v. 4, n. 10, 2024

Journal of
Engineering
Research

TECHNOLOGICAL USE OF COLOSSOMA MACROPOMUM: FROM INTENSIVE BREEDING IN BFT (BIOFLOC TECHNOLOGY) TO THE USE OF PACKAGING IN MODIFIED ATMOSPHERES

Marcondes Agostinho Gonzaga Junior
Adjunct Professor of the Department of Fisheries Engineering, ``Universidade Federal de Rondônia`` – UNIR, Presidente Medici - Rondônia, Brazil
http://lattes.cnpq.br/8738530137856048

Vinicius Dias Costa
Student of the Fisheries Engineering course, ``Universidade Federal de Rondônia`` – UNIR, Presidente Medici-Rondônia, Brazil
http://lattes.cnpq.br/2151348999291632

João Vitor Ferreira Mangarotti
Student of the Zootechnics course, ``Universidade Federal de Rondônia`` – UNIR, Presidente Medici - Rondônia, Brazil
http://lattes.cnpq.br/3705348094937932

Donovan Filipe Henrique Pinto
Adjunct Professor of the Department of Fisheries Engineering, ``Universidade Federal de Rondônia`` – UNIR, Presidente Medici - Rondônia, Brazil
http://lattes.cnpq.br/1634958316623230

Severino Adriano Lima de Oliveira
Adjunct Professor of the Department of Fisheries Engineering, ``Universidade Federal de Rondônia`` – UNIR, Presidente Medici - Rondônia, Brazil
http://lattes.cnpq.br/1397036699259283

Carlos Victor Bessa Correa
Professor of Food Technology Course, ``Universidade do Estado do Amazonas`` – UEA, Manaus - Amazonas, Brazil
http://lattes.cnpq.br/0410590041688259

Abstract: The tambaqui Colossoma Macropomum (CUVIER 1818) is a fish with potential for zootechnical production, using the modified atmosphere packaging method (EAM). EAM consists of replacing the atmosphere around the product in packaging with gases such as CO2, N2 and O2. The tambaqui used was produced in a Biofloc Technology system (bioflocs), until it reached a size of 400g, called "curumim". Three treatments were carried out: A (control), B (100% CO2) and C (vacuum). The samples were packaged and kept refrigerated at 2 ± 1°C, being subjected to analysis at times 0, 1, 7, 14, 21 and 30 days of refrigerated storage. Physicochemical parameters such as pH, N-BVT, TBA were evaluated, in addition to microbiological analyses. On the 30th day of storage, the treatments exceeded the microbiological limit established by legislation (7 Log CFU/g). During the storage period, the presence of Salmonella or E. coli was not detected. TBA indices remained below 1.5 mg MA/kg. It is concluded that atmosphere C (vacuum) and 100% CO2 stood out compared to the control aerobic treatment, extending the useful life by up to 21 days, being effective in maintaining physical-chemical and quality parameters within acceptable limits. established by legislation.
Keywords: Bioflocs; Curumim; Fish processing; Refrigerated storage.

INTRODUCTION

Aquaculture has grown faster than capture fisheries over the past two years and is expected to increase even further over the next decade. In 2020, aquaculture animal production reached 87.5 million tons and capture fishery production fell to 90.3 million tons, representing a decrease of 4.0% compared to the average recorded in the previous three years (FAO, 2022).

In the North of Brazil, the species is highly appreciated by the local population and the demand for its meat is the main reason why researchers have given importance to developing a technological package that will improve the production of this species (Santos et al., 2022). Tambaqui curumim is a type of cultivation in which fish are fattened to around 400-500g, widely consumed and sold as a product for ready-to-eat meals (SEPROR/SEPA, 2015).

The microbiota generated is an excellent source of nutrients for fish, resulting in better growth and feed conversion (Debbarma et al., 2022; Avnimelech, 2006). In this process, the inorganic nitrogen present in the water is converted and made available in the form of microbial protein that is ingested by cultivated organisms, improving protein conversion from 20% to 45% (Avnimelech, 2000).

