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Quality and Safety in Commercial Baby Foods

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Abstract Nutrient-rich baby foods are required with particularly high standards of quality and safety expressed through product specifications or attributes. These foods are generally subjected to thermal processes that could involve a reduction of essential elements, as well as in the formation of potentially harmful molecules. This paper aimed at detecting the presence, in some baby foods, of compounds derived from Maillard reactions, 5-hydroxymethylfurfural (HMF) and total Maillard Reaction Products (MRPs), as well as at evaluating the hypothetical levels of HMF daily intake by infants and children fed with the tested products. Baby food samples included milk powders, lyophilized meat-based foods, powdered creams based on cereals, homogenized jarred foods based on processed cheese, fish, vegetables, and meat. As far as the healthiness of the tested foods is concerned, significant quantities of total MRPs were found. The lyophilized meat-based foods samples showed the highest levels of total MRPs. At 380 nm, all the samples exceeded the total MRPs concentration of 1000 mg/100g. The analysis revealed the presence of HMF in all the samples under study. However, none of the samples exceeded the threshold concentration of 20 mg/Kg. The highest values were recorded for the category of lyophilized meat-based foods and for a sample of homogenized veal-based food. The results for the hypothetical daily levels of HMF intake by babies showed that, for the age group over 12 months, a value of 3.6 mg was reached. The largest percentage contribution was imputable to the homogenized jarred foods based on proteins and vegetables.

Keywords: *baby food, HMF, Maillard Reaction Products, diet*

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1. Introduction

In the recent decades, the reduction of time to be dedicated to the preparation of home meals has already led to the appearance of ready-to-eat food products on the market. Also called convenience foods, fully or partially cooked when packed, they are easy to prepare, fast to heat and with a highly desirable aspect. If once the time preparation of a meal was greater than 60 minutes, nowadays, on average, 5-30 minutes may be needed [1]. Also, the foods specifically manufactured for infants and young children have had a similar evolution. Prepared baby foods and formulas, intended for use of children aged between 4 months and 3 years, provide an appealing alternative for working mothers. They are also designed to meet the nutritional needs of children: high energy input, high protein and essential amino acid requirements, specific requirements for vitamins, minerals, macro and micronutrients, appropriate lipid content and little salt.

Convenience foods, which come to our tables after undergone numerous processing steps needed to get the finished product, may contain unwanted components, sometimes simply "ugly" or bad tasting, other times potentially harmful to health. It should also be considered that certain categories of the population are more susceptible than others to the presence of such substances. Specifically, just for newborns, infants, and children in early childhood, food products must ensure high standards of safety and quality, especially with regard to the nutritional aspect [2,3].

The harmful contaminants that can be found more often in foods are: minerals and inorganic elements at levels higher than those required by the human body; toxins such as ochratoxin A, fumonisin B1 and B2, and aflatoxins; antibiotics used on farm animals; reaction products among food ingredients, such as aromatic heterocyclic compounds, pyrazines or acrylamides; pesticides; heavy metals such as mercury; formation of semicarbazide; bacteria due to low hygienic conditions in the processing environment or to contamination of starting materials used, such as cronobacteria which pose higher risk to children [4-11].

By cooking at more or less high temperatures, some components may be inactivated (e.g., microorganisms) or their formation can be prevented (e.g., toxins). This is why the food industry often employs processes of homogenization, heating and cooking to obtain safe and less perishable products.

At the same time, numerous reactions can occur during thermal processes leading to the loss of thermolabile substances, such as vitamins and some essential amino acids and resulting in a reduction of the nutritional value of the finished food product. In addition, also particular chemical-physical mechanisms may be triggered, such as caramelization, lipid oxidation, and Maillard reaction, which can lead to the formation of harmful compounds [12,13]. In particular, in the Maillard reaction substances such as acrylamide, 5-hydroxymethylfurfural (HMF) and aromatic heterocyclic amines are formed. The products obtained from this reaction have multiple effects: some can be carcinogenic, others seem to be related to diabetes and Alzheimer's, whereas others instead show positive effects such as a high antioxidant and antimutagenic activity [14,15,16,17,18].

