

Composition of broilers meat

J. de Oliveira,¹ S. V. Avanço, M. Garcia-Neto, and E. H. G. Ponsano

Faculty of Veterinary Medicine. Unesp Univ Estadual Paulista, 793 Clóvis Pestana,
Araçatuba – SP, 16050-680, Brazil

Primary Audience: Chicken Scientists, Chicken Producers, Nutritionists, Veterinarians, Researchers

SUMMARY

Brazil stands out in the ranking of broiler chicken production, holding the positions of the world's largest exporter and the third largest producer, scores that demand continuous attention to market requirements with regard to product quality, including the search for alternative sources of feed ingredients. This research's goal was to examine the effects of using *Rubrivivax gelatinosus* biomass in the feed of broilers on proximate composition, cholesterol content, and fatty acid profile of the meat cuts. Two hundred Cobb 500 male chicks were randomly assigned to one of the 4 dietary treatments containing zero, one, 2 or 3 g of dried *R. gelatinosus* biomass per kg of the finisher ration. At the end of the experiment, 20 birds from each treatment were slaughtered and their carcasses were cut into breast and thigh for the analyses of proximate composition, cholesterol, and fatty acids, all performed by standard methodologies. Data were analyzed by ANOVA and t test for the multiple comparisons of means using 5% of significance. Proximate composition and cholesterol concentration in both breast and thigh meats did not differ among treatments ($P > 0.05$). The biomass at 3 g/kg in the diet increased EPA in breast but decreased it in thigh. Nevertheless, no concentration of the biomass altered the ratio n-6/n-3 in either cut. Thus, the use of *R. gelatinosus* biomass at 3 g/kg in broilers' rations was shown to be harmless or even beneficial to broiler meat composition.

Key words: fatty acids, cholesterol, food composition, *Rubrivivax gelatinosus*

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DESCRIPTION OF PROBLEM

Aviculture is the most dynamic sector of Brazilian commercial meat production. During the last decades, broiler meat production has been receiving good scores in domestic and foreign market rankings, with expressive evolution in quality and quantity. Currently, Brazil stands out as the first world exporter and the third world producer of broiler meat. In 2013, 12.3 million tons of broiler meat were produced, from which 68% was distributed in the internal market and

the remaining 32% was directed for exportation, generating a currency income of 7.7 billion dollars for the country [1, 2].

As a consequence of such supply at a low cost and good quality, Brazilian consumers have been changing their meat consumption habits, going from beef to broiler. In 2013, for example, the broiler meat consumption was 42 kg per capita [1–3].

More than providing energy, the lipids in broiler meat also play a role in the acceptance of the product due to the influence on sensory properties like texture, color, and flavor [4]. However, the presence of lipids in food,

¹Corresponding author: josiecarlim@yahoo.com.br

especially cholesterol and saturated fatty acids (SFA), is often associated with the risk of cardiovascular diseases [5].

According to the Food and Agriculture Organization of the United Nations [6], the substitution of SFA for polyunsaturated fatty acids (PUFA) in humans' food may decrease the cholesterol content in the blood. Moreover, the consumption of unsaturated fats is associated with beneficial effects for the cardiovascular system, unlike saturated fats [7]. So, distinct sources of lipids in broilers diets have been used as a way of modifying the lipid profile of the meat [8].

The photoheterotrophic cultivation of *Rubrivivax gelatinosus* in food industry effluents causes depollution and raises a biomass containing proteins with essential amino acids, lipids, minerals, and carotenoids [9]. More than an option for the biological treatment of wastewaters, the bacterial activity yields a product that can be used as an ingredient in poultry and fish feeding and so improve the quality of the final food products [10].

The objective of this work was to evaluate the effects of using *Rubrivivax gelatinosus* biomass in broiler diets on the quality of the meat regarding proximate composition, cholesterol content, and fatty acids profile.

MATERIALS AND METHODS

The experiment was carried out at the Faculty of Veterinary Medicine - UNESP in Araçatuba/SP, Brazil, from June to July 2011. All the procedures used in the study herein were conducted in accordance with the guidelines for experiments with animals in Brazil [11].

