Monitoring sugar content in infant foods

Controlo do teor de açúcar em alimentos para crianças

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Stephanie Noronha Azevedo dos Santos
Master's student in Pharmaceutical Sciences
Institution: Universidade Federal do Amazonas
Address: Rua Tupiara, 41F, núcleo 11, Cidade Nova 2, CEP: 69096-220
E-mail: stephanienoronha@outlook.com

Ariane Mendonça Kluczkovski
Post-Doctorate in Food Sciences
Institution: Universidade Federal do Amazonas
Address: Av. General Rodrigo Otavio Jordão Ramos, 6200, Coroado I, Manaus - AM, CEP: 69067-005
E-mail: ariane@ufam.edu.br

Tatiane Pereira de Souza
Post-Doctorate in Pharmaceutical Sciences
Institution: Universidade Federal do Amazonas
Address: Av. General Rodrigo Otavio Jordão Ramos, 6200, Coroado I, Manaus - AM, CEP: 69067-005
E-mail: tpsouza@ufam.edu.br

Samir de Carvalho Buzaglo Pinto
Master of Pharmaceutical Sciences
Institution: Universidade Federal do Amazonas
Address: Rua Misushiro, 154, Condomínio Acqua, Parque 10, CEP: 69054-672
E-mail: sam.carvbp@hotmail.com

Allyne Conceição Pereira da Silva
Master's student in Pharmaceutical Sciences
Institution: Universidade Federal do Amazonas
Address: Rua C 17, 1812, Japiim, CEP: 69076-560
E-mail: allyne_silva@live.com

Hanna Barbosa Lemos
Pharmacy Graduate Student
Institution: Universidade Federal do Amazonas
Address: Rua Horizonte, 10, Cidade Nova 1
E-mail: hannabarbosale@gmail.com

Izabela dos Santos Mar Teixeira
Pharmacy Graduate Student
Institution: Universidade Federal do Amazonas
Address: Rua C 18, 1531, Japiim
E-mail: izabela.msteixeira@gmail.com

ABSTRACT
High sugar consumption increases the chance of developing diabetes, hypertension, obesity and cancer, as well as cavities and bacterial plaque between teeth. Considering the increase in health problems related to sugar intake in the population, the objective of this work was to monitor the presence and amount of sugar in baby food based on fruits and vegetables from different companies sold in Brazil. Titrimetric methods (Lane-Eynon) and total sugar content were used, based on total soluble solids (TSS) in degrees Brix. In the titration method, it was possible to quantify reducing and non-reducing sugars and total sugar by the redox reaction of Fehling's liquor. Baby food with the highest levels of total sugars, presented 22.72% (assorted fruits) and 21.84% (plum base). The lowest total sugars content was 2.50% (from pumpkin and coconut milk composition). TSS analysis confirmed the presence of sugars found in the titration method. We concluded that the baby foods evaluated had relevant sugar content and there is a need for constant monitoring to avoid excesses by children, as well as careful attention to their nutritional information declared on the label, considering that high sugar consumption causes risks to the health.

Keywords: carbohydrates, sugar, Lane-Eynon, brix.

RESUMO
O elevado consumo de açúcar aumenta a possibilidade de desenvolver diabetes, hipertensão, obesidade e cancro, bem como cáries e placa bacteriana entre os dentes. Considerando o aumento dos problemas de saúde relacionados com a ingestão de açúcar na população, o objectivo deste trabalho foi o de monitorizar a presença e quantidade de açúcar nos alimentos para bebés à base de frutas e vegetais de diferentes empresas vendidas no Brasil. Foram utilizados métodos titrimétricos (Lane-Eynon) e teor total de açúcar, com base em sólidos solúveis totais (TSS) em graus Brix. No método de titulação, foi possível quantificar os açúcares redutores e não redutores e o açúcar total pela reacção redox do licor de Fehling. Os alimentos para bebés com os níveis mais elevados de açúcares totais, apresentaram 22,72% (frutos sortidos) e 21,84% (base de ameixa). O menor teor total de açúcares foi de 2,50% (da composição de abóbora e leite de coco). A análise do TSS confirmou a presença de açúcares encontrados no método de titulação. Concluímos que os alimentos para bebés avaliados tinham um teor de açúcar relevante e que é necessário um controlo constante para evitar excessos por parte das crianças, bem como uma atenção cuidadosa à sua informação nutricional declarada no rótulo, considerando que o elevado consumo de açúcar causa riscos para a saúde.

Palavras-chave: hidratos de carbono, açúcar, Lane-Eynon, brix.

