Latin American Journal of Aquatic Research, 49(3): 465-475, 2021
DOI: 10.3856/vol49-issue3-fulltext-2659

*Research Article*

# Bromatological study of the freshwater bivalve *Anodontites trapesialis* (Lamarck, 1819) (Unionida, Mycetopodidae)

**Douglas dos Santos Silva**[1,3], **Bruno Bastos Gonçalves**[1]
**Paulo Vitor Divino Xavier de Freitas**[4] **& Carlos de Melo e Silva Neto**[2]
[1]Programa de Pós-graduacão (PPG) em Biodiversidade Animal (PPGBAN)
Universidade Federal de Goiás, Goiânia, Goiás, Brasil
[2]Programa de Pós-graduacão (PPG) Recursos Naturais do Cerrado e PPG Geografia
Universidade Estadual de Goiás, Brasil, Instituto Federal de Goiás, Cidade de Goiás, Goiás, Brasil
[3]Associação Guardiões do Cerrado (AGC), Serranópolis, Goiás, Brasil
[4]Programa de Pós-graduacão (PPG) em Zootenia, Universidade Federal de Goiás, Goiânia, Goiás, Brazil
Universidade Estadual de Goiás, Campus São Luís de Montes Belos, Goiás, Brasil
Corresponding author: Carlos de Melo e Silva Neto (carloskoa@gmail.com)

**ABSTRACT.** In Brazil, *Anodontites trapesialis* is a mussel species that occurs spontaneously in fish breeding sites. This species feeds on the remains of cultural treatments of other aquaculture species. The objective of the work is to understand the bromatological composition of mussel *A. trapesialis*. Individuals were selected to compose three samples of 500 g each of *A. trapesialis* for chemical composition, with viscera and viscera + shells being evaluated. The species presented 40.42 to 62.76 g of viscera per individual with a moisture content of 5.16% for viscera + shells and 86.5% for viscera. The mussel contains 42.6 and 12.96% crude protein, 3.16 and 1.76 of ether extract, 0.76 and 2.5% of crude fiber for viscera and viscera + shells. The total digestible nutrients were 74.16 and 36.96% for viscera and viscera + shells and 18.43 and 52.83% of mineral material for viscera and viscera + shells. *A. trapesialis* has relevant characteristics in its chemical composition as high protein content that gives the species potential for the human, animal, and other byproducts production.

**Keywords:** *Anodontites trapesialis*; centesimal composition; food use; minerals; calcium; protein; alternative food; aquaculture

## INTRODUCTION

With a complex life cycle, the Unionidae freshwater bivalves have their early stages of development in the inner demibranch (Bonetto & Ezcurra 1962, Silva-Souza et al. 2011). Then the planktonic larvae, called glochidia or lasidium, complete their development cycle as temporary parasites in fish gills (Fryer 1970, Mansur et al. 1987). Thus, after complete metamorphosis (~27 days after fixation), the freshwater bivalves release themselves from the fish to become benthic organisms (Castellanos & Landoni 1990). The bivalve *Anodontites trapesialis* is a freshwater bivalve from the Unionidae family, present from southern Mexico to northern Patagonia, and reside in generally lentic habitats associated with substrate between 1 and 2 m deep (Simone 1994). This species can be found in abundance in ponds of farms and fish farms (Felipi & Silva-Souza 2008). It is a hermaphrodite species (Callil & Mansur 2007) capable of storing a large number of larvae (3200 to 3500) in a single individual of about 10 cm shell length (Bonetto & Ezcurra 1962, Hebling 1976). *A. trapesialis* may impair aquaculture because despite the minimal injuries to fish caused by parasites, especially considering the short-term infection, the parasites can reduce fish growth and increase vulnerability to opportunistic pathogens (Silva-Souza & Eiras 2002).

Corresponding editor: César Lodeiros

In Brazil, *A. trapesialis* occurs spontaneously in fish breeding sites and is considered to present an aggressive behavior of invasive species (Felipi & Silva-Souza 2008). This species feeds on the remains of cultural tracts of other aquaculture species and grows along with the reservoirs, only being noticed when the reservoirs are depleted or dry. The shells of *A. trapesialis* (average 15 cm length and 60 g weight) consist of three layers: the periostracum, the prismatic layer, and the nacreous layer (Callil & Mansur 2005).

On the other hand, *A. trapesialis* has been considered a good opportunity for aquaculture, and some studies have reported its potential as a food source with high nutritional values (Tello-Panduro et al. 2003). The species also offer the potential for animal feed, food supplements, especially in mineral supplementation, and even in human food as supplements and substitutes for the food industry (Klunklin & Savage 2018a,b). Piwoni-Piórewicz et al. (2019) realized that the shells of different bivalve mollusks vary and may have specific compositions. In this work, the authors verified different calcium carbonate compositions in the lagoon cockle *Cerastoderma glaucum*, soft-shell clam or sand gaper *Mya arenaria*, Baltic macoma *Limecola balthica*, and bay bivalve *Mytilus trossulus*. In addition, some bivalve species are used in the production of mineral compounds, and they are already studied for their use in the production of raw materials for industry, for example, the use of their shells to supply calcium carbonates (Yao et al. 2014, Jovic et al. 2019). Finally, species such as *Anodonta* sp. have an interesting potential for producing half pearls (Mabe) and round pearls in southeastern Mexico, based on its multicolored and lustrous pattern nacre layer (Saucedo et al. 2021).

Thus, the potential and various uses of bivalve compositions warrant the first step of determining the composition of this species. The objective of the work is to determine the bromatological composition of bivalve *A. trapesialis*.

## MATERIALS AND METHODS

*Anodontites trapesialis* (Figs. 1a-b) were manually collected (n = 210; length = 15 ± 5 cm) during September 2019 (dry season) from a fish farm (16°48'45.82"S, 49°32'8.73"W) in the municipality of Guapó, State of Goiás, Brazil. The samples were transported to the Federal University of Goiás (UFG) aquaculture sector using plastic bags filled with water from sample sites under constant aeration. The specimens were euthanized and dissected for shell separation.

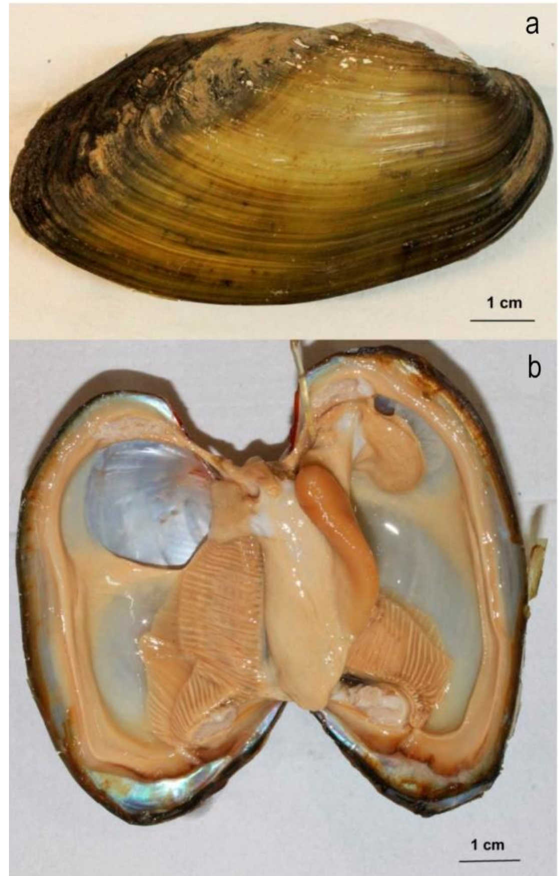


**Figure 1.** a) Adult individual of bivalve (*Anodontites trapesialis*) with a closed shell, b) the same adult individual with open-shell showing tissues and organs.

Individuals were selected to organize three samples (samples triplicated) of 500 g each of *A. trapesialis* to evaluate bromatological composition. The samples were dried in a forced ventilation oven at 65°C for three days. All material from the composite samples, including shells and internal bivalve material, was crushed in the Lippel crusher and then passed through a Wiley mill in 1.0 mm (20 meshes) sieves. It was decided to use the whole bivalve due to the difficulty of separating the shell from internal structures in the already dried bivalve and the low meat yield of the internal components after the bivalve dried.

