meio de agregação de valor aos produtos tornando-os mais saudáveis aos consumidores. E o buriti pode ser utilizado como um alimento alternativo para a incorporação de propriedades benéficas aos produtos oriundos de animais que se alimentam deste fruto. Este estudo objetivou avaliar o rendimento de carcaça, composição química e coloração da carne e gordura de tracajás (*Podocnemis unifilis*), em idade reprodutiva, alimentados com os diferentes níveis de suplementação à base de buriti, durante 30 e 50 dias. Observou-se que a suplementação durante um período de até 50 dias não causou prejuízo ao rendimento de carcaça dos

animais e que a suplementação causou alterações nos padrões de coloração da carne e gordura dos animais a partir de 30 dias de suplementação.

Palavras-chave: quelônio, produção animal, aquicultura, quelonicultura.

RESUMEN

Una forma de incrementar la rentabilidad de la cría de tortugas es ofrecer productos aún más diferenciados, por ejemplo, agregando valor a los productos y haciéndolos más saludables para los consumidores. Además, M. flexuosa puede utilizarse como un alimento alternativo para la incorporación de propiedades beneficiosas en productos derivados de animales que se alimentan de este fruto. El presente estudio tuvo como objetivo evaluar el rendimiento en canal, la composición química y el color de la carne y la grasa de tortugas de río de manchas amarillas (Podocnemis unifilis) en edad reproductiva alimentadas con diferentes niveles de suplementos a base de fruta de M. flexuosa durante 30 y 50 días. La suplementación por un período de hasta 50 días no afectó el rendimiento en canal de los animales, y la suplementación provocó cambios en los patrones de coloración de la carne y la grasa de los animales después de 30 días de suplementación.

Palabras clave: quelonia, cría de animales, acuicultura, cría de quelonios.

1 INTRODUCTION

Yellow-spotted river turtle (*Podocnemis unifilis*) is a semiaquatic turtle distributed throughout the Amazon basin that is widely used for food consumption (Andrade, 2008). Free-roaming birds produce an average of 29 eggs per posture (Terán *et al.,* 1995), and the minimum commercial weight of these animals is 1 kg live weight (BRASIL, 2008).

The International Union for Conservation of Nature (IUCN) and Conservation on International Trade in Endangered Species of Wild Fauna and Flora (CITIES) were included in the list of animals vulnerable to extinction. This species is in good condition for breeding in captivity, easily adapting to the conditions imposed in breeding management, in addition to being well accepted by consumers (Pezzuti *et al.,* 2008).

The commercial production of *P. unifilis* in captivity can be used as an alternative to reduce trafficking, a source of income for communities, and for the

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preservation of cultural identity since consuming this species is part of Amazonian culture. However, this cultural habit is threatened by legal restrictions on the use of this natural resource, which are aimed at its protection.

Although IN 07/2015 regulates the commercial rearing of yellow-spotted river turtle, there is little information in this document or in the current literature that may serve as a subsidy for the implementation of a production unit of legalized chelonians for zootechnical rearing in Brazil, the loggerhead turtle. Giant amazonian river turtle (*Podocnemis expansa*), yellow-spotted river turtle (*Podocnemis unifilis*), Pitiú (*Podocnemis sextuberculata*) and scorpion mud tutle (*Kinosternon scorpioides*) (BRAZIL, 2008). Among the species with the greatest advances, we can mention the Amazonian turtle (Sá *et al.,* 2004; Andrade *et al.,* 2008; Almeida; Abe, 2009) and the muçuã (Araújo *et al.,* 2013a; Araújo *et al.,* 2013a; Araújo *et al.,* 2013b), which already have some established zootechnical indices.

One way to increase the profitability of turtle farming is by providing even more differentiated products, for example, by adding value to the products and making them healthier for consumers.

Currently, the demand for functional foods for human consumption has been increasing due to the increasing demands of consumers regarding the properties of the products consumed. One way to produce healthier food is by changing the diet of animals to generate foods such as meat.

The *M. flexuosa* plant is a palm tree easily found in the Amazon region. The pulp of its *M. flexuosa* fruit contains considerable amounts of carotenoids, polyphenols and ascorbic acid and can be used in the prevention of numerous diseases caused by oxidative stress. Its lipid fraction is composed basically of tocopherol and oils, with a predominance of oleic, palmitic and omega-9 fatty acids, which help in the prevention of cardiovascular diseases (COSTA *et al.,* 2011). In addition, large amounts of sulfur-containing amino acids and the tryptophan precursor of niacin are present. Because of these properties, *M. flexuosa* can be used as an alternative food for the incorporation of beneficial properties into products derived from animals that feed on this fruit (Rodriguez-Amaya, 2008).

In addition to the abovementioned properties, the pulp can be easily preserved by freezing, and after one year of freezing, the pulp will continue to have the same color, consistency and flavor (Almeida; Silva, 1994), facilitating its handling and use.

The present study aimed to evaluate the carcass yield, chemical composition, and meat and fat color of reproductive age yellow-spotted river turtle (*Podocnemis unifilis*), fed different levels of *M. flexuosa* fruit-based supplements for 30 and 50 days.

2 MATERIALS AND METHODS

2.1 AUTHORIZATION

The present study complies with the rules for the use of animals in experiments and was approved by the Ethics Committee on the Use of Animals in Experiments of Embrapa Amapá (CEUA/Embrapa-Amapá) protocol 020-CEUA/CPAFAP and registered in the National Management System of the Genetic Heritage and Associated Traditional Knowledge under the number A856EA9.

