Fatty acid composition and lipid nutritional quality of adult and pediatric enteral diets

Composição de ácidos graxos e qualidade nutricional lipídica de dietas enterais adultas e pediátricas

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ABSTRACT  
This study evaluates the fatty acid composition and lipid nutritional quality of enteral diets (ED), focusing on patients requiring enteral nutrition (EN). EN is crucial for patients unable to take adequate oral nutrition. The emphasis is on the importance of unsaturated fatty acids, particularly those from the omega-6 (n-6) and omega-3 (n-3) series, present in diets. These fatty acids are associated with health benefits, such as preventing cardiovascular disease and modulating the immune system. Seven adult ED and three pediatric ED were analyzed, using techniques such as gas chromatography to identify the fatty acid profile. Chemometric analysis, including Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA), was employed to explore patterns and similarities between samples. The PCA results indicate that there were similarities and distinctions between the samples studied, especially samples DA6 and DA7. HCA corroborated these observations, identifying four distinct groups. The analysis of lipid nutritional quality indices revealed that some samples meet the recommended proportions of fatty acids, while others present discrepancies, especially in relation to the $\Sigma n-6/\Sigma n-3$ and $\Sigma PUFA/\Sigma SFA$ ratios. These findings emphasize the importance of considering the lipid composition of ED, to ensure adequate nutrition and benefit the health of EN-dependent patients. Understanding these aspects contributes to more informed choices when prescribing enteral diets, optimizing clinical results.

Keywords: nutritional therapy, formulated foods, lipid composition, pediatric patients, adult patients.

RESUMO  
Este estudo avalia a composição de ácidos graxos e a qualidade nutricional lipídica de dietas enterais (DE), com foco em pacientes que necessitam de nutrição enteral (NE). A NE é crucial para pacientes incapazes de obter nutrição oral adequada. A ênfase está na
importância dos ácidos graxos insaturados, principalmente os das séries ômega-6 (n-6) e ômega-3 (n-3), presentes nas dietas. Esses ácidos graxos estão associados a benefícios à saúde, como prevenção de doenças cardiovasculares e modulação do sistema imunológico. Foram analisados sete DE adultos e três DE pediátricos, utilizando técnicas como cromatografia gasosa para identificar o perfil de ácidos graxos. A análise quimiométrica, incluindo Análise de Componentes Principais (PCA) e Análise Hierárquica de Cluster (HCA), foi empregada para explorar padrões e semelhanças entre amostras. Os resultados do PCA indicam que houve semelhanças e distinções entre as amostras estudadas, especialmente as amostras DA6 e DA7. O HCA corroborou essas observações, identificando quatro grupos distintos. A análise dos índices de qualidade nutricional lipídica revelou que algumas amostras atendem às proporções recomendadas de ácidos graxos, enquanto outras apresentam discrepâncias, principalmente em relação às relações $\sum_n-6/\sum_n-3$ e $\sum PUFA/\sum SFA$. Esses achados enfatizam a importância de considerar a composição lipídica do DE, para garantir uma nutrição adequada e beneficiar a saúde dos pacientes dependentes de NE. A compreensão desses aspectos contribui para escolhas mais informadas na prescrição de dietas enterais, otimizando os resultados clínicos.

**Palavras-chave:** terapia nutricional, alimentos formulados, composição lipídica, pacientes pediátricos, pacientes adultos.

### 1 INTRODUCTION

Enteral nutrition (EN) is a specialized diet administered through a nasogastric or post-pyloric tube for patients who are unable to eat adequately orally (SANZ-PARIS et al., 2017). It is recommended when oral nutrition cannot meet at least 70% of nutritional needs or when problems in the digestive system impair the adequate absorption of nutrients (SANZ-PARIS et al., 2017; CHURCH; ZOELLER, 2023). According to Führ et al. (2022), EN plays a fundamental role in the patient’s recovery, especially in home care, which has represented a great demand in recent years.

The lipid composition of enteral diets (ED) is extremely important in maintaining health, especially in patients who require exclusive long-term use (CUTCHMA et al., 2016). Lipids are considered essential components of cell membranes, serve as an energy reserve and act in the transport of fat-soluble vitamins. Furthermore, it plays a significant role due to its high caloric density (CALDER et al., 2018; FIACCADORI et al., 2021). Patients undergoing EN therapy necessity to receive lipids in adequate quantity and
quality, especially when affected by specific medical conditions (BOLOGNESE et al., 2021).