In this paper, the potential presence of molecules derived from the Maillard reaction was verified. HMF and the total Maillard Reaction Products (MRPs) were then dosed in a number of baby food products collected from the market, not limited to milk-based infant formulas that represent the main field of analysis of the scientific literature, see for example [19,20]. Particular attention was paid to HMF that has not to exceed certain limit levels in foods intended for young children. As a possible reference value, the HMF limit of 20 mg/kg fixed by the European Fruit Juice Association [21] was considered. A limit more stringent with respect to the only other limit in honey of 40 mg/kg [22,23].

2. Material and Methods

2.1. Sampling Collection

Samples of baby food were found in local supermarkets. 45 samples were selected as follows:

- 2 growing up milk powders intended for babies aged 1 to 3 years;
- 2 meat-based lyophilized preparations;
- 5 cereal-based porridges;
- 3 cheese-based homogenized jarred preparation;
- 5 fish-based homogenized jarred preparation;
- 4 vegetable-based homogenized jarred preparation;
- 24 meat-based homogenized jarred preparations.

2.2. Sampling Preparation

2.2.1. Protein-based Homogenized Jarred Baby Food Samples

0.5 g of the product was diluted in 10 ml of acidified distilled water (1%) and extracted for 10 minutes. The solution was centrifuged (ALC 4218 centrifuge) at 3000 rpm for 10 minutes. The solid fraction, separated from the supernatant, was then subjected to a new extraction step. The liquid phases were collected and brought to a final volume of 10 ml.

2.2.2. Vegetable-based Homogenized Jarred Baby Food Samples

0.5g of the product was dissolved in 10 ml of acidified distilled water (1%) and extracted for 10 minutes. The solution was centrifuged (ALC 4218 centrifuge) at 3000 rpm for 10 minutes. The solid fraction, separated from the supernatant, was then collected and brought to a final volume of 10 ml.

2.2.3. Meat-based Freeze-dried Preparations, Cereal-based Powder Creams, and Milk Powder Samples

125 ml of water were added to two aliquots of 5 g of freeze-dried meat, two aliquots of 5 g of cereal powder and two aliquots of 30 g of milk powder and each aliquot was brought to 50°C and 100°C respectively. From each solution was taken 20 g, diluted with 100 ml of water and extracted for 30 min. The solution was then filtered (Whatman Schleicher & Schüll filter paper Grade 589/1, 125 mm, Merck, Darmstadt, Germany).

2.3. Sample Analysis for the Determination of HMF and Total MRPs

2.3.1. Sample Analysis for HMF Determination

The sample extracts previously prepared were analyzed at room temperature at two wavelengths: 266 nm and 284 nm.

2.3.2. Sample ANALYSIS for Total Maillard Reaction Products Determination

The Maillard's reaction can be ideally divided into three steps: a first phase involving the formation of colorless compounds that do not absorb in the spectrum of the visible and that can be analyzed at 280 nm; a second, more advanced, step that can be monitored at 360 nm and finally a third step which leads to the formation of colored high molecular weight compounds, the melanoidin, which absorb at 420 nm [24,25]. The extracts of the previously prepared samples were therefore analyzed at room temperature at the three different wavelengths to highlight the three reaction steps.

2.3.3. Equipment

All analyses were performed using a Cary 60 UV-Vis Spectrophotometer (Agilent, CA, United States).

3. Results and Discussion

3.1. HMF Evaluation

The results obtained show the presence of 5-hydroxymethylfurfural (HMF) in all the analyzed samples as shown in Table 1 and Table 2. It can be noted that, as regards the foods highest in carbohydrates, the concentrations are far below the above-mentioned threshold values for fruit juices [21].

As can be seen in Table 1, for cereal-based porridges analyzed at 266 nm the values vary between a minimum of 1.23 mg/kg for the whole cereal sample prepared at 50°C and a maximum of 8.62 mg/Kg for the same sample prepared at 100°C. At 284 nm the minimum value of HMF was determined for the wheat semolina sample prepared at 50°C instead the HMF value is 5.90 mg/Kg, whereas the maximum was for 4 cereals porridge heated at 100°C. It is therefore evident that the recommended temperature of 50°C provides a wide margin of safety.