2.2 ANIMALS AND ENVIRONMENT

Thirty-six females of the species *Podocnemis unifilis* belonging to the Embrapa Amapá herd with a mean age of 9 years were selected according to weight and health status individually and identified; the mean initial weight was 5,174 kg (± 570), and the minimum slaughter weight was determined by legislation (BRASIL, 2015). The animals were housed in masonry tanks with 40% dry area and 60% wet area.

2.3 EXPERIMENTAL DESIGN AND DURATION

The experiment was conducted for 50 days, preceded by an acclimatization period of 10 days. A completely randomized experimental design was used, with three treatments, 0% (S0), 15% (S15) and 30% (S30), and three replicates each, totaling 9 experimental units, with 4 animals per experimental unit.

2.4 SUPPLEMENT

It was performed some modifications after pretests using artisanal pelletizing so that the results could be positively replicated by rural producers (Santos *et al.,* 2011).

With the selected fruits, the epicarp was split in half, exposing the stone, which was discarded, while the peel and pulp were dehydrated in an oven at 60°C for 72 h. With the dry raw material, the plant was taken to the feed factory for milling. After this step, the fibers and, in part, the flour were obtained. This byproduct was sieved until *Mauritia flexuosa* flour was obtained. Subsequently, the flour obtained during processing was mixed with water at 60°C and pelletized in an electric meat grinder. The pellets were then dried in a forced circulation oven at 60°C for 72 h. After cooling, the samples were bagged and stored in a dry environment.

2.5 FOOD MANAGEMENT

The animals were fed a supplement based on the buriti fruit (*Mauritia flexuosa*) in pellet form, which was supplied daily according to the established treatments, namely, S0: 0% supplement; S15: 15% supplement; and S30: 30% supplement, relative to the calculated amount of feed.

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The supplement was supplied at 10 am, and after 1 h, extruded commercial fish feed containing 28% crude protein (CP) was provided at a proportion of 0.5% of the live weight per day (LW/day) for seven days per week.

2.6 CARCASS YIELD

After 30 and 50 days of feeding the animals the supplement, three animals from each treatment were euthanized for evaluation of carcass yield parameters. Euthanasia was performed according to the procedures of CFMV Resolution No. 1.000/2012.

The animals were placed in a container containing a proportion of water and ice at a temperature of 0 to -2°C for stunning until the animal was completely stunned, which was verified by means of the animal's motor and ocular reflexes. Subsequently, bleeding occurred for 15 minutes. Then, the sections of the spinal cord were cut. With subsequent removal of the plastron, the viscera, carcass with bone and extramuscular fat were removed according to the methodologies of (GASPAR *et al.,* 2005).

For the analyses, the following variables were measured: total weight of the animal, total weight after slaughter and bleeding, total carcass weight, weight of extramuscular fat, carapace weight, plastron weight, and visceral weight.

The carcass yield parameters were calculated from the measured values:

- Carcass yield (CY)= (carapace weight + plastron weight)*100)/total weight;
- Yield after bleeding (YAB) = (weight after bleeding × 100)/total weight;
- Fat yield (FY) = (fat weight × 100)/total weight
- Bone-in carcass yield (BCY) = (weight of the bone-in carcass × 100)/total weight
- Visceral yield (VY) = (visceral weight × 100)/total weight

2.7 ANALYSIS OF MEAT AND FAT COLOR

Samples of meat from the limbs, loins and fat of animals slaughtered after 50 days of feeding were removed from the carcasses of the slaughtered animals. The meat samples from the limbs and loin were mixed and ground in processor. The color of the ground meat sample and fat were evaluated to determine the influence of different supplementation levels (0%, 15% and 30%) on its color. The color analysis was performed using a Konica Minolta Chroma Meter CR-400 (Japan) in the CIELab* system, which is the most widely used due to the uniform distribution of colors and is perceptually uniform; i.e., the Euclidean distance between two colors corresponds approximately to the color difference perceived by the human eye (LEÓN *et al.,* 2006).

An illuminant D65 and an observer angle of 10° were used, with 10 readings of each sample. The reading system used was the CIELAB color space (L*a*b*), represented by the following color intensity parameters: L* (luminosity or clarity), a* (green–red intensity components) and b* (blue–yellow intensity components) obtained directly from the colorimeter and used to calculate the chromatic tone (h*=arctan b*/a*). For h*, 0 represents pure red, 90 represents pure yellow, 180 represents pure green, and 265 represents pure blue (Mcguire, 1992).

The color difference (ΔE) was used to indicate the distance in the uniform color space (Brainard; Stockman, 2010) via the following formula:

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}. \qquad (1)$$

where:

ΔE^* is the difference between the corresponding coordinates of two samples
ΔL^* is the difference between the L* coordinates of the samples
Δa^* is the difference between the a* coordinates of the samples
Δb^* is the difference between the b* coordinates of the samples

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To distinguish between the colors of different samples, in a more specific classification, $1.5 < \Delta E < 3.0$ was considered distinguishable, and $\Delta E < 1.5$ was considered to indicate a small difference (Drlange, 1999; Patras; Tiwari; Brunton, 2011).

2.8 ANALYSIS OF BROMATOLOGICAL COMPOSITION

To characterize the feed and *M. flexuosa*-based supplements used during the experiment, the samples were ground and dried in an oven with air circulation at 105°C until constant weight was reached, according to the IAL method (2008). In addition, the total crude protein (TPB) concentration was determined using the Kjeldahl method. The crude protein content was calculated by multiplying the total nitrogen by a factor of 5.46 (%N × 5.46) (IAL, 2008; Souza; Nogueira, 2005); Ether extract (EE): determined in a Soxhlet apparatus with petroleum ether under reflux for 4 hours (Silva; Queiroz, 2002; Souza; Nogueira, 2005); Ash (CNZ): determined gravimetrically in a muffle furnace at 105°C/4 h (IAL, 2008; Souza; Nogueira, 2005); Phosphorus (P): determined by complexation of phosphorus with ammonium vanado molybdate and determination by spectrophotometry in the visible region, according to IAL methodology (2008); and calcium (Ca): determined by complexometric titration with EDTA, according to IAL methodology (2008).