In this sense, cultivation in bioflocs (BFT system – Biofloc Technology) can be an important alternative in the production of animal protein, from tambaqui, with a significant reduction in environmental impact (Nakayama et al., 2022). These flakes formed in the environment act as a food supplement with a high protein content, a great nutritional advantage with an emphasis on the primary stages (fry and juveniles) in the cultivation of this species (Azevedo, 2022).

Regarding processing, an alternative for fish is the application of the modified atmosphere packaging method, which consists of replacing the atmosphere that surrounds the product at the time of packaging with another (a gas or optimized mixture of gases such as CO2, N2 and O2) specially prepared for each type of food, allowing better control of chemical, enzymatic and microbiological reactions, avoiding or minimizing the main degradations produced during the storage period (Zhang et al., 2022).

Packaging plays an important role in food conservation, which is essential for consumers and the industry, as it prevents physical, chemical and microbiological deterioration and, consequently, contributes to food quality and safety Zhang et al. (2022), which can also facilitate and ensure transportation, facilitate the distribution of food, identify the content in quality and quantity, identify the manufacturer and the quality standard, attract the buyer's attention, induce the consumer to purchase and inform the consumer about the composition, nutritional value and other characteristics of the food, in accordance with legislation (Realini & Marcos, 2014).

In view of the above, seeking to follow market trends by using specimens weighing approximately 400 g (tambaqui "curumim"), the present study aimed to diversify the supply of fish products through the use of a "sustainable" cultivation system (BFT), checking post-slaughter, the use of modified atmosphere packaging (EAM) with oxygen, CO2 and vacuum, evaluating the increase in the shelf life of the fish weekly for a period of thirty days.

MATERIAL AND METHODS

ENVIRONMENT AND ZOOTECHNICAL CONDITIONS

Animal experimentation using Biofloc (BFT) was developed using part of the structure of the box system at the Animal Health Experimental Center (CESA) and the control treatment was carried out in an excavated tank, both at ``Universidade Federal de Rondônia`` – UNIR, Presidente Médici Campus lasting sixty days.

For the formation and maintenance of the BFT, a 500 liter box of water was used with constant aeration using a radial compressor (0.5 CV), and sugar cane molasses was used as fertilizer to achieve a C:N ratio of 20:1. Initially, to accelerate the formation of the biofloc, 5 g of wheat bran was added to 100 liters of water in the first three days and one gram of commercial feed daily, to create a surface for the attachment and development of microorganisms (Avnimelech, 1999). After the system stabilization period, 200 liters of water were added to increase the growth of microorganisms. From this initial process, 100 liters of BFT and another 100 liters of artesian well water were distributed in the 3 experimental units that corresponded to the cultivation tanks. Regarding the control treatment, an excavated earth pond was used with a total water renewal rate in 24 hours.

The water used in the experiment was from the University's supply network and there was no significant water renewal throughout the BFT experiment, only the evaporation rates being corrected. To verify and control the fluctuations of nitrogenous compounds in the system, water analyzes were carried out weekly throughout the experiment. Where, temperature, electrical conductivity and dissolved oxygen concentration were measured using a multiparameter probe (YSI® MPS 556, precision ± 0.1) and pH (Toledo®, precision ± 0.01). Ammonia, nitrite and nitrate levels were monitored once a week using an AT 101 photocolorimetric and titration kit (Alfakit®, Florianópolis – SC, Brazil).

A total of 200 tambaqui juveniles were used, with an average weight of 50 g, from private laboratories located in the region. They were fed three times a day, at 8:00 am, 1:00 pm and 6:00 pm, with commercial extruded feed with crude protein (CP) content varying from 35 to 40% according to the stored biomass. Biometry was performed every ten days to adjust the biomass calculation and correct the amount of feed.

FISHING, SLAUGHTERING AND PROCESSING OF FISH

The fish processing stages and chemical and microbiological analyzes were carried out in the laboratory structures of the Aquaculture and Technology company Aquanorth, in the city of Manaus, in the state of Amazonas, lasting forty days.

90 specimens weighing 300 to 400g were fished and slaughtered by immersing the fish in water with 50% ice, saturated with CO2 and a temperature close to 1°C (Schropfer et al., 2016). Sample preparation began at the fishing site, pre-washing the entire fish using sodium chloride and sodium hypochlorite solutions, and then gutting it. The fish were packaged in plastic films, placed in isothermal boxes with eutectic ice, and transported by land and air to the company.