In Table 2 the highest values are those for the lyophilized Turkey samples prepared at 50 °C, 18.19 mg/Kg and 9.02 mg/Kg, at 266 nm and 184 nm respectively. The lowest ones instead refer to the Lamb sample 4.61 mg/Kg at 266 nm, and Plaice sample 2.56 mg/Kg at 284 nm. In general, the samples with higher levels of 5-hydroxymethylfurfural were the lyophilized meats and the meat-based homogenized Chicken and Veal.

Table 1. HMF Values at 266 nm and 284 nm Expressed in mg/Kg for the Cereal-based Porridges and Growing up Milk.

	HMF Content (mg/Kg)	
	266 nm	284 nm
4 Cereals (50°C)	2.95 ± 0.61	2.08 ± 0.10
4 Cereals (100°C)	8.62 ± 0.72	5.90 ± 0.22
Whole Cereals (50°C)	1.23 ± 0.17	1.08 ± 0.13
Whole Cereals (100°C)	2.73 ± 0.04	1.34 ± 0.04
Maize and Tapioca (50°C)	3.28 ± 0.35	2.30 ± 0.09
Maize and Tapioca (100°C)	3.92 ± 0.44	2.92 ±0.05
Creamy Rice (50°C)	2.44 ± 0.16	1.65 ± 0.08
Creamy Rice (100°C)	3.84 ± 0.25	2.53 ± 0.02
Wheat Semolina (50°C)	1.68 ± 0.11	1.04 ± 0.15
Wheat Semolina (100°C)	3.31 ± 0.34	2.19 ± 0.13
Growing up Milk 1	4.15 ± 0.01	2.79 ± 0.01
Growing up Milk 2	4.77 ± 0.05	2.96 ± 0.01

Values are means ± *s.d.* of three separate determinations.

Table 2. HMF Values at 266 nm and 284 nm Expressed in mg/Kg for the Meat-based Lyophilized and Various Protein- and Vegetable-based Homogenized Jarred Meals

	HMF Content (mg/Kg)	
	266 nm	284 nm
Chicken (50°C)	14.74 ± 0.99	8.71 ± 0.62
Chicken (100°C)	18.07 ± 0.39	10.14 ± 0.97
Turkey (50°C)	18.19 ± 1.9	9.02 ± 0.99
Turkey (100°C)	11.19 ± 0.11	6.13 ± 0.73
Lamb	4.61 ± 0.32	3.03 ± 0.13
Horse	8.71 ± 0.01	4.04 ± 0.76
Rabbit	8.95 ± 0.12	4.64 ± 0.08
Cheese	7.25 ± 0.10	5.60 ± 0.72
Beef 1	7.99 ± 0.46	7.19 ± 0.68
Beef 4	7.23 ± 0.87	4.04 ± 0.53
Peas and zucchini	5.86 ± 0.62	3.17 ± 0.02
Plaice	4.83 ± 0.11	2.56 ± 0.27
Chicken 1	15.70 ± 1.97	7.63 ± 0.07
Chicken 2	12.46 ± 0.19	5.89 ± 0.46
Turkey 1	8.61 ± 0.06	3.92 ± 0.09
Turkey 4	6.61 ± 0.66	3.14 ± 0.69
Vegetables 1	6.32 ± 0.09	3.67 ± 0.14
Vegetables 2	11.59 ± 0.37	5.91 ± 0.72
Veal 1	17.76 ± 0.25	9.35 ± 0.01
Veal 3	9.65 ± 0.31	4.73 ± 0.39

Values are means ± *s.d.* of three separate determinations.