One-day-old Cobb broilers (200) were reared for 45 d in floor wood shaving pens (1.5 × 3 m) equipped with drinkers and feeders inside a broiler house (7.85 × 45.7 m) equipped with an adiabatic evaporative cooling system. Birds were assigned to 4 dietary treatments with 5 pens/treatment and 10 birds/pen, according to a completely randomized design. Light heating (250W incandescent lamps) was provided during the first 15 d of rearing. The birds had free access to water and food during the trial.

During the starter (one to 21 d) and growing (22 to 35 d) phases, all birds received broiler diets formulated according to the nutritional requirements (Table 1) [12, **PPFR** <http://sites.google.com/site/ppfrprogramforfeedformulation/>]. The experimental diets were offered during the finishing phase (36 to 45 d) and consisted of the formulated diets supplemented with dried biomass at zero g/kg (T1, control group), one g/kg (T2), 2 g/kg (T3), and 3 g/kg (T4). A normal mortality rate, inherent to broiler rearing, occurred during the experiment.

The powdered bacterial biomass was obtained from cultivation of the phototrophic bacterium *Rubrivivax gelatinosus* in fish industry wastewater and averaged 57% proteins, 4% minerals, and 11% lipids containing C14:0, C16:0, C18:0, and C20:0. The biomass was dissolved in soy oil before being added to the finisher diet.

On the last d of the experiment, 4 birds from each repetition were randomly sampled for killing, plucking, eviscerating, chilling, and draining, according to Brazilian laws [13]. Breasts and thighs were deboned, ground, freeze-dried, and stored at -20°C inside plastic bags. The chemical analyses described hereafter were performed in duplicate for the defrosted samples.

Proximate analysis covered moisture (drying at 110°C to constant weight), crude protein (Kjeldhal × 6.25), total lipids (extraction with ethyl ether), and mineral content (dry ashing at 550°C) [14]. Total cholesterol was measured at 625 nm against a blank made of chromogenic reagent and calculated from a calibration curve using a spectroscope (Varian 432, São Paulo, SP, Brazil) [15].

The FA composition was analyzed by gas chromatography. First, the lipids were extracted with hexane and isopropanol, converted to methyl esters with NaOMe and methanol, and separated with ethyl ether and oxalic acid [16, 17]. Then, the extracts (1 µL) were injected with H₂ at 1.8 mL/min on a gas chromatograph (Focus CG – Finnigan, Saint Louis, MO) equipped with a CP-Sil 88 column (0.25 µm i.d.; 100 m; 0.20 µm film thickness; Varian, Sigma-Aldrich Inc., Saint Louis, MO). The temperature program began at 70°C for 4 min and increased by 13°C/min to 175°C, then by 4°C/min to 215°C and further by 7°C/min to 230°C, with a final holding time of 5 min (total 65 min). The

Table 1. Ingredient and nutrient composition of broiler diets.

Ingredient (%)		Starter ration	Grower ration	Finisher ration (36 to 45 d)			
		(1 to 21 d)	(22 to 35 d)	T1	T2	T3	T4
Corn		51.02	56.77	60.35	60.15	59.95	59.74
Soybean meal 45%		40.14	34.75	31.27	31.31	31.34	31.38
Soybean oil		4.63	4.97	5.06	5.13	5.20	5.27
Dicalcium phosphate		1.67	1.29	1.06	1.06	1.06	1.06
Limestone		1.04	0.87	0.77	0.77	0.77	0.77
Salt		0.52	0.48	0.44	0.44	0.44	0.44
Vitamin and mineral suppl. ¹		0.66	0.60	0.78	0.78	0.78	0.78
DL-Methionine		0.12	0.10	0.05	0.05	0.05	0.05
L-lisine HCl		0.16	0.16	0.17	0.17	0.17	0.17
L-threonine		0.043	0.028	0.026	0.26	0.26	0.26
<i>R. gelatinosus</i> biomass		—	—	—	0.10	0.20	0.30
Calculated composition							
Metabolizable energy	kcal/kg	3048.00	3150.00	3199.00	3199.00	3199.00	3199.00
Crude protein	%	21.83	19.64	17.98	17.98	17.98	17.98
Calcium	%	0.913	0.742	0.643	0.643	0.643	0.643
Available phosphorus	%	0.429	0.348	0.302	0.302	0.302	0.302
Potassium	%	0.604	0.598	0.590	0.590	0.590	0.590
Sodium	%	0.223	0.207	0.195	0.195	0.195	0.195
Chlorine	%	0.199	0.182	0.170	0.170	0.170	0.170
Linoleic acid	%	1.093	1.053	1.019	1.019	1.019	1.019
Digestible lysine	%	1.246	1.118	1.045	1.045	1.045	1.045
Digestible methionine	%	0.486	0.447	0.418	0.418	0.418	0.418
Digestible methionine + cystine	%	0.897	0.816	0.763	0.763	0.763	0.763
Digestible tryptophan	%	0.212	0.201	0.188	0.188	0.188	0.188
Digestible threonine	%	0.810	0.727	0.679	0.679	0.679	0.679