At the processing unit, the fish was washed again, then packaged in a modified atmosphere using an appropriate sealing machine (TECMAQ, model AP-450), subsequently packaged in poly (ethylene-co-vinyl alcohol) plastic packaging (EVOH), under the oxygen to O2 transmission rate of 28.18 cm3/m2, at 23 °C and 80% RH (relative humidity) at 1 atm. The gas mixture compositions for packaging the product were: (A) Control in air-filled atmosphere conditions; (B) atmospheric conditions (100% CO2) and (C) vacuum. Immediately after packaging, all samples were stored in a refrigerated incubator at a constant temperature (2 ± 1°C) for 30 days.

Chemical and microbiological analyzes were carried out immediately after packaging (time zero) and later on days 1, 7, 14, 21 and 30 days of storage. From the dorsal region of the fish, physical (pH) and chemical (proximal composition) analyzes were carried out according to Jesus (2001); total volatile bases (BVT), biochemical (TBA), and microbiological bases, according to the methodology proposed by the analytical standards of the Instituto Adolfo Lutz (IAL, 2008) and adapted by Gonzaga (2010).

STATISTICAL ANALYSIS

A non-parametric statistical test was performed and the Kruskal-Wallis test with multiple comparison post-test was applied. Statistical analyzes were carried out using the R software (Rstudio Team, 2020).

RESULTS AND DISCUSSION

FARMED FISH IN BFT

The average final weight gain of tambaqui juveniles raised in a BFT system is satisfactory when compared to conventional excavated pond systems. Dissolved oxygen values in the water maintained an average of 7.05 mg L -1. The average pH value in the water ranged from pH 6.25 to 7.36 and the average temperature was 28.35°C, without showing large variations throughout the cultivation. Electrical conductivity had an average value of 135 ± 15 μS/cm, not interfering with the development of the species. The average concentrations of nitrite were 0.9 mg L-1 ± 0.16 and nitrate 5.3 mg L -1 ± 0.5. These concentrations remained within the range considered ideal for rearing juvenile tambaqui (Cavero et al., 2009).

There has been work carried out with Piaractus brachypomus (pirapitinga), a rheophilic fish widely distributed in the Amazon River basin, with characteristics suitable for developing in the BFT as it is a filter-feeding fish. However, it presented yield values similar to the results found in semi-intensive (nurseries and masonry tanks) (Abad et al., 2014). Barrero et al. (2012) analyzing the quality of pirapitinga meat produced in the biofloc system, it can be concluded that cultivation in BFT does not affect the quality of the meat, maintaining the characteristics of the species. Results similar to the quality presented in this work.

QUALITY OF FISH IN EAM

The "curumim" tambaqui fish had an average length of 18.30 ± 1.25 cm and an average total weight of 0.372 ± 0.04 kg, and the chemical composition (g/100 g): Moisture (76.26 ± 0.35), Protein (17.57 ± 0.029), Lipids (2.37 ± 0.032) and Ash (1.6 ± 0.003).

pH values (Figure 1) did not differ significantly between treatments, but were significantly affected by storage time. The increase in pH is affected by the fish species, type and microbial load, capture methods, handling and storage (Teodoro et al., 2007). Treatment with high amounts of carbon dioxide showed lower pH values, partly due to the dissolution of CO2 in the moisture of the meat, which leads to a reduction in pH, through the formation of carbonic acid (Gonzaga, 2010). The pH of the control sample (A) showed a rapid increase from the 20th, reaching values above 7, which led to an increase in microorganism counts (Table 1), due to proteolytic activities. The maximum pH indicated is 6.5 ± 0.1, according to RIISPOA (Riispoa, 2002). The treatments (CO2) and (Vacuum) varied little, the pH stability may have been caused by the buffering effect of fish muscle, attributed to the presence of soluble proteins, amino acids, trimethylamine and low molecular weight substances in the fish muscle, which can mask changes in this parameter (Gonzaga et al., 2015).

The (N-BVT) values, Figure 2, were not significantly affected by the treatments, except for the control, which exceeded the limit of 30 mg/100g (RIISPOA, 2002) after approximately 20 days of storage.