From the data obtained, a mean value for HMF content in the various categories of the analyzed baby foods was also determined. At 266 nm: 3.4 mg/Kg for the cereal-based porridges, 15.55 mg/Kg for the meat lyophilized, 9.25 mg/Kg for protein-based homogenized food jar, 7.92 mg/Kg for vegetable-based homogenized food jar, and 4.46 mg/Kg for milk powders. At 284 nm the registered values are lower: 2.3 mg/kg for the cereal-based porridges, 8.5 mg/kg for the meat lyophilized, 5.08 mg/Kg for protein-based homogenized samples, 6.14 mg/Kg for homogenized food jars with vegetables and 2.87 mg/Kg for the milk powder.

For cereal and meat lyophilized porridges, the analyzes were made from the same powder base added with distilled water at two temperatures: 50°C and 100°C. The samples obtained with water at a higher temperature showed HMF levels higher than those obtained with water at a medium temperature in accordance with the temperature dependence of the Maillard reaction. At 266 nm the percentage increase showed to vary from 19.48% of Maize and Tapioca sample to 192.2% of 4 Cereals sample with a mean value of 67.36%. Only the lyophilized Turkey sample showed a decrease in values (-38.48%). At 284 nm the increase in HMF values between preparations at 50°C and those at 100°C was between 25.22% of Maize and Tapioca porridge and 183.65% of 4 Cereals porridge with a mean increase of 52.4%. In the same way, the values decreased by 32.0% for the lyophilized Turkey sample.

Figure 1 shows the percentage increase in the two different cooking temperatures.

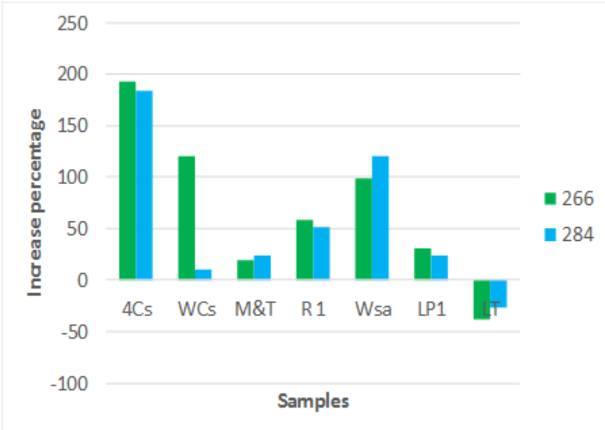

Figure 1. Comparison between the HMF value increases for the samples prepared at 50°C and 100° at 266 nm and 284 nm, expressed as percentages. Legend: 4Cs = 4 Cereal cream; WCs = Whole Cereal cream; M&T = Maize and Tapioca cream; R1 = creamy Rice porridge; Wsa = Wheat semolina; LP1 = Lyophilized chicken; LT = Lyophilized Turkey

3.2. Total MRPs Evaluation

The samples analyzed at three wavelengths of 280 nm, 360 nm and 420 nm showed the presence of consistent levels of Maillard reaction products. These three wavelengths ideally represent the three stages of the Maillard reaction and the analysis carried out showed how the reaction performance is unpredictable. It is not possible, in fact, to define if more products will be formed in the first, second or third stage of the reaction. And this is in accordance with the difficulty of a clear prediction of what will be obtained from a very heterogeneous starting sample. The results obtained are listed in Table 3 and Table 4.

At 280 nm the total MRPs values in the first reaction phase were generally found to be higher for lyophilized meat samples: Chicken 2 with 3256 mg/100g and Veal 1 with 4267 mg/100g. At 360 nm the total MRPs values in the second reaction phase were found to be higher for: lyophilized meat in general, the Cheese sample with 5104 mg/100g, the vegetable 2 sample with 5075 mg/100g and Veal 1 sample with 6080 mg/100g. At 420 nm the total MRPs values in the third reaction stage were found to be higher for the lyophilized meat samples in general, Cheese sample with 5971 mg/100g and Veal 1 with 6921 mg/100g.