Fresh bivalves were used and removed from the shell to check the chemical composition of the internal bivalve structure (called viscera in this study). The fresh mass of each bivalve was weighed on a precision scale until 200 g of fresh material per sample. Individuals with sizes and weights close to the average of the individuals were searched to compose the samples of the different treatments (shells and shells + viscera) and use the same amount of sample for each triplicate. Subsequently, the dry and fresh materials were sent for chemical analysis at the Solocria

Laboratory to determine macronutrients and micronutrients in animal tissue following the methodology recommended by Tedesco et al. (1995) and Miyazawa et al. (1999).

Phosphorus (P), calcium (Ca), and magnesium (Mg) were considered nutrients. Bromatological analyses with the characterization of dry mass (DM), crude protein (CP), ether extract (EE), crude fibers (CF), and total digestible nutrients (TDN) were also performed (Silva & Queiroz 2006, Souza et al. 2013). The values obtained from the samples were used to calculate average values and standard deviation for comparison. To observe the relationship between each evaluated parameter, multivariate analysis (principal components analysis, PCA) was used. The bromatological compositions of the 'shell + viscera' and 'viscera' were used in Pearson's correlation analysis at a statistical significance of 95% to compare the shell and viscera components with correlation coefficient for significant pairs.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

## RESULTS

The fresh weight of the viscera varied between 40.42 to 62.76 g per individual, presenting a dry mass of only 14.5% and being composed of 42.6% crude protein, 3.16 ether extract, and 0.76% crude fiber. The values of total digestible nutrients (TDN) were 74.16% and still 18.43% of mineral material.

The dry mass of *Anodontites trapesialis* (shell + viscera) varied from 25 to 130 g per individual. Dry mass values of 96.84% were 12.96% crude protein, 1.76 ether extract, and 2.5% crude fiber. The values of TDN were 36.96%. About 52.83% of *A. trapesialis* is composed of mineral material. Of this composition, 49.83% is calcium oxide (CaO), representing 94% of the mineral composition of the species. Another 1.33% of the total is phosphorus (2.5%), and only 0.23% (less than 0.5% of the total) is magnesium oxide (MgO) (Table 1, Fig. 2).

In the composition of shells + viscera, the percentage of CP is associated with P. Mineral material (MM) is associated with a percentage of Ca, as it was determined that 94% represented this material. TDN, CF, and EE are directly related to each other, with TDN and CF directly associated, while CP also influences CP in the shell in shells + viscera. The levels of CP in the shells are inversely related to the levels of Ca in the

**Table 1.** Percentage of bromatological characterization of *Anodontites trapesialis*.

| | Shell + Viscera | Viscera |
|---|---|---|
| Total digestible nutrients | 36.96 ± 1.98 | 74.16 ± 4.27 |
| Dry mass | 96.84 ± 2.56 | 14.5 ± 0.5 |
| Crude protein | 12.96 ± 3.36 | 42.6 ± 2 |
| Ether extract or lipids | 1.76 ± 0.56 | 3.16 ± 0.2 |
| Crude fiber | 2.5 ± 0.33 | 0.766 ± 0.15 |
| Mineral material or ash | 52.83 ± 0.56 | 18.43 ± 4.96 |
| Calcium | 30.33 ± 2.89 | 11.73 ± 3.95 |
| Phosphorus | 1.33 ± 0.51 | 5.76 ± 0.37 |
| Calcium oxide | 49.83 ± 0.56 | - |
| Magnesium oxide | 0.23 ± 0.04 | - |

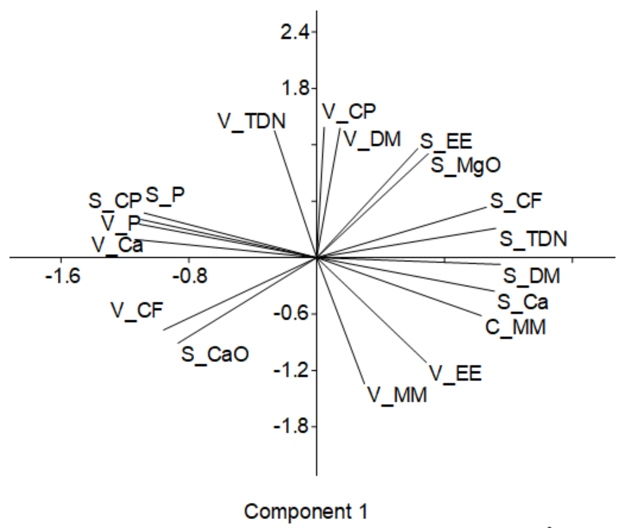


**Figure 2.** Principal components analysis of the nutritional contents of *Anodontites trapesialis* (symbols with V refer to the nutritional contents of the viscera, while with S, they refer to the contents of the shells). TDN: total digestible nutrients, P: phosphorus, Ca: calcium, DM: dry mass, CP: crude protein, EE: etheric extract or lipids, CF: crude fiber, MM: mineral material, CaO: calcium oxide, MgO: magnesium oxide.

shells (R = -0.999, *P* = 0.000) and directly related to the levels of P in the shell (R = 0.998, *P* = 0.000). A CP-DM relationship was determined considering the composition of the viscera alone, also associated with TDN, which was different from shell + viscera.

The CF composition is also associated with the viscera P and Ca, but it is unrelated to MM and EE. The correlation also highlights an inverse relationship between MM and TDN for the viscera (R = -0.999; *P* = 0.019). The main relationships between shells and viscera found by PCA (Fig. 3) and correlation reflected in a direct relationship between the shell CP with the viscera *P*-values (R = 0.998; *P* = 0.024) and an inverse

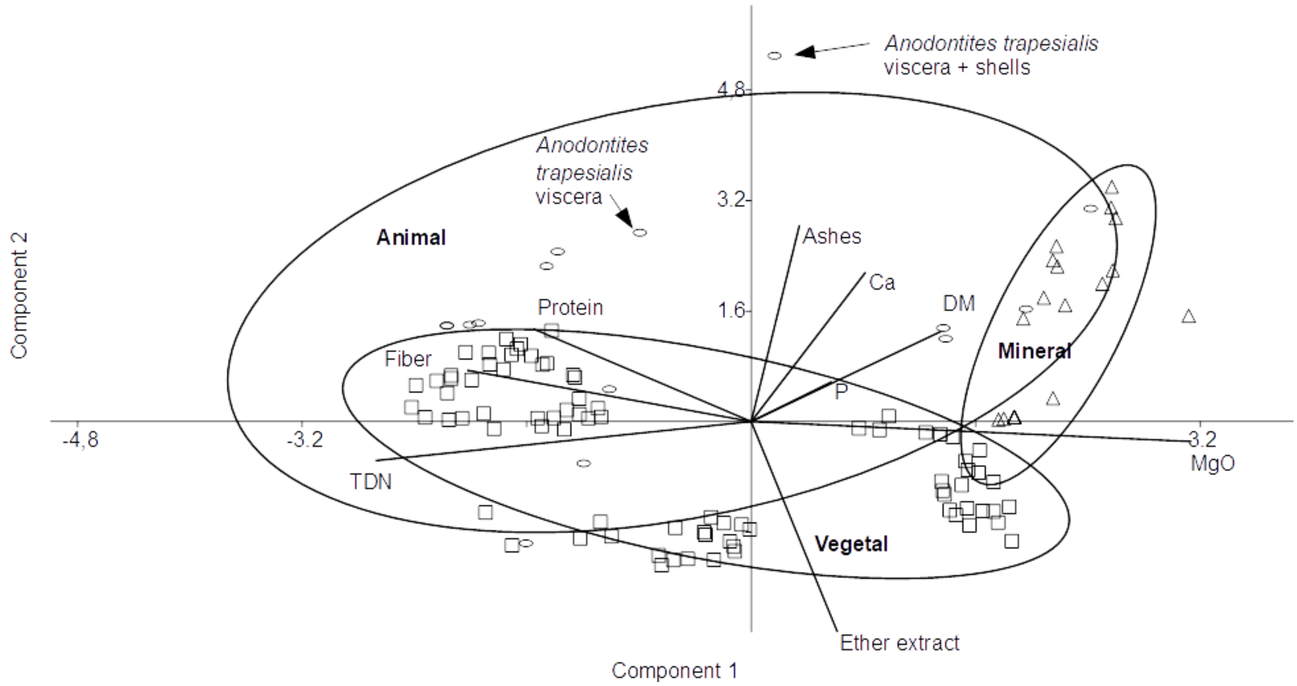


**Figure 3.** Principal components analysis of sources to animal feed composition. TDN: total digestible nutrients, P: phosphorus, Ca: calcium, DM: dry mass, MgO: magnesium oxide.