¹Aminoacid vitamin mineral supplement (quantity / kg of product):

Starter: vitamins A 1670000 UI, D3 335000 UI, E 2500 mg, K3 417 mg, B1 250 mg, B2 835 mg, B6 250 mg, B12 2000 mcg, folic acid 100 mg, biotin 9 mg, niacin 5835 mg, calcium pantothenate 1870 mg; Cu 1000 mg, Co 17 mg, I 170 mg, Fe 8335 mg, Mn 10835 mg, Zn 7500 mg, Se 35 mg, choline chloride 50% 116670 mg, methionine 250000 mg, coccidiostats 13335 mg, growth promoter 13335 mg, antioxidant 2000 mg. **Grower:** vitamins A 1335000 UI, D3 300000 UI, E 2000 mg, K3 335 mg, B1 167 mg, B2 670 mg, B6 170 mg, B12 1670 mcg, folic acid 67 mg, biotin 7 mg, niacin 4670 mg, calcium pantothenate 1870 mg; Cu 1000 mg, Co 17 mg, I 170 mg, Fe 8335 mg, Mn 10835 mg, Zn 7500 mg, Se 35 mg, choline chloride 50% - 83340 mg, methionine 235000 mg; coccidiostats 10000 mg, growth promoter 10000mg, antioxidant 2000 mg. **Finisher:** vitamins A 1670000 UI, D3 335000 UI, E 2335 mg, K3 400 mg, B1 100 mg, B2 800 mg, B6 200 mg, B12 2000 mcg, folic acid 67 mg, biotin 7 mg, niacin 5670 mg calcium pantothenate 2000 mg; Cu 2000 mg, Co 27 mg, I 270 mg, Fe 16670 mg, Mn 17335 mg, Zn 12000 mg, Se 70 mg, choline chloride 50% 100000 mg, methionine 235000mg, antioxidant 2000 mg.

temperatures for the vaporizer and the detector were 250°C and 300°C, respectively. Peaks were identified by comparison of the retention times with pure standards (Supelco, Sigma-Aldrich Inc., Saint Louis, MO). The quantification of the FA in the meat was obtained from the normalization of methyl esters areas, and the results were expressed as percentages of total fatty acids.

For the statistical analysis of the results, ANOVA and t multiple range tests were performed for thigh and breast values separately, using the GLM procedure of SAS 9.2 [18] at 5% significance.

RESULTS AND DISCUSSION

No change was found for the proximate chemical composition of breast and thigh meat due to treatments ($P > 0.05$, Tables 2 and 3). Poultry meat is made up of approximately 60 to 80% water, 15 to 25% protein, and 1.5 to 5.3% lipids. The latter is the most variable component due to the influence of diet, animal's age, breeding environment, and anatomical cut, in which the highest contents are in the thigh [19]. The values found in this experiment for the proximate composition of breast and thigh meat were in agreement with the literature [20]. Protein and

Table 2. Chemical proximate composition (wet basis) of breast meat of broilers fed different concentrations of *R. gelatinosus* biomass.

Treatments	Breast meat (%) ¹			
	Moisture	Protein	Lipids	Minerals
T1	72.0 ± 1.01	19.4 ± 0.61	3.3 ± 0.52	1.4 ± 0.08
T2	72.4 ± 1.40	19.6 ± 1.56	3.5 ± 0.33	1.5 ± 0.11
T3	71.0 ± 3.20	20.2 ± 2.09	3.8 ± 0.54	1.4 ± 0.21
T4	71.6 ± 1.27	19.4 ± 1.26	3.8 ± 0.17	1.4 ± 0.16
Mean	71.2 ± 2.03	19.7 ± 1.88	3.6 ± 0.39	1.4 ± 0.14
CV ²	2.40	6.99	10.97	9.87

¹Mean ± standard deviation.