Gonzaga (2010) found in a study carried out with pirarucu fillets in EAM, that the formation of N-BVT increased over the course of storage in samples with 50% CO2 / 50% O2, 100% CO2 and Vacuum, the value of N- BVT were approximately 15 mg/100 g of muscle for all storage forms. TBARS values were used as indicators of the degree of lipid oxidation, which quantify malonaldehyde, one of the main products formed during the oxidative process. The susceptibility of muscle tissue to oxidation is due to its high concentration of catalysts (iron and hemoglobin) and lipids (Gonzaga et al., 2015).

Figure 3 shows that there was no rancidity in the cuts kept refrigerated at 2 ± 1° and packaged with CO2 and vacuum, to the point of compromising the sensorial quality of the product under study. The tambaqui fish samples had an initial count for psychrophilic aerobic microorganisms of 2.3 log CFU/g-1 and 2.1 log CFU/g-1 for mesophiles in relation to the control (figure 3). The growth of psychrophilic aerobic microorganisms increased with each day of storage, with the control treatment being the one with the highest growth rate in 30 days (9 log CFU/g-1). In packaging with modified atmosphere there was an increase significant increase in mesophile counts, exceeding the limit of 107 CFU/g, adopted as the maximum acceptance limit in this study, in 30 days of storage. Supporting this statement is the fact that when the count reached values close to 107, a value considered to be the minimum for the beginning of the conversion of trimethylamine oxide (OTMA) to trimethylamine TMA by mesophilic microorganisms. No presence of Salmonella spp. was detected. (absence in 25 g) in none of the treatments. For coagulase-positive Staphylococcus and coliforms, the result was less than 3 CFU/g in all treatments and storage times, according to the Compendium of Norms and Standards for Food (Riispoa, 2002).

CONCLUSIONS

The use of BFT biofloc technology in the cultivation of tambaqui curumim promoted production, water savings and, as a result, a lower volume of effluents in 60 days of experiment, in addition to quality fish. Regarding the accumulation of some nitrogenous compounds such as nitrate, it is possible to suggest, for better use, the association with the cultivation of plants capable of using such compounds in their growth.

Packaging in modified atmosphere EAM and vacuum, for tambaqui curumim, provided an increase in the shelf life of the fish product, compared to aerobic treatment, maintained in these packaging conditions, and temperature abuse must be avoided and complied with. strictly adhere to good hygiene practices in the processing of raw materials. The use of packaging with 100% CO2 and Vacuum still provides quality for current consumption after 21 days of storing the product under refrigeration. Therefore, it is an effective method for preserving the limiting acceptability parameters proposed by legislation for foods derived from tambaqui fish for this size range.

REFERENCES

Abad, D., Rincón, D., & Poleo, G. (2014). Índices de rendimiento corporal en morocoto *Piaractus brachypomus* cultivado en sistemas Biofloc. *Zootecnia Tropical*, *32*(2), 119-130.

Avnimelech, Y. (2006). Bio-filters: the need for an new comprehensive approach. *Aquacultural engineering*, 34(3), 172-178. https://doi.org/10.1016/j.aquaeng.2005.04.001

Azevedo, R. M. D. G. (2022). Análise econômica de um módulo produtivo intensivo em cultivo trifásico de tilápia (*Oreochromis niloticus*) com tecnologia de bioflocos integrado com biodigestor (Bachelor's thesis, Universidade Federal do Rio Grande do Norte). https://repositorio.ufrn.br/handle/123456789/46361

Barrero, M., Paredes, A., Romero, O., & Poleo, G. A. (2012). Proximate composition and flesh quality of red bellied pacu, *Piaractus brachypomus*, cultured in two different closed systems. *Zootecnia Tropical*, 30(3), 263-268.

Cavero, B. A. S., Rubim, M. A. L., & Pereira, T. M. (2009). Criação comercial do tambaqui *Colossoma macropomum* (Cuvier, 1818). Manejo e sanidade de peixes em cultivo. Macapá, 1, 33- 46.