The lipid composition of ED is achieved by adding foods rich in essential fatty acids (FAs), especially polyunsaturated fatty acids (PUFAs) from the omega 6 (n-6) series, such as linoleic acid (LA, 18:2n-6), and the omega-3 (n-3) series such as alpha-linolenic acid (LNA, 18:3n-3) (CALDER, 2013; CALDER et al., 2018). Furthermore, ED often contain monounsaturated fatty acids (MUFA), which are involved in biological and physiological functions relevant to metabolism and health, especially in childhood (BROWN; ROEHL; BETZ, 2015; NEIA et al., 2019).

Therefore, the consumption of unsaturated FAs present in EN is extremely important for patients undergoing treatment, since both n-6 and n-3 FAs are associated with several health benefits (CALDER, 2015). This includes the prevention and treatment of cardiovascular diseases, anti-inflammatory gastrointestinal conditions, infections, as well as the prevention of injuries and modulations in the immune system, among other benefits (SHEEAN et al., 2020; FIACCADORI et al., 2021; MATSUBA et al., 2021).

In this context, the objective of this study was to evaluate the FAs composition and lipid nutritional quality of seven adult ED and three pediatric ED with the same clinical indication. Principal component analysis (PCA) and hierarchical cluster analysis (HCA) were performed to evaluate possible discrepancies and correlations between them.

2 MATERIAL AND METHODS

2.1 REAGENTS

The reagents chloroform, methanol, n-heptane and sulfuric acid purchased from Millipore Sigma (Darmstadt, Germany) were used. A standard mixture of fatty acid methyl esters (FAMEs) (FAME standard mix, C4-C24) and methyl tricosanoate (PI 23:0) were purchased from Millipore Sigma (Saint Louis, United States).

2.2 SAMPLING

A total of seven adult and three pediatric EN diets were purchased at the local market in the city of Maringá/PR/Brazil, homogenized and preserved in sealed tubes and
placed in a freezer at -18 °C until the moment of analysis. Table 1 shows the information provided by manufacturers (on the label) under lipid percentage and indications for use.

Table 1 - Nutritional information contained on enteral diet labels (100 mL sample) expressed as a percentage.

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Diet</th>
<th>Clinic indication</th>
<th>Total lipids (%/TEV) *</th>
<th>Trans</th>
<th>SFA</th>
<th>MUFA</th>
<th>PUFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>DA1</td>
<td>Patients at nutritional risk or malnourished.</td>
<td>35</td>
<td>0</td>
<td>25.86</td>
<td>55.17</td>
<td>18.97</td>
</tr>
<tr>
<td>A</td>
<td>DA2</td>
<td>Patients at nutritional risk or malnourished.</td>
<td>35</td>
<td>0</td>
<td>25.86</td>
<td>56.90</td>
<td>17.24</td>
</tr>
<tr>
<td>B</td>
<td>DA3</td>
<td>Severe ICU patients.</td>
<td>45</td>
<td>0</td>
<td>7.95</td>
<td>71.13</td>
<td>20.92</td>
</tr>
<tr>
<td>B</td>
<td>DA4</td>
<td>Moderate to severe malnutrition.</td>
<td>35</td>
<td>0</td>
<td>14.33</td>
<td>57.32</td>
<td>28.34</td>
</tr>
<tr>
<td>C</td>
<td>DA5</td>
<td>Patients at nutritional risk or malnourished.</td>
<td>30</td>
<td>0</td>
<td>27.27</td>
<td>33.33</td>
<td>39.39</td>
</tr>
<tr>
<td>C</td>
<td>DA6</td>
<td>Prevention of malnutrition and use in malnourished patients.</td>
<td>30</td>
<td>0</td>
<td>61.22</td>
<td>20.41</td>
<td>18.37</td>
</tr>
<tr>
<td>D</td>
<td>DA7</td>
<td>Immune preparation</td>
<td>24</td>
<td>0</td>
<td>54.17</td>
<td>16.67</td>
<td>29.17</td>
</tr>
<tr>
<td>A</td>
<td>PED1</td>
<td>For children aged 3 to 10 without special needs.</td>
<td>40</td>
<td>0</td>
<td>10.89</td>
<td>60.87</td>
<td>28.26</td>
</tr>
<tr>
<td>B</td>
<td>PED2</td>
<td>Children aged 1 to 10 years with moderate to severe malnutrition.</td>
<td>40</td>
<td>0</td>
<td>26.91</td>
<td>47.08</td>
<td>26.01</td>
</tr>
<tr>
<td>B</td>
<td>PED3</td>
<td>Children aged 1 to 10 years with moderate to severe malnutrition.</td>
<td>40</td>
<td>0</td>
<td>27.27</td>
<td>47.73</td>
<td>25.00</td>
</tr>
</tbody>
</table>

*TEV: total energy value. Source: Authors' elaboration, 2023.

