BOLETIM DO INSTITUTO DE PESCA
ISSN 1678-2305 online version
Scientific Article

PRODUCTION OF TILAPIA IN BIOFLOC WITH DIFFERENT SALT CONDICTIONS: AN EVALUATION OF BODY COMPOSITION AND ORGANOLEPTIC PROPERTIES

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Received: July 31, 2019
Approved: September 19, 2019

ABSTRACT

Biofloc systems for aquaculture production are excellent options to attend the increasing demand for fish. Despite the advantages, these systems lead to accumulation of nitrogenous residues that need to be avoided, which can be achieved by the addition of salts to the water. However, salts may interfere with the body composition and the organoleptic properties of fish. Therefore, we evaluate the body composition and acceptability of tilapia fillets produced under different salt conditions. Body composition was measured by moisture, ethereal extract, crude protein and minerals, and tested by Permutational Multivariate Analysis of Variance (PERMANOVA). To infer on acceptability, a sensorial analysis was performed to produce preference scales of aroma, appearance, texture, flavor and off-flavor attributes. These were summarized with Principal Coordinates Analysis and tested by PERMANOVA. The body composition shows no significance difference between salts conditions. However, the organoleptic properties according to the participants were peculiar and showed lower influence of the salt condition. In the order of preference, the most accepted fish was cultivated in a conventional system (ponds without salinity). Therefore, salt conditions in biofloc systems did not significantly change the body composition of the fish, but subtle reduced their acceptability.

Keywords: *Oreochromis niloticus;* sensorial analysis; food preference; gustative memory.

PRODUÇÃO DE TILÁPIAS EM BIOFLOCOS COM DIFERENTES CONDIÇÕES DE SAIS: UMA AVALIAÇÃOO DA CONDIÇÃO CORPORAL E PROPRIEDADES ORGANOLÉPTICAS

RESUMO

Com o aumento do consumo de pescado, a produção de peixes em bioflocos é uma ótima alternativa para suprir esta demanda. Apesar das vantagens, no sistema bioflocos há acúmulo de resíduos nitrogenados que podem ser evitados pela adição de sais na água. Entretanto, esses podem interferir na composição corporal e nas propriedades organolépticas do pescado. Desta forma, avaliamos a aceitabilidade de filés de tilápia produzidas em bioflocos com diferentes condições de sais. A composição corporal foi mensurada por meio da umidade, extrato etéreo, proteína bruta e minerais, e testada pela análise multivariada de variância permutacional (PERMANOVA). Para inferir aceitabilidade, uma análise sensorial foi realizada para produzir escalas de preferência em aroma, aparência, textura, sabor e off-flavor. Esses foram sumariados pela análise de coordenadas principais e testados com PERMANOVA. Na composição corporal não houve diferença significativa. Para as propriedades organolépticas, apenas a aparência e o sabor mostraram significância, assim como aparência, aroma, e off-flavor em relação aos provadores. Na preferência, o peixe mais aceito foi o cultivado em sistema convencional (tanques escavados sem salinidade). Desta forma, conclui-se que o tipo de sal no sistema de bioflocos não interferiu na composição corporal do pescado, mas sutilmente reduziu sua aceitabilidade.

Palavras-chave: *Oreochomis niloticus*; análise sensorial; preferência alimentar; memória gustativa.

INTRODUCTION

Despite the rapid growth, the challenge for aquaculture remains in the development of new and more efficient production systems to supply the demand for fish consumption (FAO, 2018). In this context, the biofloc technology (BFT) deserves attention (Avnimelech, 2009). Some advantages of BFT over conventional production systems in ponds include higher biosecurity, better food conversion, and greater efficiency in farming areas and in water (Hargreaves, 2013).

The BFT is based on the recycling of nutrients, mainly nitrogenized, inside a production system, avoiding additional costs with filters and bombs. The recycling of nutrients occurs through the action of beneficial microorganisms, such as microalgae and heterotrophic bacteria, which convert the toxics substances ammonium and nitrite into nontoxic nitrate. These toxic substances, when in excess in a production system, increase the secondary response of fish to stress, decreasing the final quality of the fish or even causing its death (Lima et al., 2006). Nevertheless, the toxicity of nitrogenized substances to fish is inversely related to salinity (Schuler et al., 2010; Coa et al., 2017). Thus, the use of salt in BFT systems for fish is beneficial.