1 INTRODUCTION

The early period of life, from conception to 2 years of age – the so-called first 1,000 days of life – is a critical window during which the environment, including nutrition, can have a profound influence on the development of the fetus, baby, and child (Hutchinson et al., 2021) and also the risk of disease later in life (Lima, 2019; Maniglia et al., 2021). The presence of sugar in infant foods sold for infants aged six months or older can contribute to the development of cavities, bacterial plaque in the first teeth, as well as the risk of developing a preference for sweets, which can lead to overweight, obesity and diseases related to high sugar consumption, such as diabetes, hypertension, cancer and others (Ruiz-Ojeda et al., 2019; Masztalerz-Kozubek et al., 2022). The World Health Organization issued a warning about dangerous levels of sugars in baby foods and recommendations for improvements in nutrition labeling after studying foods and beverages marketed to infants and young children in European countries, it was found that sugars accounted for 70.0% of the calories in these foods, posing a threat to child health (WHO, 2019). In Brazil, the National Health Surveillance Agency (ANVISA) published legislation applicable to nutritional labeling of packaged foods, the collegiate board resolution (RDC) 429/2020 and the Normative Instruction (IN) 75, which recently determined that the nutritional information table must contain declarations of the amounts of total sugars, added sugars, carbohydrates, among others. In order to guarantee consumers access to the necessary information to help them make the best nutritional choice (Caldas et al., 2015; ANVISA, 2020; Sinu Scientific Board, 2021). In this context, there are several analytical methods for quantifying and identifying sugars in foods, such as the Lane-Eynon methods, refractometer, liquid chromatography with refractive index and mass spectrometry by electro-spray ionization (ESI), and the titration and refractometer methodologies are the most commonly used in research in the areas of food due to the speed and low cost of performing the analyzes (Santos et al., 2016). In Brazilian foods, Marques et al. (2018), analyzed industrialized baby food with sweet flavors based on fruit for consumption from six months, sold in the city of Teresina in Piaui (Brazil) and found total sugar levels for plum baby food 21.12% and for assorted fruits 22.08%. Silva (2023) also concluded that sweet-tasting ultra-processed foods are more consumed among children aged between 6 months and 2 years old. With this, they found that the data obtained characterized the baby food analyzed as cariogenic foods, as they present in their composition very high levels of sugars described in the literature as a determining factor in the genesis of dental caries. Considering the importance of monitoring the sugar content in Brazilian infant foods, the objective of this study was to evaluate the presence and content of sugars through titration methodologies and total soluble solids, focusing on the total sugars present in baby food that report being free of sugar or additional sugars on their labels, which are sold in the municipality of Manaus in the state of Amazonas-Brazil.

2 MATERIALS AND METHODS

2.1 SAMPLING

Samples (*n*=30) of baby food were collected from June to December 2022, resulting in 6 different brands that were named in alphabetical order for ethical reasons. The samples of companies A, B, C and F were collected in the exclusive trade of food and children's products. Samples from companies D and E were purchased from large supermarket chains in the city of Manaus-AM, in October 2022. Samples from companies A, B, C, E and F were collected frozen, and samples from company's company D were at room temperature, with a pasty texture. The packages were sealed and within the expiration date. The samples were kept in a freezer in order to maintain the characteristics of the products. The table 1 shows the data present on the sample labels regarding the presence or absence of the mandatory declaration on sugars.

Table 1. Labelling information in baby food commercialized in Brazil.

Brand	N.	Code	Carbohydrates (g)	Kcal %	Sugar (g)	Added sugars
A	1	AM/AB/OS	9	3	-	-
	2	AM/MC/OS	15	3	-	-
	3	AM/MG/OS	24	8	-	-
B	4	AM/BL/GZ	26	**	0	-
	5	AM/ACD/GZ	20	**	0	-
	6	AM/PA/GZ	31	**	18	-
C	7	AM/ABM/MM1	-	-	-	-
	8	AM/ABM/MM2	-	-	-	-
	9	AM/GL/MM	19	3	Does not contain	Does not contain
	10	AM/AC/MM	5.8	3	-	-
	11	AM/ABCA/MM	25	8	-	-
D	12	AM/BAV/N	13	**	-	-
	13	AM/AM/N1	14	-	14	-
	14	AM/AM/N2	14	-	14	-
	15	AM/FS/N1	12	**	11	-
	16	AM/FS/N2	12	**	11	-
	17	AM/BA/N	21	**	18	-
	18	AM/GB/N	18	**	15	-
	19	AM/UB/N	19	**	16	-
	20	AM/BMF/N	18	-	13	-
	21	AM/MC/N	12	-	12	-
	22	AM/PBM/N	17	-	13	-
E	23	AM/MGMJ/NA1	14	5	-	-
	24	AM/MGMJ/NA2	14	5	-	-
	25	AM/AB/NA1	22	7	-	-
	26	AM/AB/NA2	22	7	-	-
	27	AM/PY/NA1	23	8	-	-
	28	AM/PY/NA2	23	8	-	-
F	29	AM/MO/PT1	32.25	10.75	-	-
	30	AM/MO/PT2	32.25	10.75	-	-