2.3 FATTY ACIDS DERIVATIZATION

Direct methylation of FAs was proposed according to Piccioli and collaborators (2019), in which 250.0 µL of sample were initially transferred into test tubes, homogenized with 2.0 mL of NaOH/MeOH (0.70 mol L⁻¹). It was subsequently taken to the Eco-Sonics Q 5.9/25 ultrasound bath (Ultronique, São Paulo, Brazil), with a power of 165 W and a frequency of 25 KHz, for 7 minutes. About 2.0 mL of H₂SO₄/MeOH (1.5
mol L\(^{-1}\)) were added to the tubes, shaken and placed again in an ultrasonic bath for another 20 minutes. Finally, 1.0 mL of hexane was added, vortexed (Phoenix, São Paulo, Brazil) for 30 seconds, and centrifuged at 2,000 rpm for 1 minute followed by the addition of 500.0 µL of internal standard (methyl tricosanoate 23:0 mg mL\(^{-1}\)). The solution was kept at -18 °C for 24 hours, then the supernatant was collected for analysis by gas chromatography with flame ionization detector (GC-FID).

2.4 GAS CROMATOGRAFY

The identification of the FAs profile of EN samples was carried out using a GC equipped with a Shimadzu GC-2010 Plus FID. Split/splitless inlet mode and CP-7420 capillary column (100 m x 0.25 mm, 0.25 µm cyanopropyl, Varian, USA) were employed. A sample volume of 2.0 µL was injected in triplicate. The gas flows used were 1.4 mL min\(^{-1}\) for the carrier gas (H\(_2\)), 30.0 mL min\(^{-1}\) for the auxiliary gas (N\(_2\)) and 30.0 and 300.0 mL min\(^{-1}\) for the flame gases (H\(_2\)) and synthetic air, respectively. The column temperature was maintained at 65 °C for 4 minutes, followed by a heating ramp ranging from 16 °C min\(^{-1}\) to 185 °C, maintained for 12 minutes. Subsequently, a new ramp of 20 °C min\(^{-1}\) was applied to 235 °C and maintained for 9 minutes, totaling an analysis time of 35 minutes. The retention times and chromatographic peak areas of the analytes of interest and the standard used were used to identify the FAMEs. The results obtained were expressed as a relative percentage of total fatty acids.

2.5 CHEMOMETRIC ANALYSIS

The FAs identified by GC-FID for the ED were subjected to a multivariate statistical analysis using the unsupervised PCA and HCA techniques to explore similarities between the samples in relation to their lipid composition. Both were carried out using the software R (version 4.3.0, 2023).

2.5.1 Principal Component Analysis

PCA is a mathematical technique that reduces the dimensionality of multivariate data by finding linear combinations (PCs) of the original variables. The PCs are
determined from the eigenvalues and eigenvectors of the data covariance matrix, representing the directions with greater variability. It is used to project data into a smaller space, allowing for simpler visualization and understanding of the relationships between samples and characteristics (GRANATO et al., 2018).

PCA analysis was applied to an 18 x 10 data matrix (18 compounds x 10 samples = 180 data points), in which the three main components obtained through linear regressions were selected: the first (PC1), second (PC2) and third component (PC3). PCs are calculated iteratively to capture the maximum variation in the original data, such that PC1 explains more variation than PC2, PC2 explains more than PC3, and so on.

2.5.2 Hierarchical Cluster Analysis

HCA is a statistical analysis method used to group samples into groups based on their similarities. The HCA result is represented in a dendrogram, which shows the hierarchy between groups of samples (GRANATO et al., 2018). The grouping was carried out considering the squared Euclidean distances between the samples, and the methodology for linking the groups adopted was Ward’s criterion.