**Table 2.** *Anodontites trapesialis* percent chemical composition in comparison to different marine bivalve and oyster species. M: moisture, CP: crude protein, EE: etheric extract or lipids, CF: crude fiber, Ash: mineral material, CaO: calcium oxide, MgO: magnesium oxide.

| Species | Portion | M | CP | EE | CF | Ash | CaO | MgO | Author |
|---|---|---|---|---|---|---|---|---|---|
| *Anodontites trapesialis* | Shell + Viscera | 4.12 | 12.96 | 1.76 | 2.5 | 52.83 | 49.83 | 0.23 | This study |
| *Anodontites trapesialis* | Viscera | 86.5 | 42.6 | 3.16 | 766 | 18.43 | - | - | This study |
| *Perna perna* | Viscera | 84.19 | 9.09 | 1.1 | 3.5 | 1.58 | | | Furlan et al. (2007) |
| *Perna perna* | Viscera | 84 | 9.01 | 1.1 | | 1.6 | | | Furlan et al. (2011) |
| *Crassostrea gigas* | Viscera | 76.11 | 12.36 | 2.8 | | 2 | | | Andrade et al. (2018) |
| *Crassostrea madrasensis* | Viscera | 82.64 | 9.41 | 3.25 | 3.2 | 1.1 | | | Asha et al. (2014) |
| *Crassostrea rhizophorae* | Viscera | 82 | 9.7 | 1.7 | | 3.2 | | | Martinho & Cruz (2004) |
| *Crassostrea madrasensis* | Shell | 80.45 | | | | | 47.49 | 619 | John & Mary (2016) |
| *Mytella falcata* | Viscera | 76.68 | 17.26 | 3.84 | 1.03 | 1.8 | | | Lira et al. (2004) |
| *Anomalocardia brasiliana* | Viscera | 75.35 | 17.46 | 2.68 | 2.39 | 2.24 | | | Lira et al. (2004) |
| *Tagelus plebeus* | Viscera | 76.7 | 16.39 | 2.84 | 2.35 | 1.61 | | | Lira et al. (2004) |
| *Protothaca antiqua* | Viscera | 84.54 | 9.94 | 0.73 | 2.61 | 2.11 | | | Pinheiro et al. (2020) |
| *Crassostrea iredalei* | Waste | 3.98 | 73.89 | 8.92 | 8.65 | - | | | Peralta et al. (2018) |

relationship between *P*-values of the viscera and Ca contents in the shells (R = -0.999, *P* = 0.000).

## DISCUSSION

The present results demonstrated that the bivalve *Anodontites trapesialis* has particular characteristics in its bromatological composition, making the species worth considering for its use in animal production. Among the most relevant characteristics found are the percentages of crude protein (fresh viscera 42.6% and shells + viscera 12.96%), high levels of total digestible nutrients for fresh viscera 74.16%, and mineral material (52% of the shell) (Table 2). For the minerals, CaO (49.83%) is considered to be high when compared to other sources of mineral materials, such as bovine bone ash with about 33% Ca (Mattar et al. 2014) and bone meal with only 13.65% Ca (Venegas 2009).

In a preliminary study by Dondoni et al. (2017) with processing *A. trapesialis* shells, CaO varied between

**Table 3.** Nutritional composition of different sources for animal feed. DM: dry mass, TDN: total digestible nutrients, Ca: calcium, P: phosphorus, MgO: magnesium oxide, DM: dry mass; NDF: Neutral detergent fiber, Pr.Gr.: higher proportion of grass, Pr.Lg.: higher proportion of legume, Hcel.: hemicellulose (the Abbv. keys are linked in the "description" column) NCR 2001.