[1] (-) not informed

2.2 DETERMINATION OF SUGARS

2.2.1 Total sugars (reducing and non-reducing)

The physical-chemical analysis procedures were carried out in triplicate at the Nucleus of Studies in Composition and Toxicology and Food (NECTA) of the Faculty of Pharmaceutical Sciences - UFAM. Infant food samples were subjected to determination of the presence of sugars using the Lane-Eynon method. Sugar content was quantified using the Lane-Eynon method for all the samples. The titration method evaluates the concentration of reducing sugars in a sample based on their reducing action towards certain metallic salts. In this process, the sample reduces copper sulfate in an alkaline tartrate system (Fehling's solution). AOAC Official Method 923.09, 2005.

2.2.2.1 Materials and Reagents

Fehling's solutions: "A" solution: dissolved 34.64 g $CuSO_4 \cdot 5H_2O$ in Milli-Q water, diluted to 500 mL, and filtered through glass wool; "B" solution: dissolved 173 g potassium sodium tartrate$\cdot 4H_2O$ and 50 g NaOH in Milli-Q water, diluted to 500 mL, kept for 2 days, and filtered through a 0.45 µm filter paper.

Methylene blue indicator solution: 0.1 g of methylene blue ($C_{16}H_{18}ClN_3S \cdot 2H_2O$) dissolved in 100.00 mL Milli-Q water. Invert sugar standard solution: 9.50 g pure sucrose, 100 mL Milli-Q water, and 5 ml of conc. HCl. Stored for 3 days at 20–25°C and then diluted to 1 L. Neutralized with 1 M NaOH immediately before use.

2.2.2.2 Determination of Initial Reducing Sugar Content

It was titrated with 10.0 mL of boiling Fehling's A and Fehling's B solution. The end point was determined by mixing 1% methylene blue until the blue color of the indicator disappeared to a brick red end point. The titration was completed within 3 minutes. The titration was performed in duplicates and the average value was taken. Accurately 5 mL of baby food sample was measured, and 50 times diluted solution was prepared, and the pH was adjusted to 8.0. This solution was transferred into a burette.

2.2.2.3 Determination of Non-Reducing Sugar Content

About 5 mL of baby food sample was mixed with 3 mL of conc. HCl and it was kept at 68°C for 30 minutes. The pH of the mixture was adjusted to 8.0-, and 50-times diluted solution was prepared using this hydrolyzed sample. This solution was transferred into a burette. Titration was performed as the above procedure.

2.2.2.4 Calculation

$\frac{100\ x\ vb\ xf}{M\ X\ V}$ = % reducing sugar

$$\frac{(100\ x\ vb\ x\ 2\ x\ f\ )}{M\ X\ V}\ x\ 0{,}96 = \%\ non\ reducing\ sugar$$

Where: vb = volume of the volumetric flask used (mL); f = Fehling's solution factor; M= mass of sample in grams; V= number of ml of the diluted sample solution used in the titration (mL).

Total sugars are expressed by the following calculation:

(Reducing sugar + non-reducing sugar) = % Total sugars

2.3 DETERMINATION OF SUGARS BY TOTAL SOLUBLE SOLIDS CONTENT

The content of soluble solids was performed according to Santiago et al. (2022) with adaptations. Readings were taken, in ºBrix at 20ºC, in a digital refractometer (ATC, 0° to 90° Brix), placing the samples directly in the equipment cell, after calibration with distilled water.

2.4 STATISTICAL ANALYSIS

The results of sugar concentrations obtained in the analysis methodologies were submitted to statistical analysis of arithmetic mean and standard deviation of all samples, using the statistical tool available in Microsoft Excel® (2012 version), organized in tables.

3 RESULTS

3.1 REDUCING SUGARS BY THE LANE-EYNON METHOD

The content of reducing sugars, non-reducing sugars and total sugars found in baby food were gathered in Table 2. The samples with the highest content of reducing sugars was the Pitaya fruit with 18.73%, followed by the sample (n.15) with assorted fruits, including papaya and apple, with 14.02%. The lowest reducing sugar content was found in the sample (n.11), with the composition of groats and pineapple fruit juice with cinnamon, with only 0.38%. Regarding non-reducing sugars, the sample (n.14) with the highest content had plum fruit composition, with 12.27%, followed by pear and plum fruit porridge, with 9.88%. The lowest value was from sample 10, of pumpkin and coconut composition, with only 1.14%. For the total sugar content, the order was pitaya fruit with 22.72%, followed by the assorted fruit samples (n.15) with 21.84%, and the one made with plum (n.14) with 21.80% of content. The lowest total sugar content was in sample 10 (pumpkin and coconut milk composition), with 2.50%.