2.9 STATISTICAL ANALYSIS

The results were subjected to analysis of variance, and in the case of significant differences, they were compared by Tukey's test at 5% probability (ZAR, 1999).

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3 RESULTS AND DISCUSSION

The results of the chemical composition analysis of the feed and supplement used in the experiment can be found in Table 1. It was observed that the artisanal pelletizing of the supplement provided a satisfactory decrease in moisture, 98.07% of dry matter, similar to that of commercial feed. An important characteristic for the preservation of the supplement over time.

Table 1. Chemical composition of the feed and supplement supplied to *P. unifilis* specimens during the experimental period

Composition (%)	Commercial feed*	Supplement
Dry matter	97,61 ± 0,25	98,07 ± 0,28
Crude protein	28,01 ± 0,87	3,67 ± 0,25
Ether extract	2,66 ± 0,39	1,35 ± 0,04
Minerals	14,46 ± 0,16	2,69 ± 0,20
Calcium	2,16 ± 0,09	0,09 ± 0,02
Phosphorus	0,98 ± 0,02	0,04 ±0,00

*Commercial feed containing 28% crude protein.
Source: Authors

The mean values of the carcass yield parameters measured for *P. unifilis* fed supplemented diets containing the fruit of *M. flexuosa* are shown in Table 2. It was possible to verify that there was no significant difference between the different treatments and different durations of supplementation. in relation to the parameters of carcass yield, demonstrating that supplementation with *M. flexuosa* fruit for *up to* 50 days does not affect the carcass yield of adult female *P. unifilis*.

Table 2. Mean values of carcass yield of *Podocnemis unifilis* fed with different levels of *Mauritia flexuosa*-based supplements for 30 and 50 days

Treatments	**Time (Days)**	**CY (%)**	**YAB (%)**	**FY (%)**	**BCY (%)**	**VY (%)**
0%	30	41,29a	97,51a	6,45a	33,42a	14,20a
	50	44,59a	96,63a	2,27a	31,55a	12,30
15%	30	41,60a	96,80a	5,72a	30,32a	15,01a
	50	42,28a	97,17a	3,74a	31,66a	14,49a
30%	30	40,03a	96,95a	3,75a	30,04a	17,28a
	50	43,49a	91,95a	4,22a	31,04a	13,95a

CY: Carcass yield; YAB: Yield after bleeding; FY: Fat yield; BCY: Bone-in carcass yield; VY: Visceral yield.
Source: Authors

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Different lowercase letters indicate significant differences between treatments according to the Tukey test ($p<0.05$). Source: Authors

Regarding the color of the products (meat and fat), it was possible to verify that the color coordinates of the ground meat at 30 days of supplementation (Table 3) indicated that the luminosity L*, representative of the luminosity between black (0) and white (100), decreased significantly when the *Mauritia flexuosa* concentration increased to 15% in the food supplement, becoming a darker color but returning to values similar to those of the control (T0) when 30% supplementation was offered.

Table 3. CIELab* coordinates of ground meat and *P. unifilis* fat-fed with *M. flexuosa* supplement at different concentrations (0%, 15% and 30%) for 30 and 50 days

Coordinate	Period	Ground meat			Fat		
		T0	T15	T30	T0	T15	T30
L*	30	32,48 ± 0,34 a	27,99 ± 0,85 b	31,90 ± 1,49 a	50,96 ± 0,62 a	51,26 ± 1,23 a	54,58 ± 0,89 b
	50	32,06 ± 1,25 a	31,06 ± 0,82 b	29,19 ± 0,52 c	54,83 ± 1,62 a	54,35 ± 2,23 a	58,74 ± 1,89 b
a*	30	14,73 ± 0,80 a	16,66 ± 0,95 b	20,38 ± 0,91 c	17,52 ± 0,98 a	18,26 ± 1,59 a	19,57 ± 0,54 a
	50	16,15 ± 0,64 a	16,65 ± 1,05 a	16,27 ± 0,50 a	18,29 ± 1,54 a	19,14 ± 2,63 a	15,91 ± 1,51 b
b*	30	4,41 ± 0,74 a	5,01 ± 0,59 b	8,36 ± 0,77 c	13,25 ± 1,01 a	17,69 ± 0,72 b	18,28 ± 0,53 b
	50	2,969 ± 0,46 a	3,407 ± 0,25 b	3,934 ± 0,45 c	15,17 ± 2,16 ab	14,43 ± 0,90 a	16,01 ± 2,05 b
C*	30	15,45 ± 0,96 a	17,56 ± 0,94 b	22,10 ± 1,11 c	23,80 ± 0,66 a	22,64± 1,25 a	20,85 ± 0,53 b
	50	16,44 ± 0,70 a	16,97 ± 1,03 a	16,76 ± 0,57 a	24,40 ± 1,77 a	23,71 ± 2,18 a	22,99 ± 1,26 a
h*	30	15,02 ± 1,89 a	16,43 ± 1,61 b	21,30 ± 1,44 c	36,41 ± 1,50 a	38,23 ± 1,84 a	40,53 ± 1,56 b
	50	10,22 ± 1,22 a	11,69 ± 0,61 b	13,37 ± 1,22 c	37,35 ± 2,61 a	36,44 ± 2,53 a	46,13 ± 4,61 b

Different lowercase letters indicate significant differences between treatments according to the Tukey test ($p<0.05$).
Source: Authors

The values observed in the a* coordinate in the ground beef treatments were positive and differed significantly according to the supplementation percentage, indicating that the color of the ground meat tended to increase when there was an increase in *Mauritia flexuosa* supplementation in the diet. The b* coordinate also showed increasing and significant differentiation between treatments with increasing supplementation rates, indicating a trend of these samples toward a yellow color.