The disadvantage of use salt in BFT is that dissolved salts in the water directly affect the osmotic equilibrium of fish, imposing to the animal the necessity of absorbing more or less water to maintain body salt concentrations (Baldisserotto, 2013; Pascke and Lanzendorf, 2017). Salinity also has influence on the blood of tilapia, what suggest physiological changes (Bosisio et al., 2017). In addition to the salt concentration, the ionic balance is also important since each chemical element has a specific physiological function (Thabet et al., 2017). Therefore, the water where fish are produced directly interferes with the health (Lemos et al., 2018) and meat quality of fish. The absorption, retention or elimination of salts in a production system may influence the centesimal composition of fish. The proportions of proteins, lipids and minerals depend on the animal's age (Santos et al., 2012) but are also affected by the way that fish are reared (Corrêia et al., 2013) and food is supplied (Boscolo et al., 2010). So, it is expected that the way that a fish is reared also affect its organoleptic properties.

A clear example of the interrelation between body composition and organoleptic properties is the composition of the ethereal extract of the fish since fish with higher fat indices have a more homogeneous texture (Van Dongen et al., 2012). In addition to texture, appearance, aroma and flavor are essential properties that determine the preference for a product (Poinot et al., 2013).

Appearance is the first interaction between a consumer and a product. A good appearance can represent the beginning of the process of choosing a food because appearance can cognitively alter taste, in addition to the aroma, which is usually the second organoleptic property the consumer encounters (Delwiche, 2004).

Taste, the last encountered response, may be the main organoleptic property due to the great influence the other organoleptic properties have on it (Martin et al., 2014). In addition to the influence of other properties, the taste itself may present undesirable organic substances, such as geosmine and methylisoborneol (Souza et al., 2012), that transmit strange flavors in food, which can cause consumer refusal and harm fish farming (Souza et al., 2012).

In this way, it is imperative that fish produced in the BFT is acceptable by the consumer. Thus, we test the hypothesis that different conditions of salt dissolved in BFT affects the quality of tilapia, due to assimilation and possible accumulation. Specifically, we evaluated the body composition (moisture, ether extract, protein and minerals) and organoleptic properties of fillets (aroma, appearance, texture, flavor and off-flavor) from fish produced in two different types of salts (common salt and marine salt) and in a conventional system (ponds without salts).

MATERIALS AND METHODS

Ethics Committee

The study was conducted after obtaining the favorable opinion of the Animal Ethics Committee. A favorable opinion for the execution of the sensorial analysis was also obtained through the Committee of Ethics in search with Human Beings of the State University of Western Paraná (CEP / CAAE 07597418.1.0000.0107 / nº of opinion 3.200.166).

Fish Farming

The study was developed at the Institute of Research in Environmental Aquaculture in association with the State University of Western Paraná, from March 1st, 2019, to May 1st, 2019, where six fish fattening tanks with 1200 L of water were maintained in a BFT system. Each tank housed 100 tilapias with a mean weight of 0.0846 ± 0.004 kg and farmed for 56 days. In the laboratory, three tanks were randomly assigned for fish production in water with common salt (sodium chloride) and three tanks for fish in water with marine salt (ionic balance). A preliminary analysis of the water was carried out to formulate the salt similar to the ionic proportions of the marine water. The water of cultivation of both types of BFT had a saline concentration of 10 $g.L^{-1}$.

Centesimal Analysis (Body Composition)

After farming, 10 fish of each tank were caught for centesimal evaluation. The fish were eviscerated, desquamated, beheaded and then crushed and sent to the Laboratory of Reproduction Technology for Aquatic Animals (LATRAAC). In the LATRAAC, triplicates of crushed fish from each tank were analyzed to get averaged values of moisture, ethereal extract, crude protein and minerals.