Debbarma, R., Meena, D.K., Biswas, P., Meitei, M.M & Singh, S.K. (2022). Porcionamento de resíduos microbianos na nutrição de peixes por meio da produção frugal de bioflocos: um paradigma sustentável para o esverdeamento do meio ambiente. *Journal of Cleaner Production*, 334, 130246. https://doi.org/10.1016/j.jclepro.2021.130246

FAO -Food and Agricultural Organization. (2022). *Relatório da FAO sobre o Estado Mundial da Pesca e Aquicultura (SOFIA) observa o crescimento impulsionado pela aquicultura*. FAO.ORG

Instituto Adolfo Lutz – I.A.L. Métodos físico-químicos para Análise de Alimentos. 4. Ed. São Paulo: IAL, 1020 p. 2008.

Jesus, R. S. D., Lessi, E., & TENUTA-FILHO, A. (2001). Estabilidade química e microbiológica de" minced fish" de peixes amazônicos durante o congelamento. *Food Science and Technology*, 21, 144-148. https://doi.org/10.1590/S0101-20612001000200004

Júnior, G., & Agostinho, M. (2010). Avaliação da qualidade de filés de Pirarucu (*Arapaima Gigas*, Cuvier 1829), refrigerados e embalados sob atmosfera modificada (Master's thesis). http://repositorio.furg.br/handle/1/2202

Junior, M.G., Jorge, M.B., Cortez-Vega, W.R., Pizato., S., & Prentice-Hernández, C. (2015). Atributos de qualidade de filés de beijupirá (*Rachycentron canadum*) refrigerados e embalados em atmosfera modificada. *Food Process Technol*, 6 (445), 2. http://dx.doi.org/10.4172/2157-7110.1000445

Leistner, L. (1992). Food preservation by combined methods. *Food research international*, 25(2), 151-158. https://doi.org/10.1016/0963-9969(92)90158-2

Nakayama, C. L., Silva, L. F. S., Santos, F. A. C. D., Boaventura, T. P., Favero, G. C., Palheta, G. D. A., ... & Luz, R. K. (2022). Zootechnical Performance and Some Physiological Indices of Tambaqui, *Colossoma macropomum* Juveniles during Biofloc Maturation and in Different Feed Regimes. Agriculture, 12(7), 1025. https://doi.org/10.3390/agriculture12071025

Realini, C. E., & Marcos, B. (2014). Active and intelligent packaging systems for a modern society. Meat science, 98(3), 404-419. https://doi.org/10.1016/j.meatsci.2014.06.031

RIISPOA – Regulamento da inspeção industrial e sanitária de produtos de origem animal. (2002). Pescados e derivados. Ministério da Agricultura, Pecuária e Abastecimento.

Rodrigues. P. T., (2013). Manual de qualidade da água para aquicultura. Piscicultura. Florianópolis/SC. http://cpamt.sede.embrapa.br/biblioteca/capacitacao-continuada-detecnicos-da- cadeia-produtiva-dapiscicultura/modulo-2/Manual-Qualidade Agua-Aquicultura.pdf

Rstudio Team. RStudio: Integrated Development for R. RStudio, PBC, Boston, MA, 2020.http://www.rstudio. Com

Santos, T. S. D., Souza, E. D. S., Bragagnolo, N., Costa, A. R. D., Jordão Filho, J., & Almeida, N. M. D. (2022). Essential fatty acids in farmed tambaqui (*Colossoma macropomum*) from the Brazilian Amazon Area. *Acta Scientiarum. Animal Sciences*, 45. https://doi.org/10.4025/actascianimsci.v45i1.57090.

SEPROR – Secretaria de Estado de Produção Rural. (2015). Relatório Técnico: Desperdício de pescado no Amazonas. Secretaria Executiva de Pesca e Aquicultura – SEPA. http://. sepror.am.gov.br/ano-2015/

Teodoro, A. J., Andrade, É. C. B. D., & Mano, S. B. (2007). Evaluation of the use of modied atmosphere packaging in sardine (*Sardinella brasiliensis*) preservation. Food Science and Technology, 27, 158-161. https://doi.org/10.1590/S0101-20612007000100028

Zhang, X., Pan, C., Chen, S., Xue, Y., Wang, Y., & Wu, Y. (2022). Effects of modified atmosphere packaging with different gas ratios on the quality changes of golden pompano (Trachinotus ovatus) fillets during superchilling storage. Foods, 11(13), 1943. https://doi.org/10.3390/foods11131943