| Name | Description | Abbv. key | TDN | Moisture | Crude protein | Ether extract | Crude fiber | Ashes | Ca | P | MgO | DM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mussel | *A. trapesialis* viscera | *A. trapesialis* viscera | 74.2 | 14.5 | 42.6 | 3.2 | 7.7 | 18.4 | 11.7 | 5.8 | 0 | 86 |
| Mussel | *A. trapesialis* viscera+shell | *A. trapesialis* viscera+shell | 37 | 96.8 | 13 | 1.8 | 2.5 | 52.8 | 30.3 | 1.3 | 0.2 | 3.2 |
| Alfalfa | Meal, 17% CP | ALM | 56.4 | 9.7 | 19.2 | 2.5 | 74.4 | 11 | 1.47 | 0.28 | 0.29 | 90 |
| Almond | Hulls | ALH | 58.4 | 13.1 | 6.5 | 2.9 | 65.5 | 6.1 | 0.28 | 0.13 | 0.13 | 87 |
| Apple | Pomace, wet | APP | 57.1 | 64.1 | 7.7 | 5 | 95.7 | 2.6 | 0.2 | 0.14 | 0.09 | 36 |
| Bakery byproduct | Byproduct meal | BBBM | 93.5 | 15.3 | 12.5 | 9.5 | 20.4 | 3.8 | 0.2 | 0.36 | 0.13 | 85 |
| Bakery byproduct | Bread, waste | BBBW | 89.3 | 31.7 | 15 | 2.2 | 12 | 2.8 | 0.14 | 0.2 | 0.05 | 68 |
| Bakery byproduct | Cereal byproduct | BBCB | 87.6 | 11.5 | 9.1 | 3.5 | 13.9 | 3.2 | 0.17 | 0.29 | 0.1 | 89 |
| Bakery byproduct | Cookie byproduct | BBCK | 95 | 9.9 | 9.7 | 10.6 | 19.2 | 3 | 0.23 | 0.29 | 0.13 | 90 |
| Barley | Grain rolled | BGR | 82.7 | 9 | 12.4 | 2.2 | 28 | 2.9 | 0.06 | 0.39 | 0.14 | 91 |
| Barley | Malt sprouts | BMS | 66.4 | 9.5 | 20.1 | 2.3 | 68.8 | 7.4 | 0.24 | 0.51 | 0.18 | 91 |
| Barley | Silage, headed | BSH | 60.2 | 64.5 | 12 | 3.5 | 90.8 | 7.5 | 0.48 | 0.3 | 0.18 | 36 |
| Beet, sugar | Pulp dried | BSPD | 69.1 | 11.7 | 10 | 1.1 | 68.9 | 7.3 | 0.91 | 0.09 | 0.23 | 88 |
| Bermudagrass | Coastal, hay, early head | BCH | 52.9 | 12.9 | 10.4 | 2.7 | 110.1 | 8.1 | 0.49 | 0.27 | 0.19 | 87 |
| Bermudagrass | Tifton-85, hay, 3-4wk growth | BTH | 55.3 | 12.7 | 13.7 | 2.7 | 113.1 | 6.5 | 0.39 | 0.22 | 0.15 | 87 |
| Blood | Meal, ring dried | BMRD | 76.4 | 9.8 | 95.5 | 1.2 | 0 | 2.5 | 0.3 | 0.3 | 0.03 | 90 |
| Blood | Meal, batch dried | BMBD | 76.4 | 9.8 | 95.5 | 1.2 | 0 | 2.5 | 0.3 | 0.3 | 0.03 | 90 |
| Brewers grains | Dried | BGD | 76.4 | 9.3 | 29.2 | 5.2 | 69.6 | 4.3 | 0.3 | 0.67 | 0.26 | 91 |
| Brewers grains | Wet | BGW | 65.9 | 78.2 | 28.4 | 5.2 | 70.2 | 4.9 | 0.35 | 0.59 | 0.21 | 22 |
| Canola | Seed | CS | 127 | 10.1 | 20.5 | 40.5 | 29.4 | 4.6 | 0.44 | 0.68 | 0.21 | 90 |
| Canola | Meal, mech. Extracted | CME | 69.9 | 9.7 | 37.8 | 5.4 | 50.3 | 7.4 | 0.75 | 1.1 | 0.53 | 90 |
| Chocolate | Byproduct | CB | 103 | 4.8 | 11.9 | 20.5 | 39.5 | 2.1 | 0.22 | 0.3 | 0.22 | 95 |
| Citrus | Pulp dried | CPD | 79.8 | 14.2 | 6.9 | 4.9 | 46.4 | 7.2 | 1.92 | 0.12 | 0.12 | 86 |
| Corn, yellow | Cobs | CYC | 54.2 | 9.2 | 3 | 0.6 | 128.4 | 2.2 | 0.1 | 0.06 | 0.06 | 91 |
| Corn, yellow | Distillers grains with solubles, dried | CYD | 79.5 | 9.8 | 29.7 | 10 | 58.5 | 5.2 | 0.22 | 0.83 | 0.33 | 90 |
| Corn, yellow | Gluten feed, dried | CYGD | 74.1 | 10.6 | 23.8 | 3.5 | 47.6 | 6.8 | 0.07 | 1 | 0.42 | 89 |
| Corn, yellow | Gluten meal, dried | CYGMD | 84.4 | 13.6 | 65 | 2.5 | 19.3 | 3.3 | 0.06 | 0.6 | 0.14 | 86 |
| Corn, yellow | Grain, cracked, dry | CYGCD | 85 | 11.9 | 9.4 | 4.2 | 12.9 | 1.5 | 0.04 | 0.3 | 0.12 | 88 |
| Corn, yellow | Grain, ground, dry | CYGGD | 88.7 | 11.9 | 9.4 | 4.2 | 12.9 | 1.5 | 0.04 | 0.3 | 0.12 | 88 |
| Corn, yellow | Grain, steam-flaked | CYGS | 91.7 | 11.9 | 9.4 | 4.2 | 12.9 | 1.5 | 0.04 | 0.3 | 0.12 | 88 |
| Corn, yellow | Grain, rolled, high moisture | CYGRHM | 88.5 | 28.2 | 9.2 | 4.3 | 13.9 | 1.5 | 0.03 | 0.3 | 0.12 | 72 |
| Corn, yellow | Grain, ground, high moisture | CYGGHM | 91.5 | 28.2 | 9.2 | 4.3 | 13.9 | 1.5 | 0.03 | 0.3 | 0.12 | 72 |
| Corn, yellow | Grain and cob, dry, ground | CYGDDG | 83.5 | 10.8 | 8.6 | 3.9 | 29.5 | 1.7 | 0.06 | 0.29 | 0.13 | 89 |
| Corn, yellow | Grain and cob, high moisture, ground | CYGCHMG | 86.6 | 32.9 | 8.4 | 3.9 | 30.4 | 1.7 | 0.05 | 0.28 | 0.12 | 67 |
| Corn, yellow | Hominy | CYH | 83.1 | 11.5 | 11.9 | 4.2 | 27.3 | 2.7 | 0.03 | 0.65 | 0.26 | 89 |
| Corn, yellow | Silage, immature <25% DM | CYSI | 65.6 | 76.5 | 9.7 | 2.5 | 88.2 | 4.8 | 0.29 | 0.24 | 0.19 | 24 |
| Corn, yellow | Silage, normal 32-38% DM | CYSN | 68.8 | 64.9 | 8.8 | 3.2 | 73.1 | 4.3 | 0.28 | 0.26 | 0.17 | 35 |
| Corn, yellow | Silage, mature >40% DM | CYSM | 65.4 | 55.8 | 8.5 | 3.2 | 72 | 4 | 0.26 | 0.25 | 0.16 | 44 |
| Cotton seed | Whole seeds with lint | CSSL | 77.2 | 9.9 | 23.5 | 19.3 | 90.4 | 4.2 | 0.17 | 0.6 | 0.37 | 90 |
| Cotton seed | Hulls | CSH | 34.3 | 11 | 6.2 | 2.5 | 149.9 | 2.8 | 0.18 | 0.12 | 0.17 | 89 |
| Cotton Seed | Meal, solvent, 41% CP | CSMS | 66.4 | 9.5 | 44.9 | 1.9 | 50.7 | 6.7 | 0.2 | 1.15 | 0.61 | 91 |
| Fats and oils | Calcium soaps | FOCS | 164 | 4.7 | 0 | 84.5 | 0 | 15.5 | 12 | 0 | 0 | 95 |
| Fats and oils | Hydrolyzed tallow fatty acids | FOHTFA | 176 | 0.2 | 0 | 99.2 | 0 | 0 | 0 | 0 | 0 | 100 |
| Fats and oils | Partially hydrogenated tallow | FOPHT | 96.6 | 0 | 0 | 99.5 | 0 | 0 | 0 | 0 | 0 | 100 |
| Fats and oils | Tallow | FOT | 147 | 0.2 | 0 | 99.8 | 0 | 0 | 0 | 0 | 0 | 100 |
| Fats and oils | Vegetable oil | FOVO | 184 | 0 | 0 | 99.9 | 0 | 0 | 0 | 0 | 0 | 100 |
| Feathers | Hydrolyzed meal | FHM | 72.8 | 6.7 | 92 | 4.6 | 0 | 3.5 | 0.33 | 0.5 | 0.22 | 93 |
| Feathers | Hydrolyzed meal with some viscera | FHMV | 80.1 | 8.5 | 85 | 8.8 | 0 | 5.5 | 1.36 | 0.77 | 0.06 | 92 |
| Fish byproducts | Anchovy, meal, mech. | FBAM | 76.1 | 8 | 71.2 | 4.6 | 0 | 16 | 4.06 | 2.69 | 0.27 | 92 |
| Fish byproducts | Menhaden, meal, mech. | FBMM | 79.9 | 8.8 | 68.5 | 10.4 | 0 | 19.7 | 5.34 | 3.05 | 0.2 | 91 |
| Grasses, cool season | Pasture, intensively managed | GCSPI | 66.6 | 79.9 | 26.5 | 2.7 | 70.8 | 9.8 | 0.56 | 0.44 | 0.2 | 20 |
| Grasses, cool season | Hay, all samples | GCSH | 56.3 | 11.9 | 10.6 | 2.6 | 103.9 | 7 | 0.58 | 0.23 | 0.2 | 88 |