We follow the step-by-step methodology described by Mizubuti et al. (2009) for the determinations of body composition in moisture, ethereal extract, crude protein and minerals, that we shortly resume. Moisture was established by dehydration of the samples in a heated stove at 105 ºC until the weight was constant. The ethereal extract was obtained by dry matter, submitted to Soxhlet methodology and extracted with anhydrous ethyl ether. Crude protein was determined after the samples were dehydrated and defatted, and the quantification of total nitrogen was performed by the Kjeldahl method with a conversion factor of 6.25% of protein nitrogen. Exposing the dehydrated material in a muffle at 550 ºC for 4 h was carried out to determination of the minerals.

Microbiological Analysis

Before the sensory analysis, 100 g of fillets of tilapia produced in water with common salt, marine salt and without salt were submitted for microbiological analysis. For the three fillet samples, the absence of *Salmonella* spp. and levels < $1,0x10^1$ for total coliforms and thermotolerant coliforms were observed, and sensory analysis was able to be applied to the fillets (Brasil, 2001).

Sensorial Analysis

For sensory analysis, the fish produced in the BFT were captured, filleted in a fridge and frozen at -18 ºC, and the conventional fish (tank excavated and produced in water with salinity in 0 $g.L^{-1}$) were bought from a duly licensed producer. The sensory analysis was carried out in the Fish Technology Laboratory of the State University of Western Paraná, where three types of fillets (of fish produced in common salt, marine salt and nonsalt culture), with approximately 0.020 kg, were submitted to 53 participants. The fillets were thawed, seasoned with salt (1%), fried (three minutes at 180 °C), coded and served to participants in a randomized fashion to avoid biased responses due to the order of submission (Dutcosky, 2011).

As the intrinsic and extrinsic information of products is likely to interfere with the choice of the consumers (Pieniak et al., 2007; Gaviglio et al., 2014; Spence, 2015), the participants of the sensory analysis were only informed that fish fillet would be served. Participants were submitted to two affective tests, paired order and paired acceptance. In the paired ordering test, the judges were asked to indicate in ascending order which sample they liked best (one to three, one for the most liked and three for the least liked). In the paired acceptance test, the following organoleptic properties were judged: appearance, aroma, texture, flavor and off-flavor. For paired acceptance, the answers were attributed through a nine-point hedonic scale, where a value of one was judged to be very disagreeable and a value of nine was liked very much (Dutcosky, 2011).

Through the echeloned answers, it was defined that attributed values from one to three meant that the participants did not like the evaluated fish (within each attribute), from four to six was indifferent and from seven to nine meant the evaluator liked the fish (within each attribute evaluated) (Dutcosky, 2011).

Data Analysis

The evaluation of fish body composition (moisture, ethereal extract, crude protein and minerals) was carried out by permutational multivariate analysis of variance (PERMANOVA) for main effects, followed by bivariate comparisons for products using the same method (pairwise PERMANOVA), all with 999 permutations (Anderson, 2001).

The organoleptic attributes evaluated by participants in the sensorial analysis were initially summarized by principal coordinates analysis (PCoA) using the Euclidean distances method (McCunne and Grace, 2002) to obtain a visualization of the main preference gradients of participants in relation to the three products. In addition to this visualization, a PERMANOVA test (999 permutations) for the main effects was also carried out to evaluate the preference of the products, controlling for participants' effects. A radar chart (Chambers et al., 1983), with scaled values from 0 to 1, was made to better illustrate the observed differences among product preferences. PERMANOVA analyses reached the assumptions of homoscedasticity and normality. When the PERMANOVA tests identified significance effects, separated ANOVA tests were carried out for each response. All analyses were performed in Rstudio (version 1.2.1335) at a significance level of 5%.

RESULTS

Responses were discreetly summarized and allocated in percentages within the groups defined by the hedonistic scale (Table 1) and verified a strong preference trend for fish produced in saltwater. When summarizing the values attributed by the participants for the three evaluated products (Figure 1), the off-flavor (7.38 ± 1.93) had the best classification, that is, the evaluated products showed no clay taste, followed by taste (7.33 ± 1.51), texture (7.11 ± 1.57), aroma (7.13 ± 1.54) or appearance (6.79 ± 1.50). These results indicate that the majority of participants liked all the products offered in the study.