2.6 NUTRITIONAL QUALITY INDECES

Data from FA composition analyzes were used to determine the nutritional profile of the lipid fraction evaluated by the atherogenicity index (AI) (equation 1), thrombogenicity index (TI) (equation 2), hypocholesterolemic/hypercholesterolemic index (H/H) (equation 3), n-6/n-3 sum ratio (equation 4), PUFA/SFA ratio (equation 5), as well as the sum of FAs, including eicosapentaenoic FA (EPA) and docosahexaenoic FA (DHA) represented in equation 6, as explained below.

\[
AI = \frac{[12:0 + (4x14:0) + 16:0]}{MUFA + n - 6 + n - 3} \quad \text{Equation (1)}
\]

\[
TI = \frac{(14:0 + 16:0 + 18:0)}{[(0.5xMUFA) + (0.5xn - 6) + (3x n - 3) + \left(\frac{n - 3}{n - 6}\right)]} \quad \text{Equation (2)}
\]
\[ HH = \left[ \frac{(18:1n-9 + 18:2n-6 + 18:3n-3 + 20:5n-3 + 22:6n-3)}{(12:0 + 14:0 + 16:0)} \right] \quad \text{Equation (3)} \]

\[
\text{Omega family proportion} = \frac{\Sigma[n-6]}{\Sigma[n-3]} \quad \text{Equation (4)}
\]

\[
\text{Proportion of polyunsaturated and saturated fatty acids} = \frac{\Sigma[PUFA]}{\Sigma[SFA]} \quad \text{Equation (5)}
\]

\[
\text{Sum of essential fatty acids} = EPA + DHA \quad \text{Equation (6)}
\]

3 RESULTS AND DISCUSSIONS

3.1 EXPLORING FATTY ACID COMPOSITION DATA BY PCA

PCA was applied to data on the FA composition of ED with the aim of identifying existing patterns between it. The results, shown in Figure 1 in a three-dimensional space by the first three components, indicated that the first principal component (PC1) was responsible for explaining the greatest variability in the data, reaching 40.9%. Subsequently, PC2 and PC3 contributed 26.7% and 11.8%, respectively. When added together, the three components together explained 79.4% of the variability present in the data.
Figure 1 - Three-dimensional visualization of the PCA representing the scores resulting in PC1 vs. PC2 vs. PC3 of ● adult and ● pediatric ED in relation to their fatty acid compositions.

Source: Authors’ elaboration, 2023.

It is observed that samples DA6 and DA7 did not form clusters with other samples, suggesting that their fatty acid compositions presented different percentages from the others. Although both showed high and positive contributions in relation to PC1, they differ from each other. This distinction arises from the fact that sample DA6 has a negative contribution in relation to PC2, while sample DA7 exhibits positive contributions in this axis.

The remaining samples clustered on the negative side of PC1, suggesting that their compositions are more similar. However, greater similarities are observed when we analyze the other components. With regard to PC2, samples DA2, DA4 and PED1 were on the positive side, which already indicates a greater similarity between them. On the other hand, samples DA1, DA3, DA5, PED2 and PED3 were on the negative side of PC2, which indicates greater similarity in their compositions. When analyzing the third component (PC3), we observed two more groupings: DA1, PED2 and PED3 on the positive side, with more significant contributions to PED2 and PED3; while DA3 and DA5 were on the negative side. Both PED2 and PED3, as well as DA3 and DA5, had...
practically equal influences on PC1, PC2 and PC3, and therefore have similar fatty acid compositions.

3.2 EXPLORING FATTY ACID COMPOSITION DATA BY HCA

For a better interpretation of the data structure, samples of adult and pediatric ED were subjected to a HCA. This technique is often employed to identify similar groups in datasets by grouping them into clusters. HCA analyzes the data and searches for objects in an n-dimensional space, seeking to separate the invariant cluster from the others. Therefore, cluster analysis was performed to ascertain the nutritional composition between the different enteral diets and their fatty acid profiles (GONZALEZ-ORTEGA et al., 2024).

The HCA results, applying Ward's method and using squared Euclidean distances, for 10 ED (adult and pediatric) are presented in Figure 2 by a grouped heat map (dendrogram).
Figure 2 - Clustered heat map (dendogram) illustrating the fatty acid composition of enteral diets.

The heat map is a clustering method that illustrates the relationship between ED samples (rows) and FAs (columns). Each cell of the heat map represents a numerical value that indicates the amount of the FA in a specific diet sample. Colors are used to encode these values, making it easier to identify similarity between it.

In the dendrogram, the height of the links that connect the samples represents the distance between the clusters (AL-MADBOLY et al., 2023). The results found the greatest distance and height between the clusters evidence a low interaction between the ED, in addition, the dendrogram analysis demonstrated four distinct groups.