By definition, Chroma C* is the coloration of an object judged in comparison to the brightness of a white object under the same conditions (Ohta; Robertson, 2006). It is also recognized simply as the intensity of color (Rawson *et al.,* 2011), indicating its degree of saturation (Jiménez-Aguilar *et al.,* 2011); when the chroma value decreases, the color becomes less intense. By transforming itself from a vivid state into a gloomy one (Patras; Tiwari; Brunton, 2011). Regarding the C* of the ground beef, the increase in the percentage of supplement supplied to the animals for 30 days directly influenced the color intensity, making it more vivid.

The hue shade angle (h0) is the attribute that represents the perceived color (Jiménez-Aguilar *et al.,* 2011), starting on the +a* axis with the value 0 (red) and +b* with the value 90 (yellow); the –a* axis is the value 180 (green); and the –b* axis is the value 270 (blue) (Konika Minolta, [nd]). It is an angle of hue. The h0 value of ground beef from animals fed for 30 days in the respective treatments increased with increasing feed supplementation, revealing a significantly different perception of color nuance.

The fat of *P. unifilis* supplemented for 30 days showed L*, C* and h0 coordinates with significantly different values in the treatment with 30% supplementation compared to the other treatments (Table 3). The b* coordinate of the 30% treatment differed only from that of the 0% supplementation, and the a* coordinate did not differ from that of the other supplementation levels. Regarding the L* coordinate, the 30% treatment presented more luminous and lighter fat than the 0% and 15% treatments. The 15% and 30% treatments presented a more yellowish tone (b*) than the 0% treatment. For Chroma C*, the 30% treatment differed in terms of the intensity of the fat color and in the perception of the nuance of the colors of the fats (h0 angle), which became more evident in relation to the others.

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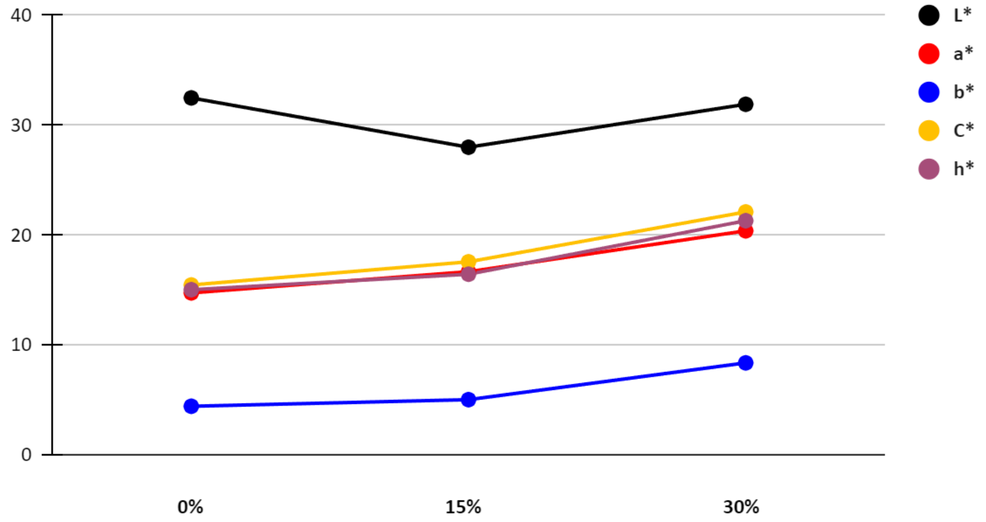
After 50 days of supplementation, the color coordinates of the ground beef plants (Table 3) of *P. uniflis* showed that the luminosity L*, which is representative of the luminosity between black (0) and white (100), decreased significantly when the availability of food supplements increased, resulting in a darker color. Meat from animals that were supplemented for 50 days showed an increasing and significant differentiation of the b* coordinate between treatments with increasing supplementation rates, indicating a trend of these samples toward a yellow color as the amount of supplement available increased. Regarding the C* coordinate of the ground beef, the increase in *M. flexuosa* supplementation during the 50 days of intake did not affect the color intensity, which remained obvious in all the treatments. The a* coordinate in the CIELab* system observed in the ground beef treatments was positive, with no significant difference as the supplementation level increased.

Figure 1 shows that among the color coordinates of the ground *P. unifilis* meat evaluated at 30 days, those most affected by increasing the concentration of *M. flexuosa* supplementation by 30% were a*, C* and the angle h ^{0}, which indicated more reddish meat with a more intense and evident color, allowing a greater perception of the colors in relation to the other treatments.

Figure 1. L*a*b*C*h ^{0} coordinates of ground *P. unifilis* meat subjected to different levels of supplementation for 30 days.