continuation

| Name | Description | Abbv. key | TDN | Moisture | Crude protein | Ether extract | Crude fiber | Ashes | Ca | P | MgO | DM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grasses, cool season | Hay, immature <55% NDF | GCSHI | 63.1 | 16 | 18 | 3.3 | 81 | 9.2 | 0.72 | 0.34 | 0.23 | 84 |
| Grasses, cool season | Hay, mid maturity 55-60% NDF | GCSMM | 59.7 | 16.2 | 13.3 | 2.5 | 94.6 | 8.8 | 0.66 | 0.29 | 0.23 | 84 |
| Grasses, cool season | Hay, mature >60% NDF | GCSHM | 56 | 15.6 | 10.8 | 2 | 110.7 | 7 | 0.47 | 0.26 | 0.18 | 84 |
| Grasses, cool season | Silage, all samples | GCSSA | 55.7 | 63.5 | 12.8 | 3.1 | 101 | 8.1 | 0.55 | 0.29 | 0.23 | 37 |
| Grasses, cool season | Silage, immature <55% NDF | GCSSI | 60.4 | 63.8 | 16.8 | 2.8 | 83.9 | 9.9 | 0.57 | 0.36 | 0.22 | 36 |
| Grasses, cool season | Silage, mid maturity 55-60% NDF | GCSSMM | 56 | 58 | 16.8 | 2.4 | 93.4 | 8.7 | 0.6 | 0.36 | 0.21 | 42 |
| Grasses, cool season | Silage, mature >60% NDF | GCSSM | 53.2 | 61.3 | 12.7 | 3 | 107.7 | 8 | 0.56 | 0.31 | 0.2 | 39 |
| Grass-legume mixtures Pr. Gr. (17-22% Hcel.) | Hay, immature <51% NDF | GLMHI | 15.7 | 15.7 | 2.4 | 81.1 | 9.2 | 1.01 | 0.31 | 0.26 | 84.3 | 84 |
| Grass-legume mixtures Pr. Gr. (17-22% Hcel.) | Hay, mid maturity 51-57% NDF | GLMHMM | 12.7 | 12.7 | 2.6 | 91.5 | 9.5 | 0.88 | 0.36 | 0.25 | 87.3 | 87 |
| Grass-legume mixtures Pr. Gr. (17-22% Hcel.) | Hay, mature >57% NDF | GLMHM | 15.3 | 15.3 | 2.3 | 104.6 | 7.9 | 0.73 | 0.27 | 0.21 | 84.7 | 85 |
| Grass-legume mixtures Pr. Gr. (17-22% Hcel.) | Silage, immature <51% NDF | GLMSI | 52.9 | 52.9 | 2.9 | 81.7 | 9.1 | 1.02 | 0.34 | 0.25 | 47.1 | 47 |
| Grass-legume mixtures Pr. Gr. (17-22% Hcel.) | Silage, mid maturity 51-57% NDF | GLMSMM | 55.5 | 55.5 | 2.9 | 90.2 | 9.5 | 0.89 | 0.36 | 0.26 | 44.5 | 45 |
| Grass-legume mixtures Pr. Gr. (17-22% Hcel.) | Silage, mature >57% NDF | GLMSM | 61.5 | 61.5 | 2.6 | 103.9 | 9 | 0.85 | 0.33 | 0.23 | 38.5 | 39 |
| Mixed grass-legume (12-15% Hcel.) | Hay, immature <47% NDF | MGLHI | 16.9 | 16.9 | 2.5 | 76.2 | 8.8 | 1.2 | 0.31 | 0.29 | 83.1 | 83 |
| Mixed grass-legume (12-15% Hcel.) | Hay, mid maturity 47-53% NDF | MGLHMM | 14.7 | 14.7 | 2.3 | 86.6 | 9.3 | 1.04 | 0.32 | 0.25 | 85.3 | 85 |
| Mixed grass-legume (12-15% Hcel.) | Hay, mature >53% NDF | MGLHM | 10.3 | 10.3 | 2 | 96.1 | 9.9 | 0.97 | 0.37 | 0.26 | 89.7 | 90 |
| Mixed grass-legume (12-15% Hcel.) | Silage, immature <47% NDF | MGLSI | 54.1 | 54.1 | 2.3 | 76.1 | 9.8 | 1.08 | 0.35 | 0.28 | 45.9 | 46 |
| Mixed grass-legume (12-15% Hcel.) | Silage, mid maturity 47-53% NDF | MGLSMM | 55.9 | 55.9 | 2.5 | 85.8 | 10.1 | 1.09 | 0.35 | 0.27 | 44.1 | 44 |
| Mixed grass-legume (12-15% Hcel.) | Silage, mature >53% NDF | MGLSM | 57.2 | 57.2 | 2.3 | 99.5 | 9.6 | 1.06 | 0.33 | 0.24 | 42.8 | 43 |
| Grass-legume mixtures Pr. Lg. (10-13% Hcel.) | Hay, immature <44% NDF | GLMLGHI | 16.2 | 16.2 | 2 | 72.2 | 9.2 | 1.3 | 0.3 | 0.3 | 83.8 | 84 |
| Grass-legume mixtures Pr. Lg. (10-13% Hcel.) | Hay, mid maturity 44-50% NDF | GLMLGHMM | 15.8 | 15.8 | 2 | 82.6 | 9.1 | 1.17 | 0.3 | 0.27 | 84.2 | 84 |
| Grass-legume mixtures Pr. Lg. (10-13% Hcel.) | Hay, mature >50% NDF | GLMLGHM | 15.7 | 15.7 | 1.7 | 95.1 | 8.7 | 1.09 | 0.28 | 0.25 | 84.3 | 84 |
| Grass-legume mixtures Pr. Lg. (10-13% Hcel.) | Silage, immature <44% NDF | GLMLGSI | 56.8 | 56.8 | 2.2 | 73.3 | 11.5 | 1.16 | 0.36 | 0.3 | 43.2 | 43 |
| Grass-legume mixtures Pr. Lg. (10-13% Hcel.) | Silage, mid maturity 44-50% NDF | GLMLGSMM | 56.7 | 56.7 | 2.1 | 82.4 | 10.8 | 1.14 | 0.34 | 0.28 | 43.3 | 43 |
| Grass-legume mixtures Pr. Lg. (10-13% Hcel.) | Silage, mid maturity >50% NDF | GLMLGSMM50 | 57.1 | 57.1 | 2 | 95.3 | 10.2 | 1.17 | 0.33 | 0.26 | 42.9 | 43 |
| Legumes, forage | Pasture, intensively managed | LFPIM | 78.6 | 78.6 | 3.7 | 57 | 10 | 1.31 | 0.37 | 0.28 | 21.4 | 21 |
| Legumes, forage | Hay, all samples | LFH | 12.2 | 12.2 | 2.1 | 70.8 | 10 | 1.52 | 0.26 | 0.3 | 87.8 | 88 |
| Legumes, forage | Hay, immature <40% NDF | LFHI | 15.8 | 15.8 | 2.1 | 64.9 | 9.5 | 1.56 | 0.31 | 0.33 | 84.2 | 84 |
| Legumes, forage | Hay, mid maturity 40-46% NDF | LFHMM | 16.1 | 16.1 | 2 | 76.3 | 9.4 | 1.37 | 0.3 | 0.3 | 83.9 | 84 |
| Legumes, forage | Hay, mature >46% NDF | LFHM | 16.4 | 16.4 | 1.6 | 90.4 | 9.2 | 1.22 | 0.28 | 0.27 | 83.6 | 84 |
| Legumes, forage | Silage, all samples | LFS | 60.9 | 60.9 | 3.1 | 82.7 | 10.4 | 1.34 | 0.32 | 0.27 | 39.1 | 39 |
| Legumes, forage | Silage, immature <40% NDF | LFSI | 58.8 | 58.8 | 2.3 | 66.9 | 11.1 | 1.39 | 0.36 | 0.3 | 41.2 | 41 |
| Legumes, forage | Silage, mid maturity 40-46% NDF | LFSMM | 57.1 | 57.1 | 2.2 | 78.4 | 10.8 | 1.36 | 0.35 | 0.28 | 42.9 | 43 |
| Legumes, forage | Silage, mature >46% NDF | LFSM | 57.4 | 57.4 | 2.1 | 90.9 | 10.3 | 1.3 | 0.33 | 0.26 | 42.6 | 43 |
| Linseed (flax) | Meal, solvent | LMS | 9.7 | 9.7 | 1.7 | 58.2 | 6.5 | 0.4 | 0.83 | 0.55 | 90.3 | 90 |
| Meat | Meal, rendered | MMR | 6.1 | 6.1 | 12.7 | 0 | 22.9 | 8.86 | 4.2 | 0.26 | 93.9 | 94 |
| Meat | Meat and bone, rendered | MMBR | 6 | 6 | 10.4 | 0 | 30.4 | 10.6 | 4.73 | 0.24 | 94 | 94 |
| Molasses | Beet sugar | MBS | 22.1 | 22.1 | 0.2 | 0.2 | 11.4 | 0.15 | 0.03 | 0.29 | 77.9 | 78 |
| Molasses | Sugarcane | MS | 25.7 | 25.7 | 0.2 | 0.6 | 13.3 | 1 | 0.1 | 0.42 | 74.3 | 74 |
| Oats | Grain, rolled | OGR | 10 | 10 | 5.1 | 44.6 | 3.3 | 0.11 | 0.4 | 0.16 | 90 | 90 |
| Oats | Hay, headed | OHH | 8.1 | 8.1 | 2.2 | 94.4 | 8.5 | 0.37 | 0.22 | 0.17 | 91.9 | 92 |
| Oats | Silage, headed | OSH | 65.4 | 65.4 | 3.4 | 99.5 | 9.8 | 0.52 | 0.31 | 0.2 | 34.6 | 35 |
| Peanut | Meal, solvent | PMS | 7.7 | 7.7 | 1.4 | 34.9 | 5.8 | 0.2 | 0.64 | 0.32 | 92.3 | 92 |
| Potato | Byproduct meal | PBM | 94.6 | 94.6 | 10.8 | 38.6 | 12.8 | 0.49 | 0.29 | 0.11 | 5.4 | 5.4 |
| Rice | Bran | RB | 9.4 | 9.4 | 15.2 | 39.2 | 10.4 | 0.07 | 1.78 | 0.81 | 90.6 | 91 |
| Rye, annual | Silage, vegetative | RASV | 70.3 | 70.3 | 3.8 | 92.7 | 9.6 | 0.43 | 0.42 | 0.16 | 29.7 | 30 |
| Safflower | Meal, solvent | SMS | 6.5 | 6.5 | 2.4 | 92.9 | 4.7 | 0.38 | 0.72 | 0.04 | 93.5 | 94 |
| Sorghum, grain type | Grain, dry rolled | SGDR | 11.4 | 11.4 | 3.1 | 16.8 | 2 | 0.07 | 0.35 | 0.17 | 88.6 | 89 |
| Sorghum, grain type | Grain, steam-flaked | SGSF | 11.4 | 11.4 | 3.1 | 16.8 | 2 | 0.07 | 0.35 | 0.17 | 88.6 | 89 |
| Sorghum, grain type | Silage | SGS | 71.2 | 71.2 | 2.9 | 99.4 | 7.5 | 0.5 | 0.21 | 0.27 | 28.8 | 29 |