In the first and second cluster, we note the largest distances, which correspond to samples DA7 and DA6, respectively. This is due to the presence of higher concentrations of myristic (14:0) and DHA (22:6n-3) in the DA7 sample, while in DA6 the majority found were 18:1n-9, 16:0 and 8:0. Furthermore, it is worth highlighting that stearic (18:0),
arachidic (20:0), capric (10:0), caprylic (8:0) and palmitic (16:0) FAs, together with EPA (20:5n-3), were also identified in higher quantities. Hexanoic (6:0), lauric (12:0), gadoleic (20:1n-9) and tetracosanoic (24:0) FAs were not detected in DA7.

According to Harcombe et al. (2013), 14:0 is a source of energy readily available for the body, 16:0 is essential for the prevention and treatment of malnutrition, in addition to producing analgesic effects and helping with intestinal discomfort (MANIN et al., 2023). Furthermore, DHA has anti-inflammatory properties, in addition to being involved in brain and eye health, promoting improvement in the patient's clinical status (CALDER, 2015).

In the third cluster, consisting of samples PED3, PED2, DA1, DA5 and DA3, although they are indicated for the same clinical condition, serving different age groups, the presence of two subclusters is noticeable. One of them consists of samples DA3 and DA5, which exhibited a similar percentage of FAs, indicated by the lower height of the link that connects them in the dendrogram, and the other consists of samples PED2, PED3 and DA1, however, it is important to highlight that, within this subcluster, sample DA1 was the most unique compared to the others.

Identifying the FA profile becomes extremely important when it comes to preventing or recovering the health of patients who use EN. Therefore, samples DA3 and DA5 present very similar colors for all FAs, with emphasis on linoleic acid (18:2n-6) (HARRIS et al., 2020) found as the second highest concentration in both samples. Therefore, the benefits of an ED rich in linoleic acid become vital, as this is a strictly essential PUFA acquired only through food, playing a fundamental role in the formation of cell membranes and in the regulation of inflammatory processes (SIMOPOULOS, 2002).

In the fourth cluster, the presence of a subcluster composed of samples DA2, DA4 and PED1 was observed, indicating similarity between them due to the height of the link that connects them being smaller. In turn, the subgroup formed by samples DA4 and PED1 stands out due to the more significant presence of oleic acid (18:1n-9) and linoleic acid (18:2n-6), while sample DA2 stands out due to its higher concentration of tetracosanoic acid (24:0) followed by oleic acid (18:1n-9) and EPA (20:5n-3). Still in
Figure 2, it was observed that among the 18 FAs found, 18:1n-9 was the most prevalent MUFA in all adult and pediatric ED, standing out primarily in the DA7 and PED 1 diets, showing a good lipid nutritional quality of these diets.

In this context, the investigation of FAs through the sum of SFA, MUFA and PUFA is essential for promoting adequate ED choices, aiming to meet not only the energy need, but also positively influence metabolic regulation, the immunological response and the general health of the patient using EN. Our results elucidate that, with the exception of DA6 and DA7, majority concentrations of MUFA were identified for adult and pediatric ED. Furthermore, in sample DA6, more than half of the composition consisted of SFA with a percentage of 53.69±1.25, which corroborates values close to the label information provided by the manufacturer. While in the DA7 sample, several discrepancies were observed, since it presented a percentage of 41.01±0.95 of the composition attributed to PUFA and 39.11±0.01 to SFA.

Regarding pediatric samples, the values found for SFA, being PED1 (11.69±0.08), PED2 (27.53±0.40) and PED3 (27.73±1.03) also show similarities with the label. Also in agreement with the label are MUFA from PED1 (56.10±1.14), PED2 (48.76±0.96) and PED3 (47.13±1.78) and the PUFA from PED1 (32.12 ±0.99), PED2 (23.70±0.14) and PED3 (23.61±0.39) with emphasis on the PED1 diet with regard to lipid nutritional quality due to its lower SFA value.
3.3 ASSESSMENT OF LIPID NUTRITIONAL QUALITY

Table 2 presents a comprehensive analysis of lipid nutritional quality indices in adult and pediatric ED, providing important insights into ∑n-6/∑n-3, ∑PUFA/∑SFA, EPA+DHA, AI, TI and H/H. These indicators play crucial roles in health assessment, offering a comprehensive overview of lipid composition and highlighting the need for balance to optimize nutritional benefits. This systematic approach to the analysis of lipid components contributes to the understanding of healthier eating strategies, adapted to the needs of different age groups.