Source: Authors

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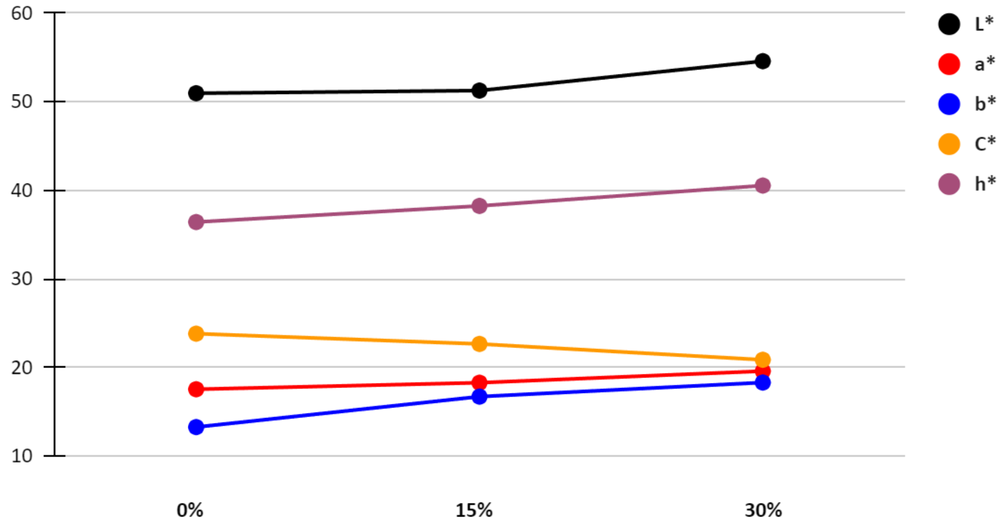
According to Figure 2, the color coordinates of the fat fraction, which were most influenced by the increase in the *M. flexuosa* based supplementation content at 30 days, were L* and b*, providing more luminous and clear fat, with more intense yellowing.

Figure 2. L*a*b*C*h 0 coordinates of fat from P. unifilis subjected to different levels of supplementation for 30 days.



Source: Authors

The coordinates of the fat fraction of yellow-spotted river turtle after 50 days of supplementation (Table 3) showed L*, a* and h ^{0} coordinates with significantly different values for the treatment with 30% supplementation compared to the others. The b* coordinate of fat in the treatment with 30% supplementation differed only from that in the treatment with 15% supplementation.

In the meat of animals supplemented for 50 days, the h0 value of the ground meat in the respective treatments increased with increasing feed supplementation, revealing a significantly different perception of the nuance of the meat colors (Figure 3).

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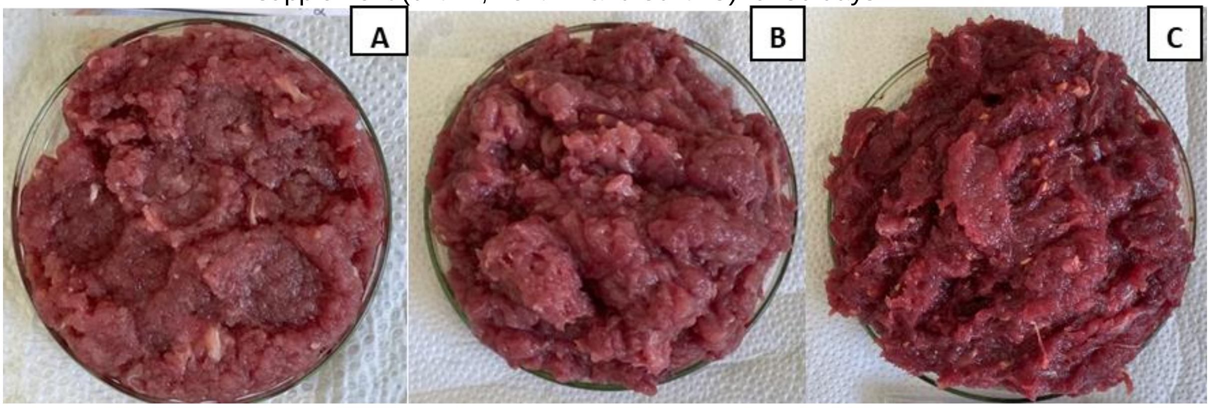
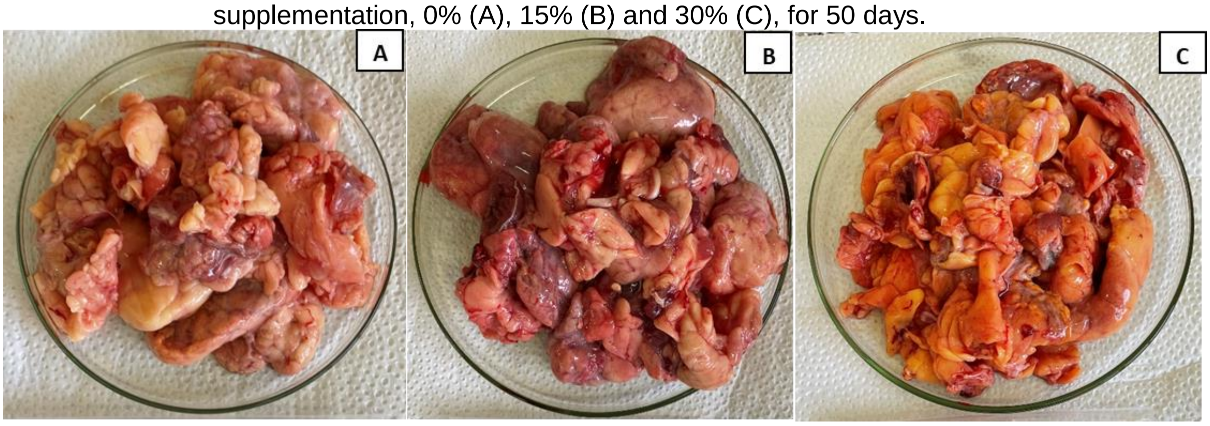
Figure 3. Staining of ground beef from *P unifilis* fed with different proportions of *M. flexuosa* supplement (0%: A; 15%: B and 30%: C) for 50 days.