Table 1. Percentage of participants (N = 53) who assigned values within hedonic scale groups (1 to 3 disliked fish, 4 to 6 found indifferent and 7 to 9 liked fish) for each organoleptic property in the production types.

		Appearance	Aroma	Texture	Taste	Off- flavor
	1 a 3	5.66	3.77	0	1.89	9.43
Common salt	4 a 6	33.96	28.3	37.74	37.74	22.64
	7 a 9	60.38	67.92	62.26	60.38	67.92
	1 a 3	0	1.89	1.89	3.77	2.04
Marine salt	4 a 6	30.19	26.42	22.64	26.42	28.57
	7 a 9	69.81	71.7	75.47	69.81	69.39
	1 a 3	0	1.92	5.66	1.89	1.89
No salt	4 a 6	45.28	25	18.87	11.32	22.64
	7 a 9	54.72	73.08	75.47	86.79	75.47

The results obtained from the experiment were not sufficient to identify significant differences ($F_{(1, 4)} = 1.85$, $p = 0.215$) in fish body composition in relation to common salt and marine salt farming (Table 2).

In the combined evaluation of all organoleptic properties answered by the participants, consistencies were observed among the acceptance levels of the products since the appearance, aroma, texture, flavor and off-flavor had negative associations with the main coordinate of the PCoA (42% explanation) and positive association with the order of preference (Figure 2A). This means that the best preference was associated with the best appearances, aromas, textures, and flavors and the absence of off-flavor. The positioning of the values in the radar diagram also confirmed this behavior in the participants (Figure 2B). However,