Table 3. Total MPRs Values at 280 nm, 360 nm and 480 nm Expressed in mg/100g for the Cereal-based Porridges and Growing up Milk

	Total MPRs Content (mg/100g)		
	280 nm	360 nm	480 nm
4 Cereals (50°C)	341 ± 10.99	1929 ± 114.56	2126 ± 49.45
4 Cereals (100°C)	2582 ±19.78	4521 ± 61.81	3983 ± 35.87
Whole Cereals (50°C)	302 ± 16.48	1175 ± 66.33	1294 ± 46.07
Whole Cereals (100°C)	1117 ± 10.16	1287 ± 10.82	1326 ± 48.08
Maize and Tapioca (50°C)	775 ± 1.92	1476 ± 13.08	1485 ± 35.75
Maize and Tapioca (100°C)	1092 ± 7,69	1835 ± 41.73	1914 ± 20.19
Creamy Rice (50°C)	133 ± 1.56	1368 ± 93.68	1477 ± 36.86
Creamy Rice (100°C)	677 ± 3.57	2026 ± 95.60	1977 ± 18.52
Wheat Semolina (50°C)	882 ± 84.58	1118 ± 28.75	1318 ± 23.54
Wheat Semolina (100°C)	700 ± 33.75	2106 ± 43.75	2104 ± 31.72
Growing up Milk 1	2077 ± 12.36	2407 ± 16.33	2785 ± 19.14
Growing up Milk 2	2334 ± 15.84	3215 ± 28.12	3840 ±23.76

Values are means ± *s.d.* of three separate determinations.

Table 4. Total MPRs Values at 280 nm, 360 nm and 480 nm Expressed in mg/100g for the Meat-based Lyophilized and Various Protein- and Vegetable-based Homogenized Jarred Meals

	Total MPRs Content (mg/100g)		
	280 nm	360 nm	480 nm
Chicken (50°C)	3888 ± 12.5	7119 ± 32.48	7481 ± 31.65
Chicken (100°C)	4683 ± 39.67	8381 ± 25.19	9075 ± 35.86
Turkey (50°C)	5185 ± 54.13	7994 ±27.55	9843 ± 33.67
Turkey (100°C)	2150 ± 33.18	5084 ± 18.45	2521 ± 19.41
Lamb	1671 ± 19.57	3570 ±11.53	4240 ± 28.26
Horse	2239 ± 26.31	4800 ± 27.19	5570 ± 25.73
Rabbit	827 ± 13.07	4363 ± 26.33	5243 ± 18.56
Cheese	2324 ± 21.54	5104 ± 19.0	5971 ± 16.45
Beef 1	2522 ± 16,77	4015 ± 20.76	4967 ± 18.37
Beef 4	1798.5 ± 24.65	3952 ± 17.83	4510 ± 19.19
Peas and zucchini	1365 ± 14.11	3520 ± 18.32	3759 ± 20.71
Plaice	812 ± 23.05	3470 ± 24.93	4057 ± 16.86
Chicken 1	2103 ± 19.66	2950 ± 13.72	3596 ± 16.49
Chicken 2	3256 ± 14.17	4665 ± 10.64	3357 ± 21.28
Turkey 1	1561 ± 11,96	3757 ± 21,45	4498 ± 24.75
Turkey 4	878 ± 9.45	3462 ± 15.35	3960 ± 18.66
Vegetables 1	1764 ± 14.62	3810 ± 14.66	4530 ± 16.49
Vegetables 2	2705 ± 20.18	5075 ± 23,19	5714 ± 24.54
Veal 1	4267 ± 24.22	6080 ± 26.30	6921 ± 26.11
Veal 3	2136 ± 15.70	4253 ± 19.44	4654 ± 23.32

Values are means ± *s.d.* of three separate determinations.

The samples of cereal-based porridges creams and lyophilized meat were prepared by adding distilled water at 50°C and 100°C and then analyzed. Like for HMF analysis, in all three phases total MRPs values increased as the sample preparation temperature increased. At 280 nm the increase varied from 20.46% for Maize and Tapioca porridge to 658.06% for the 4 Cereal sample with a mean value of 187.55%, whereas the Wheat Semolina sample showed a decrease of 20.96% and the turkey-based lyophilizate of 46.43%.