Source: Authors

Regarding the L* coordinate, animals supplemented with 30% L had more luminous and reddish fat (a*) than did the 0% and 15% L* treatments. For Chroma C*, the treatments did not significantly differ in color intensity, but the difference in color intensity (at an angle of 0) was more evident in the fat of the 30% supplementation treatment group than in that of the other groups (Figure 4).).

Figure 4. Fat staining of *P. unifilis* specimens fed with different concentrations of supplementation, 0% (A), 15% (B) and 30% (C), for 50 days.



Source: Authors

Figure 5 shows that among the color coordinates of the ground *P. unifilis* meat evaluated after 50 days of supplementation, the L*, b* and h angle were the most affected by an increase in the *M. flexuosa* supplementation concentration of 30%. ^{0} indicates more luminous meat with more yellowish nuances, allowing a greater perception of colors in relation to the other treatments.

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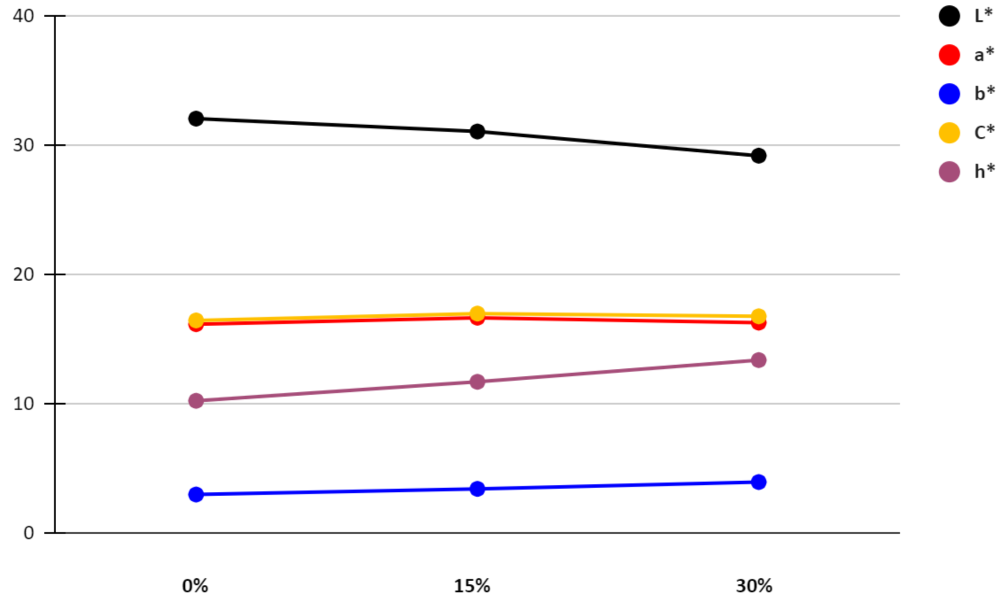
Figure 5. L*a*b*C*h ^{0} coordinates of *P. unifilis* ground beef fed with different amounts of *M. flexuosa* supplement (0%, 15% and 30%) for 50 days.



Source: Authors

Figure 6 shows that the color coordinates most affected after 50 days of *M. flexuosa* supplementation in the fat of the animals were the h0, L*, a* and b* angles. A 30% supplement strongly influenced the ability to perceive the colors (h ^{0}) of the fats, their luminosity and clarity, as they had more yellowish and reddish tones than did the other treatments.

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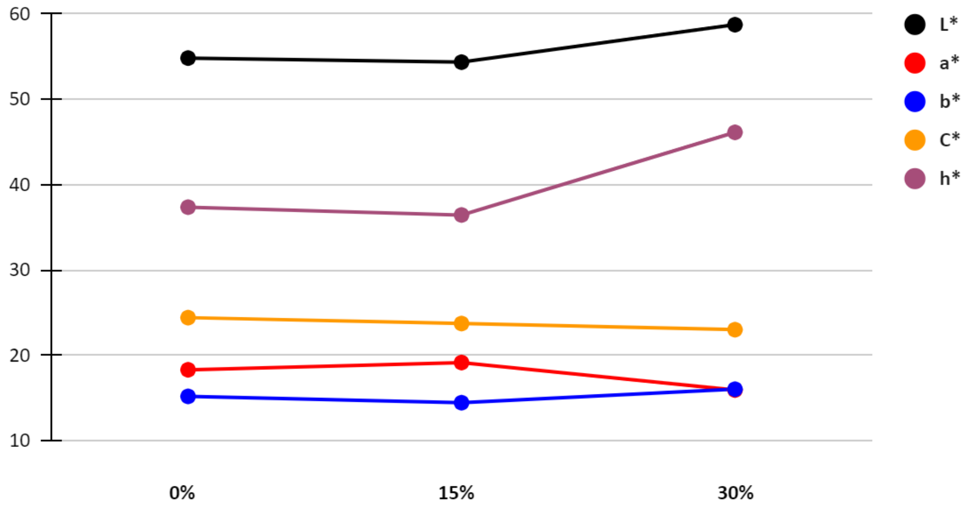
Figure 6. L*a*b*C*h 0 coordinates of *P. unifilis* fat fed with different amounts of *M. flexuosa* supplement (0%, 15% and 30%) for 50 days.



Source: Authors

The difference in color (ΔE) between samples is a very useful tool for evaluating the ability of the human eye to distinguish this difference when trained panellists are not used in sensory analysis (Golasz; Silva; Silva, 2013). ΔE* can also be used as a quality parameter to evaluate the impact of raw material transformation processes on the color of the final product.