Table 2. Reducing, non-reducing and total sugars by the Lane-Eynon method in baby food samples.

	Mean ± SD		
N.	**Reducing sugars**	**Non-reducing sugars**	**Total Sugars**
1	2.36 ± 0.04	9.66 ± 0.37	12.02 ± 0.41
2	4.16 ± 0.13	6.31 ± 0.16	10.47 ± 0.03
3	1.58 ± 0.02	4.81 ± 0.09	6.39 ± 0.11
4	1.11 ± 0.02	2.26 ± 0.04	3.37 ± 0.06
5	2.12 ± 0.14	7.77 ± 0.48	9.89 ± 0.34
6	6.93 ± 1.09	9.88 ± 0.78	16.81 ± 1.87
7	3.42 ± 0.44	3.41 ± 0.05	6.82 ± 0.49
8	2.75 ± 0.11	3.32 ± 0.09	6.07 ± 0.20
9	1.43 ± 0.09	6.88 ± 0.37	8.32 ± 0.47
10	1.36 ± 0.03	1.14 ± 0.08	2.50 ± 0.10
11	0.38 ± 0.00	2.63 ± 0.08	3.01 ± 0.08
12	3.59 ± 0.10	8.01 ± 0.51	11.60 ± 0.61
13	8.61 ± 0.58	6.94 ± 0.39	15.56 ± 0.97
14	9.53 ± 0.71	12.27 ± 7.15	21.80 ± 7.86
15	14.02 ± 6.61	7.82 ± 0.48	21.84 ± 7.09
16	11.93 ± 2.84	7.67 ± 0.23	19.05 ± 3.07
17	1.84 ± 0.05	6.22 ± 0.30	8.07 ± 0.25
18	2.24 ± 0.45	2.48 ± 0.07	4.72 ± 0.53
19	1.50 ± 0.05	1.83 ± 0.04	3.33 ± 0.09
20	2.40 ± 0.15	3.86 ± 0.047	6.26 ± 0.62
21	3.86 ± 0.23	5.31 ± 0.34	9.17 ± 0.56
22	2.16 ± 0.04	3.96 ± 0.06	6.13 ± 0.10
23	11.84± 0.02	3.90± 0.01	15.74± 0.06
24	12.46± 0.05	2.65± 0.03	15.11± 0.05
25	13.78± 0.01	4.35± 0.03	18.13± 0.01
26	13.40± 0.02	2.40± 0.05	15.80± 0.02
27	14.49± 0.02	4.78± 0.02	19.27± 0.02
28	18.73± 0.03	3.99± 0.01	22.72± 0.05
29	1.03± 0.02	2.40± 0.07	3.43± 0.05
30	0.98± 0.07	2.53± 0.03	3.52± 0.01

3.2 TOTAL SOLUBLE SOLIDS (TSS)

The values in Table 3 represent the average total soluble solids content of the samples. The highest TSS contents were found in fruits, açaí and banana (n.25) with 20ºBrix, followed by banana baby food (n.17) with 19ºBrix and by pitaya baby food (n.28) with 18ºBrix. The baby food that had the lowest content was the pumpkin and coconut composition (n.10), with only 3ºBrix.

Table 3. Total soluble solids (ºBrix) in infant food.

N.	**SST (ºBrix,)** Mean ± SD
01	12.7 ± 0.91
02	15 ± 0.70
03	13 ± 0.70
04	13 ± 0.70
05	15.7 ± 0.49

06	16 ± 0.70
07	6.3 ± 0.70
08	6 ± 0.35
09	9.1 ± 0.63
10	3 ± 0.84
11	11.2± 0.60
12	10 ± 0.70
13	15.5 ± 0.35
14	17 ± 0.70
15	10 ± 1.41
16	9.8 ± 1.27
17	19 ± 0.70
18	14 ± 2.82
19	15.5 ± 0.35
20	16± 0.70
21	16± 0.70
22	11.5± 0.35
23	13 ± 2.1
24	12± 0.70
25	20 ± 1.41
26	12± 0.49
27	17± 0.35
28	18± 0.17
29	10 ± 0.07
30	9.7± 0.14

In the comparison between the different flavors of baby food, the sample, of Pitaya flavor (n.28), was the one that presented the highest levels of A, with a content of 22.72%, however, in its nutritional information table there is no data of total sugars, disagreeing with the current legislation and making it impossible to compare nutritional data. Plum flavor samples (n.14) and fruit flavor sample 15 (n.15), presented contents of 21.80% and 21.84% respectively, presenting difference in the information of their labels that informed per portion the amount of 11.66% and 9.16%.