²Coefficient of variation.

Table 3. Chemical proximate composition (wet basis) of thigh meat of broilers fed different concentrations of *R. gelatinosus* biomass.

Treatments	Thigh meat (%) ¹			
	Moisture	Protein	Lipids	Minerals
T1	71.0 ± 0.86	21.8 ± 1.17	6.2 ± 0.52	1.2 ± 0.10
T2	73.2 ± 2.22	21.3 ± 1.64	6.3 ± 0.87	1.2 ± 0.10
T3	70.9 ± 2.42	22.1 ± 0.83	6.5 ± 0.50	1.2 ± 0.11
T4	70.8 ± 1.57	22.6 ± 1.45	6.6 ± 0.52	1.3 ± 0.08
Mean	71.5 ± 1.76	22.0 ± 1.27	6.4 ± 0.60	1.2 ± 0.09
CV ²	2.47	5.81	9.44	8.00

¹Mean ± standard deviation.

²Coefficient of variation.

moisture concentrations in breast meat were in agreement with data reported by Novello et al. [21] and Murakami et al. [22] while the lipid concentration in both breast and thigh meat were in agreement with data reported by Bragagnolo [5].

The data comparison in the reference table on food composition (Table 4) shows that the moisture content in breast and thigh meat found in this study were lesser than the content reported by the Brazilian Food Composition (TACO) [23] and the University of São Paulo – USP [24] tables. Regarding ash content, values found for breast and thigh meat were in accordance with the tables. For proteins, the values found for breast and thigh meat were similar and higher, respectively, in the comparison with the same tables.

For lipids, the values found in this experiment for breast meat were similar to those reported by TACO [23] and higher than those reported by USP. Conversely, for thigh, lipid content was similar to USP [24] and higher than the TACO [23] table. Ultimately, the total lipid content in breast meat was around half the amount in thigh meat, which is in agreement with both tables. These discrepancies among the chemical com-

ponent concentration reinforce the need for the constant review of the reference values since they may be influenced by factors like feeding, environment, genetics, and processing [21].

Cholesterol concentration in broiler muscles may vary from 30 to 120 mg/100 g, following the same lipid variations that occur due to strain, age, rearing conditions, body localization, and feeding [25]. In this study, the cholesterol concentration in either cut did not differ among treatments ($P > 0.05$; Table 5). The cholesterol content was higher in the thighs than in the breasts, which is consistent with the literature [23, 26, 27]. However, the values found in this experiment for both cuts were lower than those reported by tables PHILIPPI [26], USDA [27], and TACO [23] (Table 6) and by Rosa et al. [20], who found 91.97 mg cholesterol/100 g in thigh meat and 66.79 mg/100 g in breast meat.

Regarding the FA profile of broiler meat, SFA, MUFA, and PUFA were lower in thighs than the values reported by the reference tables (Table 7), while in breasts they were similar to the values reported by USDA [27] and PHILIPPI [26] but lower than those reported by TACO [23]

Table 4. Proximate compositions of breast and thigh meat of broilers according to some reference tables of food chemical composition.

Component (g/100 g)	TACO*		USP**		Mean values from this study	
	Breast	Thigh	Breast	Thigh	Breast	Thigh
Moisture	74.8	76.4	73.8	75.5	71.2	71.5
Minerals	1.0	0.9	1.1	0.9	1.4	1.2
Proteins	21.5	17.8	20.8	16.5	19.7	22.0
Lipids	3.0	4.9	1.8	7.0	3.6	6.4

*Brazilian Table of Food Composition – TACO (2011).
**Food Composition Table – PHILIPPI (2002).

Table 5. Cholesterol content (wet basis) in breast and thigh meat of broilers fed different concentrations of *R. gelatinosus* biomass.

Treatments	Total cholesterol (mg/100 g) ¹	
	Breast	Thigh
T1	47.88 ± 8.68	68.15 ± 7.25
T2	49.68 ± 3.86	62.98 ± 8.84
T3	46.98 ± 6.67	60.53 ± 7.79
T4	51.97 ± 4.82	64.82 ± 8.18
Mean	49.12± 6.0	64.12± 8.01
CV ²	12.34	12.54

¹Mean ±standard deviation.
²Coefficient of variation.

tables. Such differences may be due to variations in analytical methodologies, diets, and animal breeds.