continuation

| Name | Description | Abbv. key | TDN | Moisture | Crude protein | Ether extract | Crude fiber | Ashes | Ca | P | MgO | DM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sorghum, Sudan type | Hay | SSH | 13.5 | 13.5 | 2.3 | 104.8 | 8.7 | 0.54 | 0.2 | 0.32 | 86.5 | 87 |
| Sorghum, Sudan type | Silage | SSS | 71.2 | 71.2 | 3.6 | 104 | 10.9 | 0.64 | 0.24 | 0.31 | 28.8 | 29 |
| Soybean | Hulls | SOYH | 9.1 | 9.1 | 2.7 | 104.9 | 4.8 | 0.63 | 0.17 | 0.25 | 90.9 | 91 |
| Soybean | Meal, expellers, 45% CP | SOYME | 10.4 | 10.4 | 8.1 | 32.1 | 5.5 | 0.36 | 0.66 | 0.3 | 89.6 | 90 |
| Soybean | Meal, nonenzymatically browned | SOYMNB | 11 | 11 | 2.3 | 39.2 | 6.8 | 0.39 | 0.75 | 0.3 | 89 | 89 |
| Soybean | Meal, solvent, 44% CP | SOYMS44 | 10.9 | 10.9 | 1.6 | 24.9 | 6.6 | 0.4 | 0.71 | 0.31 | 89.1 | 89 |
| Soybean | Meal, solvent, 48% CP | SOYMS48 | 10.5 | 10.5 | 1.1 | 16 | 6.4 | 0.35 | 0.7 | 0.29 | 89.5 | 90 |
| Soybean | Seeds, whole | SOYSW | 10 | 10 | 19.2 | 32.6 | 5.9 | 0.32 | 0.6 | 0.25 | 90 | 90 |
| Soybean | Seeds, whole roasted | SOYSWR | 9 | 9 | 19 | 36.8 | 5 | 0.26 | 0.64 | 0.25 | 91 | 91 |
| Soybean | Silage, early maturity | SOYSEM | 59.6 | 59.6 | 5.7 | 83.5 | 12.2 | 1.07 | 0.37 | 0.35 | 40.4 | 40 |
| Sunflower | Meal, solvent | SUNMS | 7.8 | 7.8 | 1.4 | 70.3 | 7.7 | 0.48 | 1 | 0.63 | 92.2 | 92 |
| Sunflower | Oil seeds, whole | SUNOSW | 8.2 | 8.2 | 41.9 | 40.7 | 5.1 | 0.71 | 0.51 | 0.34 | 91.8 | 92 |
| Tomato | Pomace | TOP | 75.3 | 75.3 | 13.3 | 77.6 | 5.5 | 0.22 | 0.47 | 0.28 | 24.7 | 25 |
| Triticale | Silage, headed | TRISH | 68 | 68 | 3.8 | 99.3 | 9.7 | 0.57 | 0.33 | 0.19 | 32 | 32 |
| Wheat | Bran | WB | 10.9 | 10.9 | 4.3 | 58 | 6.3 | 0.13 | 1.18 | 0.53 | 89.1 | 89 |
| Wheat | Grain, rolled | WGR | 10.6 | 10.6 | 2.3 | 17.8 | 2 | 0.05 | 0.43 | 0.15 | 89.4 | 89 |
| Wheat | Hay, headed | WHH | 13.2 | 13.2 | 1.7 | 99.2 | 6.7 | 0.31 | 0.2 | 0.13 | 86.8 | 87 |
| Wheat | Middlings | WM | 10.5 | 10.5 | 4.5 | 48.8 | 5 | 0.16 | 1.02 | 0.42 | 89.5 | 90 |
| Wheat | Silage, early head | WSEH | 66.7 | 66.7 | 3.2 | 97.5 | 8.6 | 0.38 | 0.29 | 0.16 | 33.3 | 33 |
| Wheat | Straw | WS | 7.3 | 7.3 | 1.6 | 122.4 | 7.6 | 0.31 | 0.1 | 0.14 | 92.7 | 93 |
| Whey | Wet, cattle | WWC | 79.2 | 79.2 | 0.7 | 0 | 9.8 | 1.37 | 1.04 | 0.22 | 20.8 | 21 |
| Milk | Skim, dried powder | MSDP | 5.2 | 5.2 | 3.4 | 0 | 8.1 | 11.3 | 9 | 2 | 94.8 | 95 |
| Bone Meal | Steamed | BMS | 3 | 3 | 0 | 0 | 0 | 30.7 | 12.9 | 0 | 97 | 97 |
| Calcium carbonate | $CaCO_3$ | $CaCO_3$ | 0 | 0 | 0 | 0 | 0 | 39.4 | 0 | 0 | 100 | 100 |
| Dicalcium phosphate, Dibasic | $CaHPO_4$ | $CaHPO_4$ | 3 | 3 | 0 | 0 | 0 | 22 | 19.3 | 0 | 97 | 97 |
| Calcium phosphate Monobasic | $Ca(H_2PO_4)_2$ | $Ca(H_2PO_4)_2$ | 3 | 3 | 0 | 0 | 0 | 16.4 | 21.6 | 0 | 97 | 97 |
| Calcium Sulfate, Dihydrate | $CaSO_4.2H_20$ | $CaSO_4.2H_20$ | 3 | 3 | 0 | 0 | 0 | 23.3 | 0 | 0 | 97 | 97 |
| Limestone, ground | | LIMEG | 0 | 0 | 0 | 0 | 0 | 34 | 0 | 2.06 | 100 | 100 |
| Limestone, dolomite | | LIMEDO | 1 | 1 | 0 | 0 | 0 | 22.3 | 0 | 9.99 | 99 | 99 |
| Magnesium oxide | MgO | MgO | 2 | 2 | 0 | 0 | 0 | 3.07 | 0 | 56.2 | 98 | 98 |
| Potassium chloride | KCl | KCl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| Phosphate rock | | PHOSR | 0 | 0 | 0 | 0 | 0 | 35 | 13 | 0 | 100 | 100 |
| Sodium choride | NaCl | NaCl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| Sodium bicarbonate | $NaHCO_3$ | $NaHCO_3$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| Sodium phosphate, Monohydrate | $NaH_2PO_4.H_20$ | $NaH_2PO_4.H_20$ | 3 | 3 | 0 | 0 | 0 | 0 | 22.5 | 0 | 97 | 97 |
| Sodium sulfate Decahydrate | $Na_2SO_4.10H_20$ | $Na_2SO_4.10H_20$ | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 97 | 97 |
| Potassium sulfate | $K_2SO_4$ | $K_2SO_4$ | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 98 | 98 |
| Ammonium sulfate | $(NH_4)_2SO_4$ | $(NH4)_2SO_4$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| Ammonium phosphate, Dibasic | $(NH_4)H_2PO_4$ | $(NH_4)H_2PO_4$ | 3 | 3 | 0 | 0 | 0 | 0 | 24.7 | 0 | 97 | 97 |
| Ammonium chloride | | AMMOC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| Calcium choride, Anhydrous | $CaCl_2$ | $CaCl_2$ | 0 | 0 | 0 | 0 | 0 | 36.1 | 0 | 0 | 100 | 100 |
| Calcium choride Dihydrate | $CaCl_2.2H_20$ | $CaCl_2.2H_20$ | 0 | 0 | 0 | 0 | 0 | 27.5 | 0 | 0 | 100 | 100 |
| Magnesium chloride, Hexahydrate | $MgCl_2.6H_20$ | $MgCl_2.6H_20$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 100 | 100 |