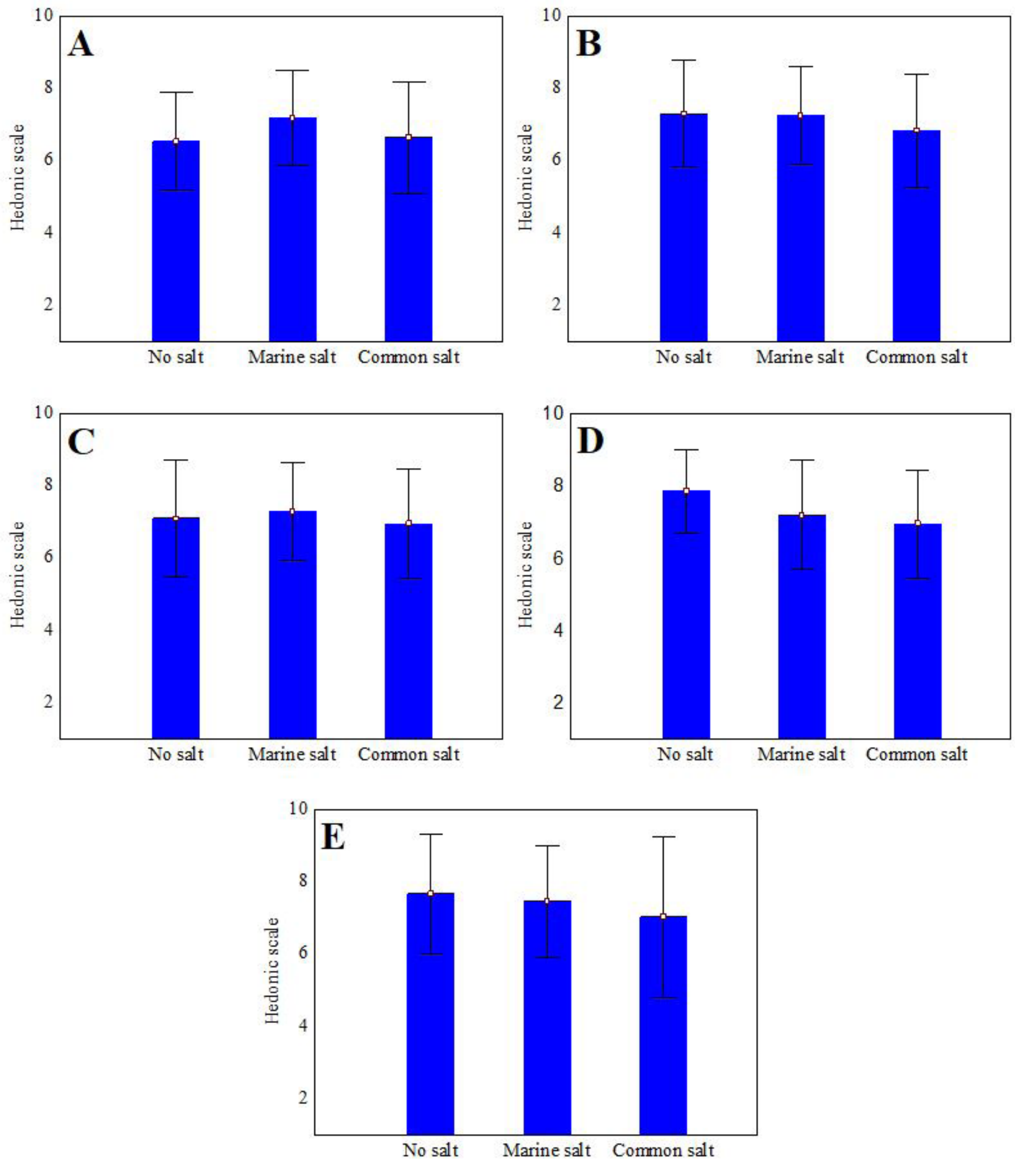

Figure 1. Mean values (N = 53) and confidence interval (bars of 95%CI) obtained from the participants in relation to the products: fish reared in water without salt (No salt), with marine salt (Marine salt) and common salt (Common salt), for the attributes: appearance (A), aroma (B), texture (C), taste (D) and off-flavor (E).

Table 2. Mean values and standard deviation of the chemical composition of fish produced in the BFT system with common salt and marine salt. Each value represents the average of three determinations (N = 3).

	Moisture	Ethereal Extract	Crude Protein	Mineral
Common Salt	74.57±1.39[a]	1.71±0.46[a]	19.33±0.91[a]	2.69±0.69[a]
Marine Salt	75.85±1.79[a]	1.45±0.22[a]	18.86±1.34[a]	3.35±1.17[a]