Regarding the difference in color perception (ΔE) between *M. flexuosa* supplementation treatments after 30 days of supplementation, it was observed that, compared with that in ground beef, there was a change in color in the ground beef of the animals subjected to 15% supplementation. Animals that did not ingest the supplement. This difference can be perceived by the human eye because it is within the range of distinction (1.5 < ΔE < 3.0), and when the supplementation concentration was increased to 30%, the difference in color was easily noticeable when the human eye was present (ΔE >3.0) (Figure 7).

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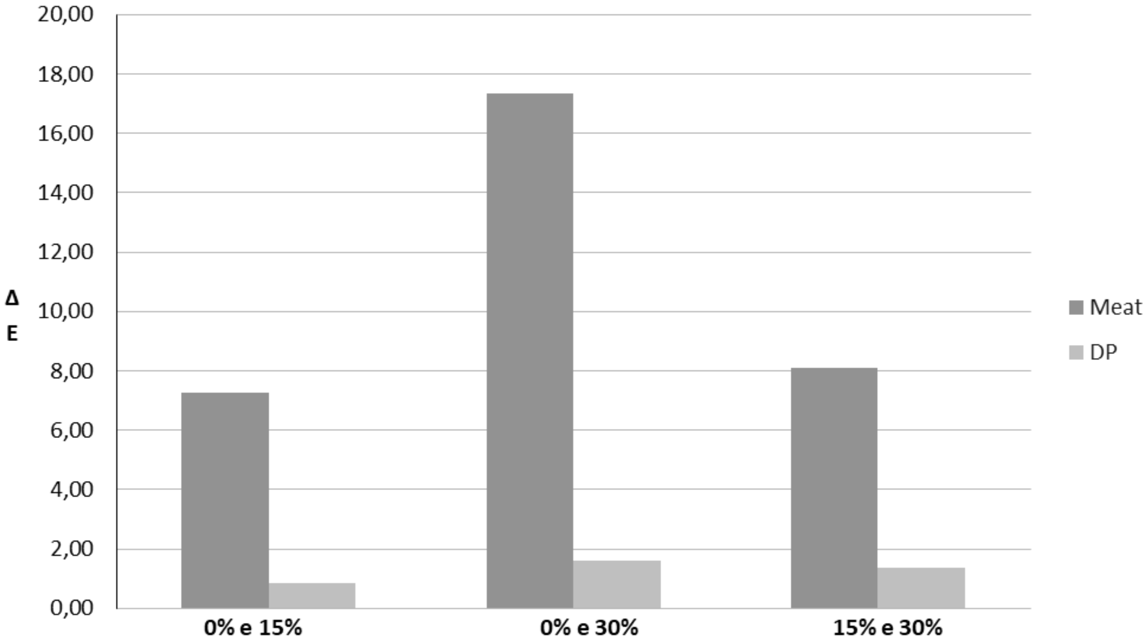
Figure 7. Color difference (ΔE) perceived between *P. unifilis* ground meat fed with different levels of *P. unifilis* supplementation with *M. flexuosa* for 30 days.



Source: Authors

Regarding fat content, the 15% supplementation group showed the smallest difference in color compared to the treatment without supplementation group (0%), right at the threshold of perception of differentiation of the human eye (1.5 < ΔE < 3). 0). However, treatment with 30% supplementation resulted in a greater difference in color (ΔE>3.0) than did 0% or 15% supplementation, which could be easily perceived by the consumer's eye (Figure 8).

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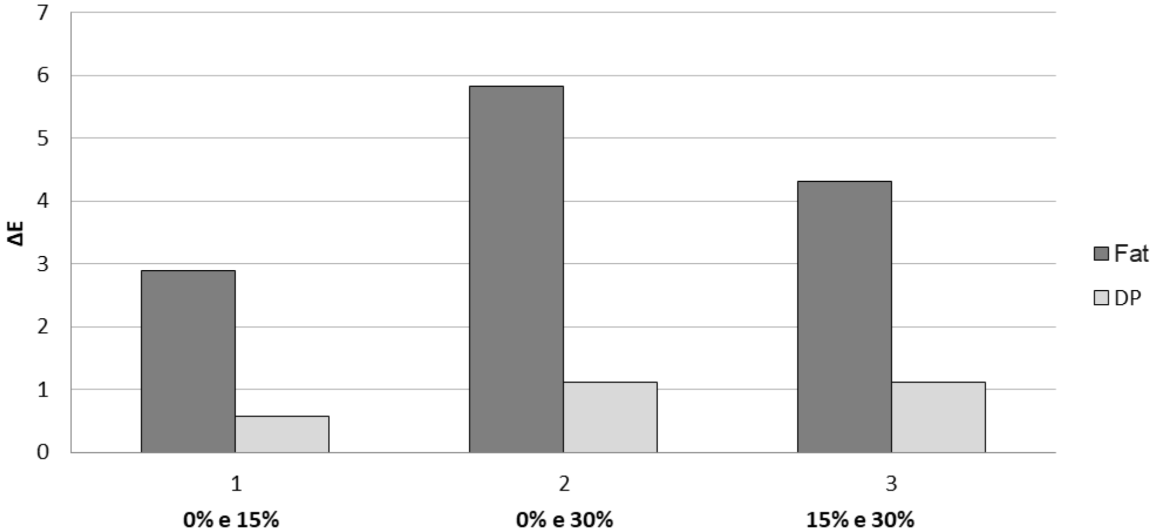
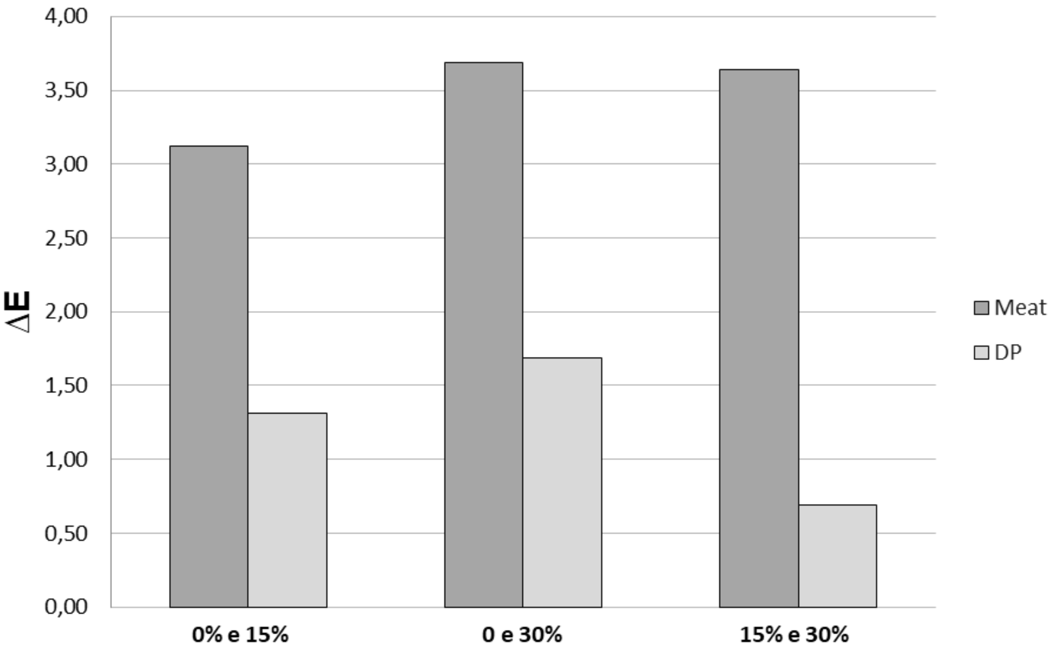
Figure 8. Perceived color difference (ΔE) between fat from *P. unifilis* fed to different levels of supplementation for 30 days.