Dietary saturated fat intake has been shown to increase low-density lipoprotein (LDL) cholesterol by inhibiting LDL receptor activity, and, therefore, has been associated with increased risk of cardiovascular disease (CVD) in humans [28]. Thus, as broiler meat already contains C14:0, C16:0, and C18:0, it is expected that the levels of these FA do not get higher owing to dietary origin. In this study, it was shown that, although the bacterial biomass contained C14:0,

C16:0, C18:0, and C20:0, it did not change the SFA content in either breast or thigh meat (Tables 7 and 8). Also, the concentration of C16:1 and C18:1 did not change in breast and thigh meat, although they were present in the bacterial biomass.

Animals are not able to synthesize PUFA via the de novo pathway but they can synthesize them from linoleic (LA, C18:2 n-6) and alpha-linolenic (ALA, C18:3 n-3) acids by using elongase and desaturase enzymes, which compete with each other [29, 30]. In microorganisms, the pathway of FA formation involves a fatty acid synthase (FAS) system made up of 4 enzymes that provide the starting C16 and C18 FA for subsequent desaturation and elongation [31]. Alternatively, the anaerobic biosynthesis of PUFA may be carried out by a specialized polyketide synthase (PKS), a variation of FAS that uses the same 4 basic reactions [32]. As the bacterial biomass contained no PUFA, it seems reasonable to suggest that *R. gelatinosus* metabolism lacks some of these reactions.

In this study, no increase in breast meat concentration of LA or arachidonic acid (ARA C20:4 n-6) - a LA derived PUFA - occurred when the biomass was used (Table 8), suggesting

Table 6. Cholesterol concentration in breast and thigh meat of broilers according to some reference tables of food chemical composition.

Component (mg/100 g)	USDA*		TACO**		PHILIPPI***		Mean values from this study	
	Breast	Thigh	Breast	Thigh	Breast	Thigh	Breast	Thigh
Cholesterol	58	77	59	91	58	83	49	64

*United States Department of Agriculture – USDA (2001).
**Brazilian Table of Food Composition – TACO (2011).
***Food Composition Table – PHILIPPI (2002).

Table 7. Saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) concentration in breast and thigh meat of broilers according to some reference tables of food chemical composition.

Component (g/100 g)	USDA*		TACO**		PHILIPPI***		Mean values from this study	
	Breast	Thigh	Breast	Thigh	Breast	Thigh	Breast	Thigh
SFA	0.44	1.10	1.10	3.0	0.33	1.01	0.26	0.25
MUFA	0.39	1.34	1.30	4.5	0.30	1.22	0.35	0.37
PUFA	0.37	1.07	Tr ¹	1.6	0.28	0.97	0.34	0.33

*United States Department of Agriculture – USDA (2001).

**Brazilian Table of Food Composition – TACO (2011).

***Food Composition Table – PHILIPPI (2002).

¹Tr = trace amounts.

Table 8. Fatty acids profile of breast meat of broilers fed different concentrations of *R. gelatinosus* biomass (%).