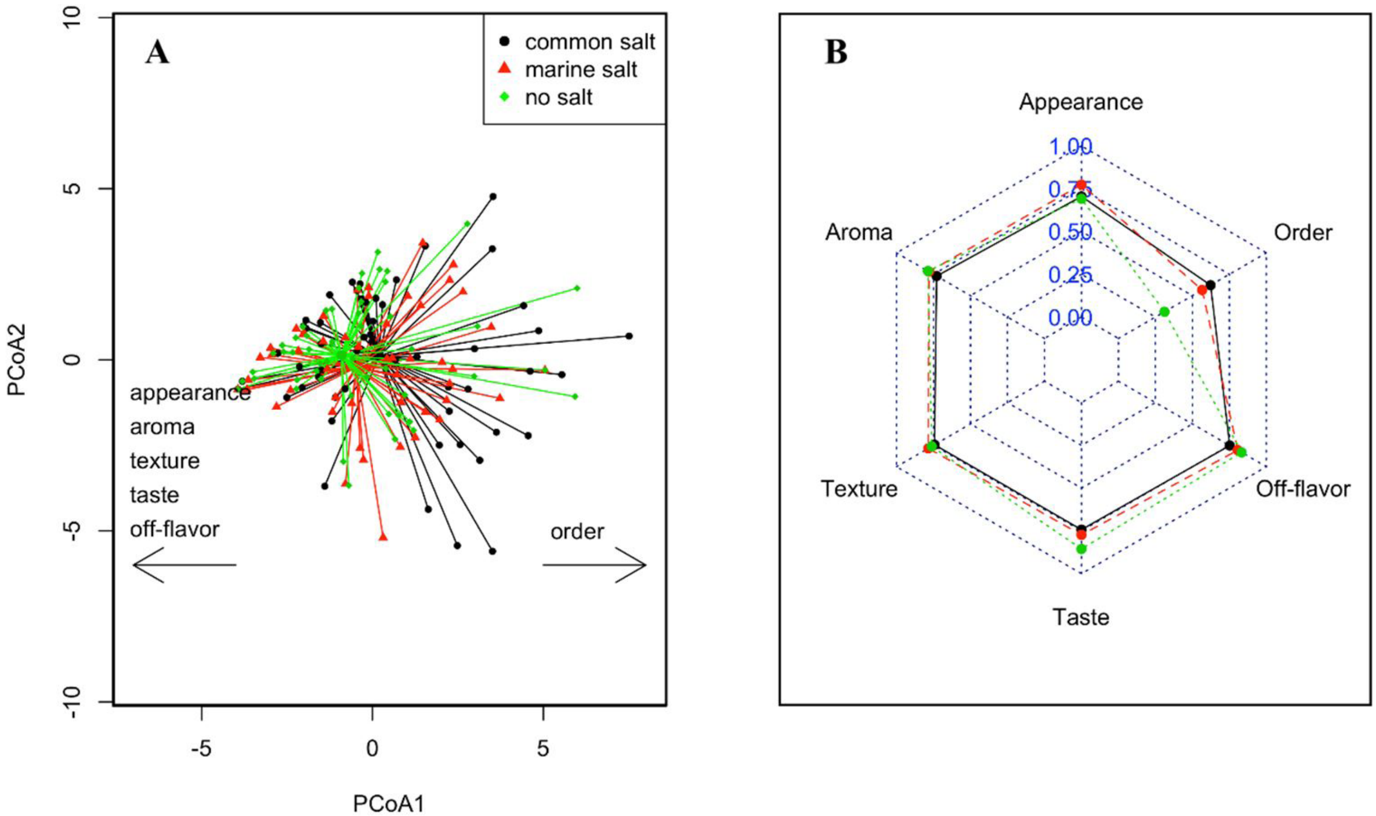

Figure 2. (A) Negative associations of organoleptic properties with the principal coordinate of PCoA, and positive with the order of preference. (B) Mean and proportional values (from 0 to 1) attributed by participants to organoleptic properties (appearance, aroma, texture, taste, off-flavor) and preference ordering for tilapia fillets grown in environments with common salt, marine salt and no salt.

although all products received high acceptance, the average score obtained from fillets from unsalted fish was relatively higher than the others ($F_{(2,104)} = 6.71$, $p = 0.0018$).

Although all the products had high acceptance, in the sensory analysis, the appearance ($F_{(52,104)} = 2.16$, $p < 0.001$), aroma ($F_{(52,104)} = 2.42$, $p < 0.001$) and off-flavor ($F_{(52,104)} = 3.50$, $p < 0.001$) had intrinsic effects on the participants. When the production types were evaluated, the appearance ($F_{(2,104)} = 4.17$, $p = 0.018$, Figure 3A), taste ($F_{(2,104)} = 4.17$, $p = 0.0041$, Figure 3D) and ordering preference ($F_{(2,104)} = 6.71$, $p = 0.0018$, Figure 3F) presented significant differences among treatments. Other organoleptic properties did not show significant differences (Figure 3B, 3D, 3E). In the ordering preference, the fish that had the highest approval were produced with no salt in the water, and the worst evaluation was for the fish produced with common salt in the water (Figure 3).

DISCUSSION

With higher productivity rates (Lima et al., 2015) when compared to the conventional system (ponds), the BFT proves to be a great alternative for large scales fish production. In addition, this technology enables the development of new products, such as fish nutritionally enriched with higher concentrations of minerals. In addiction, in our study fish body composition did not showed relevant differences between BFT systems with different salts conditions, and the values obtained for moisture, protein and minerals were similar to those found by Alves et al. (2010), Ribeiro et al. (2011) and Azevedo et al. (2016) who studied tilapia.

Even though the amount of minerals was not significantly different between the fish groups evaluated, the tasters indicated differences in taste and appearance in the sensory analyzes. This may be associated with the composition of the different types of salt present in the fillet, since tilapia assimilates the salts by osmosis and diffusion to maintain osmotic balance (Baldisserotto, 2013), and fish were produced in water with different salinity compositions.