Source: Authors

After 50 days of supplementation, the perception of color difference (ΔE) in the ground beef between treatments was within the distinguishable range (1.5 < ΔE < 3.0) but was difficult to distinguish via the eye of the consumer (Figure 9).

Figure 9. Color difference (ΔE) perceived between ground beef of *P. unifilis* subjected to different levels of *M. flexuosa* supplementation for 50 days.



Source: Authors

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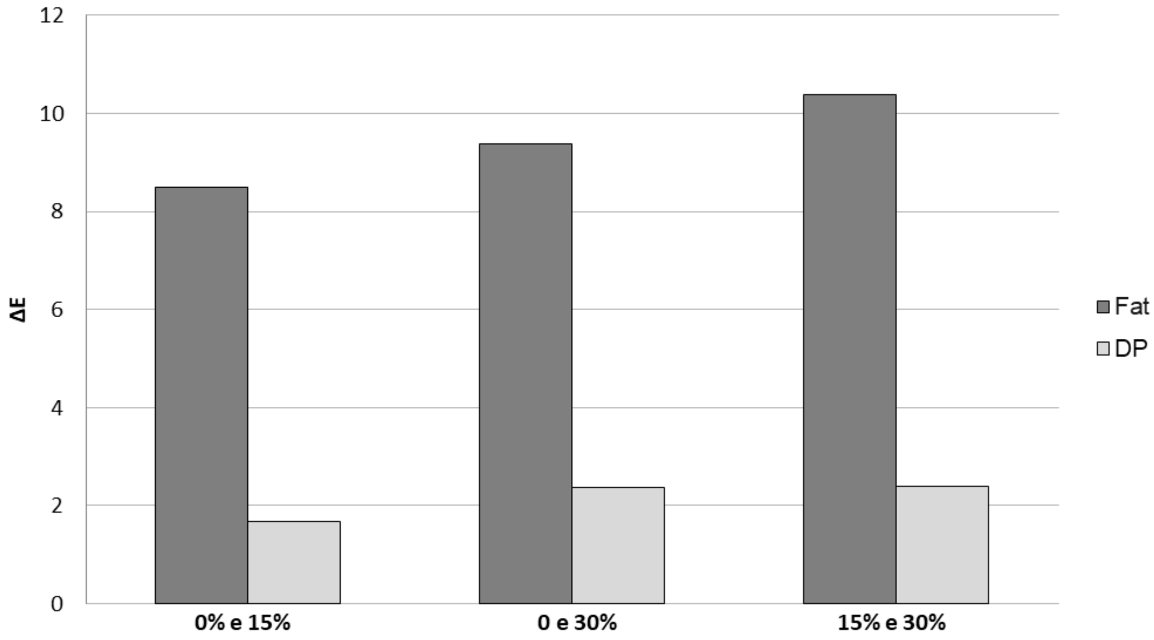
On the other hand, after 50 days of feeding, the perception of the color difference (ΔE) between the fat from animals fed the different levels of supplementation based on *M. flexuosa* presented within the range of the distinguishable (1.5 < ΔE < 3.0), with the consumer easily perceiving the difference in fat color of animals fed 15% and 30% supplementary feed (Figure 10).

Figure 10. Color difference (ΔE) perceived among the fats of *P. unifilis* fed with different levels of supplementation for 50 days.



Source: Authors

4 CONCLUSION

Therefore, it was possible to verify that the feed supplementation of adult female *Podocnemis unifilis* with a supplement based on the fruits of *Mauritia flexuosa* for a period of up to 50 days did not affect the carcass yield of the animals and that the supplementation caused changes in the pattern of coloration of the meat and fat of the animals after 30 days of supplementation, which was perceptible to the human eye.

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