At 360 nm an increase in the total MRPs values was found for the second reaction between the samples at 50°C and 100°C ranging between 9.45% of Whole Cereal porridge and 134.29% of the 4 Cereal cream with a mean value of 40.76%. Also, in this case, the lyophilized Turkey sample showed a decrease of 36.97%.

At 420 nm the increase in total MRPs for the third reaction stage between the samples at 50°C and 100°C ranged from 2.44% of Whole Cereal porridge to 87.34% of 4 Cereal prorridge with a mean value of 22.75%. Once again the lyophilized Turkey sample showed a decrease, in this case, equals to 74.39%.

As shown in Figure 2, for 4 samples out of 7, the highest increase in total MRPs values was recorded in the first reaction phase, the one where the temperature seems to have a greater influence. In the Wheat Semolina sample, the highest increase was recorded in the second reaction phase, while in the first stage a value decrease was recorded. Lyophilized Chicken sample showed a greater increase in the third reaction stage. For the lyophilized Turkey sample, the values decreased in all three stages of the reaction with a peak in the last stage.

3.3. HMF Daily Intake Assumptions by an Infant or a Baby in Early Childhood

3.3.1. Sample Meal Plans According to the Child's Age

To ensure a healthy growth and development, it is necessary to provide newborns, infants, and babies in early childhood a proper feeding aimed at meeting the specific requirements for this particular age range. The baby development stage from childbirth to 24 months is the most delicate and it is divided into four phases 0-6 months, 6 months, 7-9 months, 9-12 months and 12 months up. In the first six months of life, the primary food and, if possible, the single source of nutrition, must be breast milk or, in the event of impossibility, the milk formulated specifically for this period of life. After 6 months, it is necessary to introduce new foods, by paying attention to their consistency and quality, as they have to be nutritionally adequate according to the age group. It is from 6 months of age in fact that the infants begin to develop the oral motor skills necessary for normal child development. The babies need to be provided with homemade foods freshly prepared, i.e., the same ones for the rest of the family, but appropriately cooked. If this is not feasible, pre-packaged baby foods may be used [26]. An "extreme" diet plan, based on commercial infant formulations and infant formula only, was therefore defined (Table 5), by following, however, the appropriate dietary recommendations for specific age groups [27], [28].

After the age of 12 months, the baby should receive approximately 175 ml of iron-enriched cereals, 2 to 3 servings of homogenized jarred vegetables, 2 to 3 servings of homogenized jarred fruit, 2 to 3 servings of homogenized jarred meat 45 ml and about 720 ml of milk.

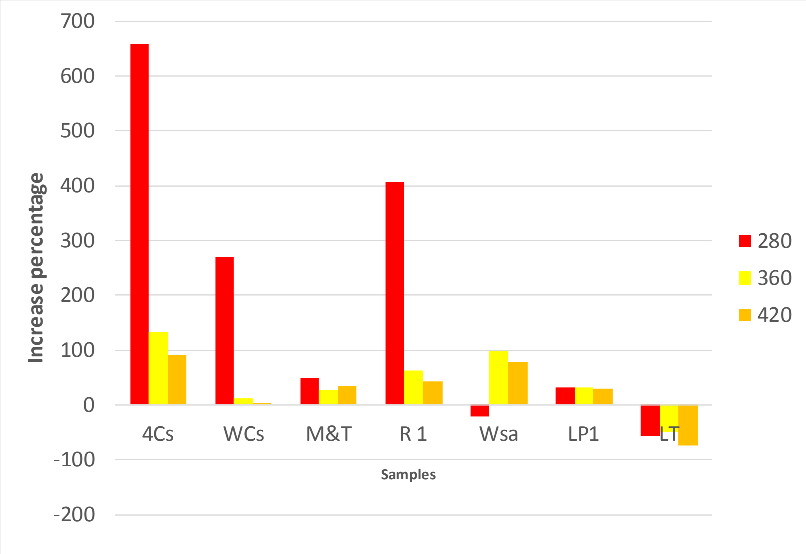

Figure 2. Comparison among the MPRs value increases for the samples prepared at 50°C and 100° at 280 nm, 360 nm, and 420 nm, expressed as percentages. Legend: 4Cs = 4 Cereal cream; WCs = Whole Cereal cream; M&T = Maize and Tapioca cream; R1 = creamy Rice porridge; Wsa = Wheat semolina; LP1 = Lyophilized chicken; LT = Lyophilized Turkey

Table 5. An Example of Meal Plans for Different Baby Age Groups: 6 Months, 7-9 Months and 9-12 Months.