4 DISCUSSION

In the analysis of the baby food using the Lane-Eynon method, it was possible to quantify the sugar content in these foods and it was verified that the values obtained for reducing sugars and non-reducing sugars were different, similarly to the work by Santos et al. (2016) using the same method. The difference may be related to the different types of sugars present in each sample from different manufacturers. Also, it can be observed that the samples between the companies do not have standards in the number of sugars available on their labels. When comparing the different flavors of baby food, the Pitaya flavor sample (n.28) with the highest total sugar content (22.72%) did not include this data in its nutritional information table, which disagrees with current Brazilian legislation and making it impossible to compare nutritional data. The plum flavor samples (n.14) and the assorted fruit flavor (n.15), presented contents of

21.80% and 21.84% respectively, showing difference in the information of their labels that informed per portion the amount of 11.66% and 9.16 %. The values of the contents found in the flavors of plum and assorted fruits correspond to those of the study by Marques (2016), who, analyzing industrialized baby food with sweet flavors based on fruits for consumption from six months, sold in the city of Teresina in Piaui (Brazil), found 21.12% total sugar contents for plum baby food and 22.08% for assorted fruits. Infant baby food with high levels of sugars are considered cariogenic foods described in the literature as a determining factor in the genesis of dental caries. Awad et al. (2023) who identified the presence of sucrose, glucose and fructose in 71 different brands of infant formulas, also warns of the presence of sugars in infant foods that are associated with the occurrence of tooth decay when associated with prolonged and nocturnal eating habits. Silva (2023) also concluded that ultra-processed foods such as cornstarch cookies and other sugary foods are the most consumed among children aged 6 months and 2 years.

The SST analysis method confirmed the presence of sugars in all collected samples. Garcia et al. (2015) presented reports that corroborate this analysis, since in the study on the types of fruits and vegetables used in baby food sold for babies and their contributions to the sugar content, it was found that the most common fruits and all relatively sweet were apple, banana and mango, and found that these fruits significantly contribute to the total sugar content of these infant foods. The methodology by Brix degrees is used in the physical-chemical analysis in works of characterization of sugars in fruit pulps and in the formulation of foods with high levels of added sugars, to evaluate the crystallization of sucrose, however there are still no studies in baby food using of this method in the literature (Oliveira et al., 2019; Freitas et al. 2020).

The sample labels did not inform the amount of total and added sugar, as required by law, which disagrees with the current ANVISA standard (2020). However, their labels contained nutritional claims such as “does not contain sugar”, “no added sugars” and “no sugar” in their products. According to Santiago (2022), the values of reducing sugars found show the presence of glucose in the composition of baby food, and the levels of non-reducing sugars indicate the presence of sucrose in these foods. Santos et al. (2022) in a study of label analysis of infant foods, found that the majority had irregularities that compromised child health and were in non-compliance with the recommendations of the World Health Organization for nutritional labeling.

The importance of adequate food introduction is associated with the prevention of non-transmissible chronic diseases. Added to this, there is the formation of eating behavior, which also begins in childhood and carries its information into adulthood. Therefore, it is based on introducing healthy foods and controlling the consumption of sugars, that adequate physiological, cognitive, sensory-motor development can be ensured, obtaining numerous benefits for the child's health, avoiding diseases related to poor diet, such as metabolic syndromes and eating disorders throughout life, thus reinforcing the importance of infant feeding as the first form of prevention and health promotion (Ramos et al., 2021; Teixeira et al., 2022).

5 CONCLUSION

The sugar content in baby food based on fruit was analyzed using different methodologies. The sample with the highest total sugar content was determined by the Lane-Eynon redox method, and the total sugar content by total soluble solids by the Brix degree method. It was also evaluated whether these baby foods followed the legislation in force, which has mandatory updates for the labeling of packaged foods, especially those that contain sugar content, and it was found that there were baby food labels collected in this study they were irregular. With this, we emphasize the importance of controlling the consumption of sugar in foods intended for children, as well as the updated nutritional information on their labels, since sugar is a highly inflammatory component in the diet related to metabolic diseases and that its consumption must be reduced during childhood, preventing the development of obesity, diabetes, cavities and others.

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