Table 2 - Lipid nutritional quality index of adult and pediatric enteral diets.

<table>
<thead>
<tr>
<th>Indexes</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>∑n-6</td>
<td>DA1 2.77± 3.68± 5.14± 5.81± 5.14± 2.14± 0.40± 4.36± 2.15± 2.17±</td>
</tr>
<tr>
<td>6/∑n-3</td>
<td>DA2 0.11ab 0.25a 0.03b 0.01ab 0.03b 0.01ab 0.03b 0.07ab 0.07ab 0.07ab</td>
</tr>
<tr>
<td>∑PUFA/</td>
<td>DA3 0.77± 0.77± 1.35± 1.45± 1.36 0.28± 1.05± 2.76± 0.86± 0.85±</td>
</tr>
<tr>
<td>∑SFA</td>
<td>DA4 0.01c 0.03a 0.04ab 0.05b ±0.07a 0.02d 0.05d 0.05b 0.01b 0.06b</td>
</tr>
<tr>
<td>EPA+D</td>
<td>DA5 0.56± 0.57± 0.74± 0.41± 0.74± 1.79± 28.77± 0.91± 0.60± 0.60±</td>
</tr>
<tr>
<td>HA</td>
<td>DA6 0.03c 0.03c 0.01b 0.01c 0.01c 0.06d 0.77a 0.02a 0.00b 0.02b</td>
</tr>
<tr>
<td>AI</td>
<td>DA7 0.11± 0.10± 0.15± 0.13± 0.15± 0.48± 0.39± 0.09± 0.12± 0.12±</td>
</tr>
<tr>
<td>TI</td>
<td>DA8 0.01c 0.01c 0.01a 0.01c 0.01c 0.04a 0.01b 0.01b 0.01a 0.01a</td>
</tr>
<tr>
<td>H/H</td>
<td>DA9 0.74± 0.21± 0.26± 0.26± 0.26± 0.63± 0.20± 0.18± 0.19± 0.19±</td>
</tr>
<tr>
<td></td>
<td>DA10 0.40± 9.24± 6.35± 7.40± 6.35± 1.80± 3.19± 10.09± 7.68± 7.53±</td>
</tr>
<tr>
<td></td>
<td>DA11 0.85a 0.85a 0.16b 0.16b 0.16c 0.17c 0.10d 0.07a 0.07a 0.16b</td>
</tr>
</tbody>
</table>

Results expressed as mean±SD (standard deviation) of triplicates expressed as percentage of relative area of total fatty acids. Values with different lowercase letters in the same line are significantly different (p < 0.05) by the Tukey test. Abbreviations: ∑ n-6: omega-6 family; ∑ n-3: omega-3 family; ∑ n-6/∑ n-3: sum of the omega-6 family in relation to the omega-3 family; ∑PUFA/∑SFA: sum of polyunsaturated fatty acids in relation to saturated fatty acids; EPA+DHA: sum of eicosapentaenoic (20:5n-3, EPA) and docosahexaenoic (22:6n-3, DHA) fatty acids; AI: atherogenicity index; TI: thrombogenicity index; H/H: ratio of hypocholesterolemic/hypercholesterolemic fatty acids. Source: Authors’ elaboration, 2023.

According to the results found in this study, the ∑n-6/∑n-3 ratio among adult samples ranged from 0.40±0.01 to 5.81±0.01, with the highest value obtained for DA4, and the lowest for DA7, with statistically different percentages (p>0.05). Pediatric formulations ranged from 2.15±0.01 to 4.36±0.07. Therefore, only samples DA1 (2.77±0.11), DA2 (3.68±0.25), DA6 (2.14±0.01), DA7 (0.40±0.01) and pediatric PED2 (2.15±0.01) and PED3 (2.17±0.03) meet the nutritionally recommended proportion, as values above 4.0 are harmful to human health (CHEN; LIU, 2020).
Regarding the $\sum$PUFA/$\sum$SFA used as a way of evaluating the impact of nutrition on cardiovascular health, our findings demonstrate that only the DA6 sample with a value of 0.28±0.02 presented an unsatisfactory result for the index, since, while the PUFA content contributes to the maintenance of cholesterol levels, SFA participates in the increase in serum cholesterol, with ideal proportion values only above 0.45 (SIMOPOULOS, 2002; CHEN; LIU, 2020).