Although not significant, the ether extract indices found in fish farmed in the BFT in our study were slightly lower than those found in conventional farmed fish (Martins et al., 2009, Alves et al., 2010; Ribeiro et al., 2011; Santos et al., 2012; Azevedo et al., 2016). Along with ethereal extract (Van Dongen et al., 2012), protein and moisture are other attributes that directly interfere with the texture of tilapia fillets (Lease et al., 2016), which were approved by consumers who participated in sensory analyzes.

Protein and moisture have an inverse relationship in food composition (Lease et al., 2016), and because tilapia has a high

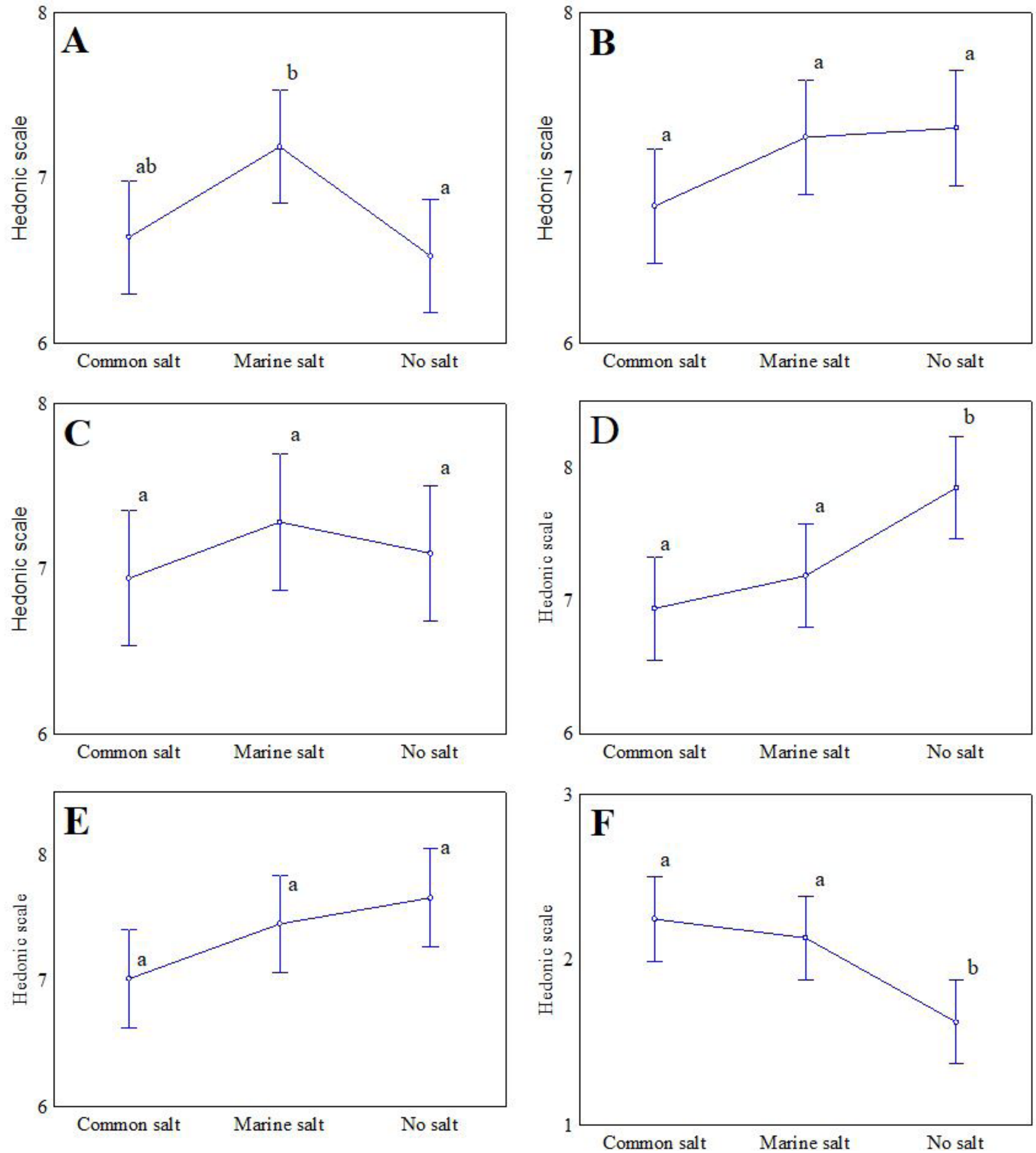

Figure 3. Mean values (N = 53) and confidence interval (bars of 95%CI) for hedonic scales for the attributes: appearance (A) aroma (B), texture (C), taste (D), off-flavor (E) and preference ordering (F), obtained of the fish fillets produced in the BFT system with common salt, marine salt and no salt in the water.

amount of protein, it is appreciated by most of the population. This wide acceptance of tilapia is related to the high protein content found in meat, as the protein is moderately associated with umami taste (Martin et al., 2014; Lease et al., 2016; Martin and Issanchou, 2019), which responds related to the pleasure of eating.

When evaluating the organoleptic properties, the tilapia fillet that presented the worst evaluation of appearance (fillet without salt) in this study had the highest score by the consumers, corroborating the results obtained by Petit et al. (2007). This author suggested that appearance is important when there are cognitive interactions with other organoleptic properties. Color, which is a strong attribute of appearance, can cognitively alter perceptions of smell and taste, although non visualization of food does not eliminate the perceptions and classifications of smell and taste (Delwiche, 2004). For Spence (2015), the appearance had more importance than the smell in the decision power of the consumer, and interference in the determination of the taste may be due to the color or tonality of the food, which comes from the process of the cooking and preparation of the food.

The taste was the main sensorial property in the consumer decision since the fish that presented the best flavor evaluation was the one that had better classification in the ordering preference. However, it is worth stressing that taste is characterized by the synesthetic among appearance, aroma and texture (Van Dongen et al., 2012; Poinot et al., 2013; Spence, 2015; Lease et al., 2016) observed in the PCoA, which retained all these properties on the primary axis. Although some