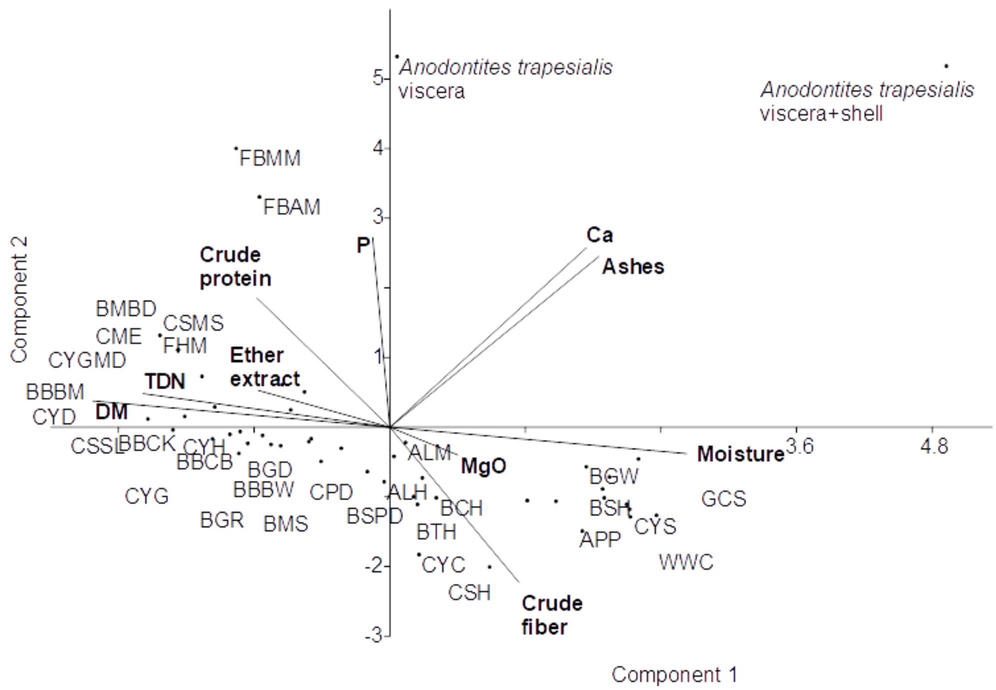


**Figure 4.** Comparison of feed sources of animal origin. DM: dry mass, TDN: total digestible nutrients, Ca: calcium, MgO: magnesium oxide, P: phosphorus. All the meanings of the acronyms can be found in Table 3.

43.4 and 45.5%. MgO varied between 0.4 and 1.0%, which are similar to those found in the present analysis. In addition, the same authors evaluated that the material obtained from the shredding of *A. trapesialis* shells has the potential for use as a soil pH corrector due to the high percentage of calcium present in the shells and its high neutralization power.

The bivalve can be utilized for its internal structures and shells, aiming for minimal processing to achieve the bivalve benefits and using the viscera separately. According to the present analyses, the bromatological aspects show that the use of the species is still fully viable, even maintaining high percentages of crude protein (12.96 ± 3.36%). Among the works already completed with oysters and bivalves, *A. trapesialis* is among the richest in protein if the viscera is considered separately (Table 3).

In initial studies by Santos et al. (2017) in the Amazon region, *A. trapesialis* showed lower protein values (4%). Similarly, Furlan et al. (2011) reported lower protein values (9.1%) for *Perna perna* species grown in Ubatuba, SP, Brazil. Santos et al. (2017) and Furlan et al. (2011) highlight the variation in the proximate composition of bivalves according to seasonality, as well as their place of origin. These authors mentioned in the paragraph above reinforce the importance of bivalve as a protein source with low lipid and caloric content, coherent with previous reports by Chakraborty et al. (2016). Other different marine bivalve and oyster species are shown in the table below (Table 2) to compare the chemical composition and characteristics, such as the percentage of protein crude and the mineral material quantity. The comparison of the bivalves' proximate compositions with other feed sources can be seen (Fig. 4). To compare the potential use of bivalves in animal feed, we highlight comparing the composition of different substrates and sources for animal feed (Table 3).

In comparison, *A. trapesialis* presents intermediate protein levels concerning other agricultural byproducts. While Eyng et al. (2011) found about 67% protein for a bone meal and 56% for a fish meal, the present analyses with *A. trapesialis* showed about 42.6% in the viscera and 12% protein considering the shells. However, the weight of the shell represents 99% of the total body weight, and this value can be considered relatively high and attractive since it has an adequate balance for poultry rations. For example, the ideal protein content is about 20% of the feed, which may be composed of several sources of protein (Carvalho et al. 2012), making bivalves good candidates for the production of this type of animal food, as assessed by Wachholz et al. (2019), who used golden flour (*Limnoperma fortunei*) for the composition of feed for birds. It is a good source of calcium with a low risk of heavy metal contamination.

Although marine bivalve aquaculture activities in Brazil are more developed than those involving freshwater bivalves (Agudo-Padrón 2015), freshwater bivalve species can occur accidentally in fish ponds producers generally see them as pests. Because, in addition to potential fish damage caused by infestation, they can also cause injuries to workers through cuts when stepping on the shells at the bottom of the tanks (Felipi & Silva-Souza 2008). Although the manual collection of individuals is quite laborious, it is common for individuals to be exposed to these hazards during maintenance or harvesting. These events were reported in a preliminary study by Sperandio et al. (2017) in an experimental fish farm located about 200 km from our collection area, where 520 individuals of *A. trapesialis* were found in a 1250 m² tank. In this context, it is important to find viable solutions for the use of bivalves, which generally end up dying and are discarded. Another potential use of the species is for pearl culture, given its nacre layer's multicolored and lustrous pattern, with potential future studies.

Thus, this work highlights initial studies that present *A. trapesialis* as an alternative for use in human food, animal, and the production of other byproducts. This value is demonstrated through the present analyses of its chemical composition, which show promising characteristics, such as the percentage of protein crude, its shell, and the mineral material quantity, containing a high percentage of calcium oxide. Based on these preliminary results, several gaps must be answered in future studies, such as investigating the different productive managements and their influences on bromatological characteristics and the seasonal variation of the bivalve bromatological characteristics (Chakraborty et al. 2016).

## REFERENCES


Agudo-Padrón, A.I. 2015. Mollusc aquaculture and malacological research in Santa Catarina State (central southern Brazil Region): a brief synthetic critical review. Brazilian Journal of Biological Sciences, 2: 377-380.

Andrade, I.M., Bertan, G., Dalmaso, B., Abadi, J. & Borba, M. 2018. Composição centesimal de ostra (*Crassostrea gigas*) e mexilhão (*Perna perna*) provenientes da aquicultura. Anais do VII Seminário de Ensino, Pesquisa e Extensão da UFFS, 8: 2 pp.

Asha, K.K., Anandan, R., Mathew, S. & Lakshmanan, P.T. 2014. Biochemical profile of oyster *Crassostrea madrasensis* and its nutritional attributes. Egyptian Journal of Aquatic Research, 40: 35-41.

Bonetto, A.A. & Ezcurra, I.D. 1962. El desarrollo del lasidium de *Anodontites trapesialis forbesianus* (LEA) (Moll. Lamell.). Physis, 23: 195-203.

Callil, C.T. & Mansur, M.C. 2005. Ultrastructural analysis of the shells of *Anodontites trapesialis* (Lamarck) and *Anodontites elongatus* (Swaison) (Mollusca, Bivalvia, Etherioidea) from the Mato Grosso Pantanal Region, Brazil. Revista Brasileira de Zoologia, 22: 724-734.

Callil, C.T. & Mansur, M.C.D. 2007. Gametogênese e dinâmica da reprodução de *Anodontites trapesialis* (Lamarck 1819) no lago Baía do Poço, planície de inundação do rio Cuiabá, Mato Grasso, Brasil. Revista Brasileira de Zoologia, 24: 825-840.

Carvalho, C.M., Fernandes, E.A., Carvalho, A.P., Caires, R.M. & Fagundes, N.S. 2012. Uso de farinhas de origem animal na alimentação de frangos de corte. Revista Portuguesa de Ciencias Veterinarias, 111: 69-73.

Castellanos, Z.A. & Landoni, N. 1990. La familia Mycetopodidae Gray, 1840 en la República Argentina. Fauna de agua dulce de la Republica Argentina, Buenos Aires, 16: 7-87.

Chakraborty, K., Chakkalakal, S.J., Joseph, D. & Joy, M. 2016. Nutritional composition of edible oysters (*Crassostrea madrasensis* L.) from the southwest coast of India. Journal of Aquatic Food Product Technology, 25: 1172-1189.

Dondoni, S., Castro, T., Sperandio, L., Alves, P. & Medeiros-Neto, A. 2017. Aproveitamento de conchas de *Anodontites trapesialis*. Resumo publicado nos Anais do I Simpósio de Ciência Animal e II Fórum de Veterinária e Zootecnia do Instituto Federal Goiano, Goiás.