Fatty acids	Treatments ¹				P-Value
	T1	T2	T3	T4	
C14:0	0.47 ± 0.05	0.49 ± 0.03	0.48 ± 0.05	0.43 ± 0.04	0.40
C16:0	19.74 ± 0.32	20.05 ± 0.32	20.17 ± 0.85	19.49 ± 0.51	0.45
C18:0	6.13 ± 0.11	6.15 ± 0.2	6.23 ± 0.13	5.69 ± 0.58	0.23
C20:0	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0	0.07 ± 0.02	0.69
∑ SFA	26.42 ± 0.43	26.77 ± 0.48	26.96 ± 0.78	25.68 ± 1.00	0.20
C14:1	0.09 ± 0.03	0.09 ± 0.01	0.09 ± 0.03	0.09 ± 0.01	1.00
C16:1	2.95 ± 0.34	2.81 ± 0.17	3.01 ± 0.85	2.98 ± 0.43	0.96
C18:1 n-9	31.75 ± 0.63	32.04 ± 0.05	32.08 ± 0.11	31.94 ± 0.06	0.61
C20:1	0.22 ± 0.07	0.29 ± 0.03	0.31 ± 0.02	0.33 ± 0.03	0.05
∑ MUFA	35.01 ± 0.49	35.23 ± 0.15	35.49 ± 0.76	35.34 ± 0.42	0.70
C18:2 n-6	31.3 ± 0.4 ^a	30.46 ± 0.44 ^b	30.21 ± 0.33 ^b	31.46 ± 0.24 ^a	0.00
C18:3 n-3	2.56 ± 0.15	2.43 ± 0.43	2.31 ± 0.19	2.54 ± 0.41	0.71
C20:4 n-6	1.12 ± 0.06	1.06 ± 0.06	1.08 ± 0.08	0.95 ± 0.14	0.20
C20:5 n-3	0.04 ± 0.01 ^b	0.04 ± 0.01 ^b	0.04 ± 0.02 ^b	0.12 ± 0.01 ^a	0.00
C22:6 n-3	0.14 ± 0.02	0.14 ± 0.03	0.13 ± 0.04	0.11 ± 0.02	0.56
∑ PUFA	35.16 ± 0.54^a	34.13 ± 0.72^b	33.77 ± 0.26^b	35.18 ± 0.49^a	0.02
∑ n-6	32.42 ± 0.43 ^a	31.52 ± 0.47 ^b	31.29 ± 0.30 ^b	32.41 ± 0.21 ^a	0.00
∑ n-3	2.74 ± 0.17	2.61 ± 0.38	2.48 ± 0.15	2.77 ± 0.41	0.64
n-6/n-3	11.86 ± 0.69	12.25 ± 1.76	12.65 ± 0.88	11.87 ± 1.76	0.87
PUFA/SFA	1.33 ± 0^a	1.27 ± 0.01^b	1.25 ± 0.05^b	1.37 ± 0.03^a	0.00

¹Means ± standard deviations.

^{a,b}Values in the lines followed by distinct letters are significantly different ($P > 0.05$) according to t test.

SFA – Saturated fatty acids; MUFA – Monounsaturated fatty acids; PUFA – polyunsaturated fatty acids.

once more that the enzymes involved in this synthesis could not be activated with the biomass concentration used in the experiment. This result may have a practical interpretation since ARA is known to act as a pro-inflammatory, pro-aggregatory, and immunoactive agent [32], and its excessive consumption may concur to the development of chronic diseases due to increased inflammatory response [33].

On the other hand, the enzymes seem to have been activated toward the production of EPA from ALA when the highest concentra-

tion of the biomass was used (Table 8). In humans, EPA is converted in prostaglandins 3 (PGE3), leukotrienes 5 (LTB5), and thromboxane 3 (TXA3), which are potentially anti-inflammatory and antithrombotic and inhibit the synthesis of inflammatory mediators derived from the arachidonic acid [7].

In thigh meat, the use of the biomass at 3 g/kg significantly increased the PUFA content, especially due to the increase of LA (Table 9). At the same time, the same concentration of the biomass led to a decrease in the concentration

Table 9. Fatty acids profile of thigh meat of broilers fed different concentrations of *R. gelatinosus* biomass (%).