organoleptic properties have not shown significance when evaluated individually, what truly translates the taste response is the interaction between them (Petit et al., 2007). The recurrent consumption of a determined food enables an association between the sensory attributes and the food, for example, when a consumer feels the taste of a particular food when only the aroma of the food is actually felt (Delwiche, 2004).

With frequency of consumption and synesthetic learning, it can be said that each consumer assumes a food culture (Olsen et al., 2008), and this defines the organoleptic characteristics of foods that the consumer likes or does not like. Thus, when a person does not like a determined food, it means that the consumer associates the consumed food with a bad feeling that has already passed or even something that is not related to its food culture (Olsen et al., 2008), which is called gustatory memory. Sanceda et al. (1994) reinforced the influence of gustatory memory on food choice when it describes that a determined group of participants preferred to consume similar foods that they were already accustomed to consuming.

In this study, the choice of unsalted fish as the best food may be associated with gustatory memory since saltwater fish are not commonly consumed in the western region of Paraná. Thus, food culture and taste memory, which are inherent in each participant, may interfere with the sensory analysis (Sanceda et al., 1994; Olsen et al., 2008), as observed in our study, which showed that the effect of the participants was significant for appearance, aroma and off-flavor.

CONCLUSION

The BFT production systems with common salt and marine salt did not showed relevant alterations in the body composition of the tilapia. However, the organoleptic properties, performed through sensory analyzes, showed that the composition of salt in the production system interferes with the quality of the tilapia fillet. Although the fish reared with two conditions of salts have been showed a subtle reduction in the preference of tasters in relation to ponds, the BFT is promising. Furthermore, the synesthesia is fundamental for the definition of taste, which is the main organoleptic property assumed by consumers in choosing a food, and the customer's preference for a particular food is directly related to food culture and gustatory memory. These induce consumers to prefer regional foods and foods that they are accustomed to consuming, being a personal action. At the end of the study, it was concluded that fish, especially fish produced in BFT, is a great alternative to meet current and future food demands.

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