Eyng, C., Nunes, C.G.V., Nunes, R.V., Rostagno, H.S., Albino, L.F.T., Vieites, F.M. & Pozza, P.C. 2011. Composição química, valores energéticos e digestibilidade verdadeira dos aminoácidos de farinhas de carne e ossos e de peixe para aves. Revista Brasileira de Zootecnia, 4: 575-580.

Felipi, P.G. & Silva-Souza, Â.T. 2008. *Anodontites trapesialis* (Lamarck, 1819): um bivalve parasito de peixes de água doce. Semina: Ciências Agrárias, 29: 895-903.

Fryer, G. 1970. Biological aspects of parasitism of freshwater fishes by crustaceans and mollusks. In: Taylor, E.R. & Muller, R. (Eds.). Aspects of fish parasitology. British Society for Parasitology, 8: 103-118.

Furlan, E.F., Galvao, J.A., Salan, E.O. & Oetterer, M. 2011. Composição centesimal e valor calórico de mexilhões *Perna perna* cultivados no litoral norte de São Paulo, Brasil. Boletim do Instituto de Pesca, 37: 85-93.

Furlan, E.F., Galvão, J.A., Salán, E.O., Yokoyama, V.A. & Oetterer, M. 2007. Estabilidade físico-química e mercado do mexilhão (*Perna perna*) cultivado em Ubatuba-SP. Ciência e Tecnologia de Alimentos, 27: 516-523.

Hebling, N.J. 1976. The functional morphology of *Anodontites trapezeus* (Spix) and *Anodontites trapesjalis* (Lamarck) (Bivalvia: Mycetopodidae). Boletim de Zoologia, 1: 265-298.

John, A.T. & Mary, J. 2016. Chemical composition of the edible oyster shell *Crassostrea madrasensis* (Preston 1916). Journal of Marine Biology and Aquaculture, 2: 1-4.

Jovic, M., Mandic, M., Šljivic-Ivanovic, M. & Smičiklas, I. 2019. Recent trends in application of shell waste from mariculture. Studia Marina, 32: 47-62.

Klunklin, W. & Savage, G. 2018a. Physicochemical properties and sensory evaluation of wheat-purple rice biscuits enriched with green-lipped mussel powder (*Perna canaliculus*) and spices. Journal of Food Quality, 2018: 7697903.

Klunklin, W. & Savage, G. 2018b. Addition of defatted green-lipped mussel powder and mixed spices to wheat-purple rice flour biscuits: physicochemical, in vitro digestibility and sensory evaluation. Food Science & Nutrition, 6: 1839-1847.

Lira, G.M., Mancini-Filho, J., Sant'ana, L.S., Torres, R.P., Oliveira, A.C.D., Omena, C.M.B.D. & Silva-Neto, M.D.L.D. 2004. Perfil de ácidos graxos, composição centesimal e valor calórico de moluscos crus e cozidos com leite de coco da cidade de Maceió-AL. Revista Brasileira de Ciências Farmacêuticas, 40: 529-537.

Mansur, M.C.D., Schulz, C. & Garces, L.M.M. 1987. Moluscos bivalves de água doce: identificação dos gêneros do sul e leste do Brasil. Acta Biologica Leopoldensia, 9: 181-202.

Mattar, E.P.L., Frade-Júnior, E.F. & Oliveira, E.D. 2014. Caracterização físico-química de cinza de osso bovino para avaliação do seu potencial uso agrícola. Pesquisa Agropecuária Tropical, 44: 65-70.

Norwegian Refugee Council (NRC). 2001. Nutrient requirements of dairy cattle. National Academy Press, Washington DC, pp. 283-289.

Peralta, E.M., Monaya, K.J.M., Simora, R.M.C. & Serrano Jr., A.E. 2018. Chemical composition and antioxidant properties of Philippine oyster (*Crassostrea iredalei*) residue. Philippine Journal of Natural Sciences, 22: 19-27.

Pinheiro, B.G.M., Da Costa, P.C.R., Ribeiro, S.D.C.A. & Santos Passos, P.H. 2020. Análise centesimal e de descrição do teor de aminoácidos presente nos sarnambis (*Protothaca antiqua*) coletados na ilha de Algodoal-PA/Centesimal and description analysis of the amino acids content in sarnambis (*Protothaca antiqua*) collected in the island of Algodoal-PA. Brazilian Journal of Development, 6: 21677-21686.

Piwoni-Piórewicz, A., Strekopytov, S., Humphreys-Williams, E. & Kukliński, P. 2019. Elemental composition of invertebrates shells composed of different $CaCO_3$ polymorphs at different ontogenetic stages: a case study from the brackish Gulf of Gdansk (the Baltic Sea). Biogeosciences, 34 pp. doi: 10.5194/bg-2019-367

Santos, P.D., Martins, M.P., Moura, J.L. & Santos, I.I. 2017. Analise bromatologica de moluscos *Prisodon obliquus* e *Anodontites trapesiali* encontrados na região da Amazônia. Jornada Acadêmica, Universidade Federal do Oeste do Pará, Pará.

Saucedo, P.E., Acosta-Salmón, H., McLaurin-Moreno, D., Castillo-Domínguez, A., Melgar-Valdés, C. & Mazón-Suástegui, J.M. 2021. Freshwater pearl culture in Mexico: historic contex, presente status, and future perspectives. Reviews in Aquaculture, 11. doi: 10.1111/raq.12527

Silva-Souza, Â.T. & Eiras, J.C. 2002. The histopathology of the infection of *Tilapia rendalli* and *Hypostomus regani* (Osteichthyes) by lasidium larvae of *Anodontites trapesialis* (Mollusca, Bivalvia). Memórias do Instituto Oswaldo Cruz, 97: 431-433.

Silva, D.J. & Queiroz, A.C. 2006. Análise de alimentos: métodos químicos e biológicos. UFV, Viçosa.

Silva-Souza, A.T., Guardia-Felipi, P. & Arrebola, N.R. 2011. Embryonic development of *Anodontites trapesialis* (Lamarck, 1819) (Bivalvia: Mycetopodidae). Brazilian Journal of Biology, 71: 139-144.

Simone, L.R.L.D. 1994. Anatomical characters and systematics of *Anodontites trapesialis* (Lamarck, 1819) from South America (Mollusca, Bivalvia, Unionoida, Muteloidea). Studies on Neotropical Fauna and Environment, 29: 169-185.

Sperandio, L., Dondoni, S., Castro, T., Medeiros Neto, A. & Alves, P. 2017. Ocorrência de *Anodontites trapesialis* em viveiros de piscicultura do Instituto Federal Goiano - Campus Urutaí. Resumo publicado nos anais do XIV Simpósio Internacional de Carcinocultura e XI Simpósio Internacional de Aquicultura, Natal.

Tedesco, M.J., Gianello, C., Bissani, C.A., Bohnen, H. & Volkweiss, S.J. 1995. Análise de solo, plantas e outros materiais. Universidade Federal do Rio Grande do Sul, Porto Alegre.

Tello-Panduro, B., García-Vásquez, Y., Vivanco-Medina, M., Viteri, J.D., Baça, J. & Taboada, O.M. 2003. Secado de tilapia (*Oreochromis* sp.), almejas (*Anodontites trapesialis*) y camarón gigante (*Macrobrachium rosenbergii*). Proceedings of the Segundo Congreso Iberoamericano Virtual de Acuicultura, pp. 775-783.

Yao, Z., Xia, M., Li, H., Chen, T., Ye, Y. & Zheng, H. 2014. Bivalve shell: not an abundant useless waste but a functional and versatile biomaterial. Critical Reviews in Environmental Science and Technology, 44: 2502-2530.

Venegas, F. 2009. Efeito de doses de farinha de carne e osso como fonte de fósforo na produção de milho verde (*Zea mays* L.). Ensaios e Ciência: Ciências Biológicas, Agrárias e da Saúde, 13: 63-76.

*Received: 2 November 2020; Accepted: 11 March 2021*

Wachholz, L., Nunes, R.V., Gonçalves-Junior, A.C., Eyng, C., Castilha, L.D., Cirilo, E.H., et al. 2019. Effect of the use of golden mussel flour contaminated with lead as a source of calcium on the performance of broilers. Semina: Ciências Agrárias, 40: 2783-2794.