Fatty acids	Treatments ¹				P-Value
	T1	T2	T3	T4	
C14:0	0.49 ± 0.02	0.47 ± 0.02	0.49 ± 0.01	0.45 ± 0.03	0.13
C16:0	19.81 ± 1.06	20.17 ± 0.76	20.26 ± 0.6	19.77 ± 0.75	0.83
C18:0	5.58 ± 0.03	4.96 ± 0.21	5.59 ± 0.32	5.3 ± 0.4	0.12
C20:0	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0.03	0.07 ± 0	0.84
∑ SFA	25.96 ± 0.44	25.68 ± 0.53	26.42 ± 0.82	25.59 ± 1.03	0.65
C14:1	0.11 ± 0.01	0.11 ± 0.01	0.11 ± 0.01	0.11 ± 0.01	0.19
C16:1	3.48 ± 0.44	3.49 ± 0.27	3.69 ± 0.52	3.5 ± 0.3	0.89
C18:1 n-9	33.19 ± 0.82	33.01 ± 0.04	33.41 ± 0.31	33.01 ± 0.09	0.65
C20:1	0.33 ± 0.02 ^a	0.31 ± 0.01 ^a	0.26 ± 0.03 ^b	0.25 ± 0.03 ^b	0.00
∑ MUFA	37.11 ± 1.12	36.92 ± 0.24	37.47 ± 0.45	36.7 ± 0.29	0.65
C18:2 n-6	29.93 ± 0.09 ^b	29.99 ± 0.57 ^b	29.36 ± 0.23 ^b	30.74 ± 0.27 ^a	0.00
C18:3 n-3	2.25 ± 0.1	2.37 ± 0.17	2.27 ± 0.22	2.47 ± 0.46	0.73
C20:4 n-6	0.67 ± 0.08	0.63 ± 0.02	0.6 ± 0.2	0.63 ± 0.04	0.89
C20:5 n-3	0.11 ± 0.01 ^a	0.09 ± 0.01 ^a	0.04 ± 0.01 ^b	0.06 ± 0.02 ^b	0.00
C22:6 n-3	0.08 ± 0.02	0.07 ± 0.02	0.07 ± 0.02	0.07 ± 0	0.85
∑ PUFA	33.04 ± 0.12^{b,c}	33.15 ± 0.66^b	32.34 ± 0.43^c	33.97 ± 0.23^a	0.00
∑ n-6	30.6 ± 0.01 ^b	30.62 ± 0.56 ^b	29.96 ± 0.37 ^b	31.37 ± 0.25 ^a	0.00
∑ n-3	2.44 ± 0.11	2.53 ± 0.16	2.38 ± 0.21	2.6 ± 0.48	0.77
n-6/n-3	12.54 ± 0.59	12.13 ± 0.69	12.65 ± 1.08	12.34 ± 2.38	0.96
PUFA/SFA	1.27 ± 0.04^{a,b}	1.29 ± 0.05^{a,b}	1.22 ± 0.05^b	1.33 ± 0.05^a	0.09

¹ Means ± standard deviations.
^{a-c} Values in the lines followed by distinct letters are significantly different (*P* > 0.05) according to t test.
SFA – Saturated fatty acids; MUFA – Monounsaturated fatty acids; PUFA – polyunsaturated fatty acids.

of EPA, reinforcing the competitive behavior of the enzymes involved in the production of n-6 and n-3 PUFA. Since C20:1 does not act as a precursor for PUFA synthesis, a possible explanation for the decrease of this FA in thighs may be the dilution caused by increasing amounts of the biomass in the experimental diets.

For both breast and thigh meat, the significant effects caused by the experimental diets on ∑ PUFA, ∑ n-6, and PUFA/SFA were influenced by the LA concentration. An important finding of this study was that the ratio n-6/n-3 did not differ statistically among the treatments in either breast (*P* = 0.8754) or in thigh meat (*P* = 0.9664). This seems to be a positive result since the suitable ratio n-6/n-3 in the dietary PUFA guarantees the equilibrium of coagulation, inflammation, and immune response and modulates many genes involved in oxidative processes, so avoiding the emergence of many chronic diseases [7, 32].

According to Simopoulos [34], before industrialization, human diets had n-6/n-3 ratio around 1 to 2:1 due to the great consumption of fruits, vegetables, and fish containing n-3 FA. After industrialization, this ratio progressively

increased, largely due to the use of refined oil from oil rich plants and grains with high n-6 (mainly LA) such as soybean, corn, and sunflower as the substitute for saturated fats and also due to the decrease in the consumption of fish, fruits, and vegetables. Even though the recommended ratios for the dietary n-6/n-3 vary from 2:1 to 10:1, currently, in Western diets, this ratio may range from 10:1 up to 25:1 or 50:1, i.e., very far from the nutritionally recommended balance [29, 35]. The ratios n-6/n-3 found in this experiment, around 12:1, were expected for broiler meat [5, 21], suggesting that the use of the product was not harmful to the FA profile.

CONCLUSIONS AND APPLICATIONS

1. The supplementation of broiler diets with *Rubrivivax gelatinosus* biomass did not alter the proximate composition or the cholesterol content of meat but, at 3 g/kg, the product increased EPA in breast and LA in thigh and decreased EPA in thigh, without changing the ratio n-6/n-3 in either cut.

2. The use of the biomass at 3 g/kg was considered harmless or even beneficial to the composition of the meat, providing an interesting perspective for the improvement of broiler product quality, following the current world tendency for the consumption of functional food.

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