Timing	6 Months	7-9 Months	9-12 Months
Awakening	Milk 200-230 ml	Milk 200-230 ml	Milk 140-170 ml
Breakfast	Milk 170-200 ml Iron enriched Cereals 5 ml	Milk 170-200 ml Iron enriched Cereals 45 ml Fruit jar 15 ml	Milk 140 ml Iron enriched Cereals 125 ml Fruit jar 45 ml
Lunch	Milk 170-200 ml Vegetable jar 5 ml Meat jar 15 ml	Milk 140-170 ml Iron enriched Cereals 45 ml Vegetable jar 15 ml	Milk 140 ml Rice or other cereal 30 ml Meat jar 15 ml Vegetable jar 45 ml
Dinner	Milk 170-200 ml Iron enriched Cereals 5 ml Vegetable jar 5 ml Fruit jar 5 ml	Milk 170 ml Iron enriched Cereals 45 ml Meat jar 15 ml Fruit jar 15 ml	Milk 140 ml Pasta or other cereal 30 ml Meat jar 15 ml Vegetable jar 45 ml Fruit jar 30 ml
After dinner	Milk 170-200 ml	Milk 140-170 ml	Milk 140 ml

3.3.2. The Determined Content of HMF

Table 6 summarizes the mean values of HMF present in the baby food samples here analyzed. The highest values were found at 266 nm and therefore the mean values obtained at this wavelength were taken into account to estimate the highest level of HMF intake for each baby food category.

It is important to note that to obtain 180 ml of milk, 30 g of powdered milk is the needed amount and to obtain 200 g of cereal, on average, 20 g of cereal powder is enough, whereas for the homogenized food products the value in ml is almost equal to that in g. For the calculations carried out, it was assumed that all cereals, including pasta and rice, were equivalent. Homogenized meat, fish or cheese baby foods were considered together under the most generic "homogenized protein-based group".

Moreover, in the hypothetical diet here considered, HMF values derived from homogenized fruit preparations were not included since these products should not have been exposed to an excessive heating from which this substance is generated. Not even the HMF's contribution from meat-based lyophilized broths, sometimes used for the preparation of cereal-based creams, was considered. In Table 7 hypothetical daily levels of 5-hydroxymethylfurfural intake by infants and babies in early childhood are listed according to the age group and along with the daily percentages derived from any food category.

Table 6. HMF Content for Different Baby Food Products. Data are Expressed as Mean Values (in mg/kg)

Baby Food Category	HMF
Creamy cereals porridge	3.4
Meat lyophilized	15.55
Meat jars	9.25
Vegetable jars	7.92
Milk powder	4.46

It is possible to see that in the stages of 6 months and 7 to 9 months, the highest contribution of HMF is derived from milk powder. From 9 months onwards as the powdered milk intake decreases, that of homogenized proteins and vegetable increases.

Table 7. Daily HMF Intake Level from a Hypothetical Diet Based Only on Commercial Baby Foods Expressed in mg/kg and as Percentage from Each Food Category on the Daily Total Amount

Age	Daily amount of HMF (mg/kg)	Daily Percentage HMF Intake
6 Months	0.99	77.57% from milk powder
		8.02% from vegetable jars
		0.34% from creamy cereals porridge
		14.06% from meat jar
7-9 Months	0.93	75.11% from milk powder
		12.77% from vegetable jars
		4.93% from creamy cereals porridge
		7.19% from meat jar
9-12 Months	1.6	34% from milk powder
		44.66% from vegetable jars
		3.94% from creamy cereals porridge
		17.39% from meat jar
> 12 Months	3.62	14.76% from milk powder
		49.15% from vegetable jars
		1.64% from creamy cereals porridge
		34.44% from meat jar

In particular, as shown in Figure 3, homogenized vegetables after 9 months of age represent the main source of 5-hydroxymethylfurfural. From 12 months on, in addition to vegetables, homogenized proteins represent a high source of HMF.