For the sum EPA + DHA, Ientz et al. (2022) states that this combination transcribes the intake of dietary fat related to positive impacts on health, thus, through the evaluation of enteral diets, viable proportions were observed for all samples, both adults and pediatrics.

Furthermore, in Table 2, the AI, TI indices show a relationship between the lipid profile of individual FAs and its effects on health, especially the development of cardiovascular diseases as mentioned by Paszczyk and Tońska (2020) and Biandolino et al. (2020). Therefore, low values of AI and TI are expected, which was observed that among adult samples for AI, DA6 (0.48±0.04) obtained the highest value, followed by DA7 (0.39±0.01), while samples DA1 (0.11±0.01), DA2 (0.1±0.01), DA3 (0.15±0.01), DA4 (0.13±0.01) and DA5 (0.15±0.01) did not differ significantly from each other (p>0.05), elucidating the lowest results. And, the pediatric diets PED2 (0.12±0.01) and PED3 (0.12±0.01) did not show significant differences, but PED1 was different, showing a lower value (0.09±0.01). Therefore, despite the distinctions found between the formulations, all ED meet the ideal health recommendation described by Wołoszyn et al. (2020) to be less than 1.0.

Similarly, for TI our results also demonstrated that DA6 presented the highest value among adult samples, being 0.63±0.06, respectively, as well as pediatric samples, PED1 with 0.18±0.01 also represented the lowest statistically significant value (p<0.05). However, upon analysis of this index, it is worth highlighting that the DA6 sample obtained a value higher than the nutritionally recommended value (below 0.50), which implies inferior nutritional quality for this diet, increasing the risk for the development of
coronary diseases and the formation of clots in the vessels blood (SANTOS-SILVA; BESSA; SANTOS-SILVA, 2002).

Finally, the H/H index indicates the relationship between Fas and cholesterol metabolism so that it is desirable in high quantities. Based on the findings of this study, adult samples with a value range of 1.80±0.17 to 9.24±0.85 presented the highest results for the formulation DA1 (8.40±0.39) and DA2 (9.24±0.85), respectively, without statistical differences (p>0.05). However, the lowest percentage obtained for DA6 (1.80±0.17) indicated an undesirable result compared to the health-promoting recommendation of a value greater than 2.0, which corresponds to a reduction in the risk of cardiovascular diseases (NEIA et al., 2023). In agreement, this phenomenon was also reported by Néia et al. (2023) in only one sample of enteral nutrition analyzed.

In general, among the pediatric samples, PED1 obtained the highest value of 10.09±0.07 (p<0.05), followed by PED2 7.68±0.16 and PED3 7.53±0.15 which did not differ from each other (p>0.05) where they all found with values ideal for those recommended, demonstrating reliability for these diets in relation to the H/H index.
4 CONCLUSION

Detailed analysis of FA composition data using techniques such as PCA and HCA provided valuable insights into the distinct characteristics of the enteral diets studied. PCA revealed complex patterns in FA compositions, with PC1 playing a significant role in data variability, followed by PC2 and PC3. Samples DA6 and DA7 stood out as exceptions, showing unique compositions in relation to other diets, which may have important implications for the personalization of nutritional prescriptions.

HCA, used to identify similar groups, resulted in a dendrogram that highlights distinct clusters between samples, reinforcing the diversity in the lipid compositions of ED. The presence of subclusters highlights specific nuances in the samples, indicating the need to consider not only the general categories, but also the peculiarities of each formulation.

The assessment of lipid nutritional quality, expressed through indices such as \(\sum n-6/\sum n-3\), \(\sum PUFA/\sum SFA\), EPA+DHA, AI, TI and H/H, provided valuable information about the potential impact of these diets in cardiovascular and metabolic health. The importance of balancing the relationships between FAs to meet ideal nutritional recommendations is highlighted. Some samples have demonstrated compliance with these recommendations, while others require careful review to optimize their lipid profiles.

The findings of this study not only enrich the understanding of FA compositions in ED, but also provide a solid foundation for future research and adjustments in formulations to meet specific patient needs. The integrated approach of analytical techniques and nutritional assessment contributes to advances in EN, promoting more informed and personalized choices in nutritional care. Finally, it is important to highlight the need to monitor and ensure that EN formulas are appropriate to nourish those who need it.
REFERENCES