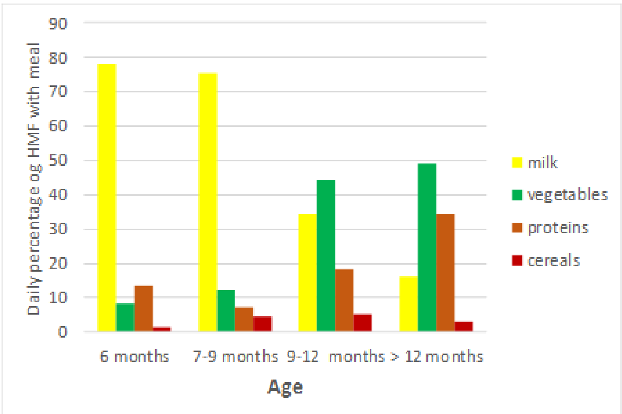

Figure 3. Percentage of HMF intake on the daily total amount of a hypothetical diet based on only commercial products for each category of food

In Cereal creams instead HMF is not so much present because they are prepared with large amounts of water relative to the powder used to obtain the final baby soup.

3. Conclusions

In food samples for infants and babies, HMF has always been found, even if in quantities below the limit of 20 mg/kg, along with generally high quantities (for each wavelength) of Total Maillard Reaction Products. This means that, in a hypothetical diet based just on commercial baby food products, non-negligible amounts of HMF/kg body weight would be daily taken by infants and babies. A relevant aspect considered the presence of an incomplete detoxifying system in this age group. Furthermore, these samples also showed a low antioxidant capacity and a rather high fatty acid oxidation (in the case of lipid-based foods) (data here not reported), thus confirming poor quality in products which, conversely, given the type of consumers to which they are intended, should pay particular attention to both the appropriate raw material selection and the use of adequate production processes.

References

[1] Guinè, R.P.F., Food, Diet, and Health: Past, Present and Future Tendencies, Nova Science Publishers, New York, 2010.

[2] Abdullah Sani, N., Hartantyo, S.H.P., Forsythet, S.J., “Microbiological assessment and evaluation of rehydratation instructions on powdered infant formulas, follow-up formulas, and infant foods in Malaysia”, Journal of Dairy Science, 96 (1), 1-8, Jan 2013.

[3] De Maria, F., Drogue, S., “EU Trade Regulation for Baby Food: Protecting Health or Trade?”, The World Economy, 40 (7), 1430-1453, Aug 2016.

[4] Tsuchida, H., Tachibana, S., Komoto, M., “Isolation and Identification of 2-(D-threo-Trihydroxypropyl)-5-(D-glycero-2’,3’-dihydroxypropyl)pyrazine and its 6-Isomer from Browning Reaction between Xylose and Ammonium Formate”, Agricultural and Biological Chemistry, 40 (6), 1241-1242, 1976.

[5] Gassin. A.L., Van Geest, I., “Communication in Europe on Semicarbazide and Baby Food”, Journal of Risk Research, 9 (8), 823-832, Feb 2007.

[6] Laine, A.M., Medina, D.A., Food Quality: Control, Analysis and Consumer Concerns, Nova Science Publishers, New York, 2011.

[7] Baneras, L., Trias, R., Godayol, A., Cerdàn, L., Nawrath, T., Schulz, S., Anticó, E., “Mass spectrometry identification of alkyl-substituted pyrazines produced by Pseudomonas spp. Isolates obtained from wine corks”, Food Chemistry, 138 (4), 2382-2389, Jun 2013.

[8] Fatih Cengiz, M., Pelin Boyaci Gündüz, C., “Acrylamide exposure among Turkish toddlers from selected cereal-based baby food samples”, Food and Chemical Toxicology, 60, 514-519, Oct 2013.

[9] Shen, Y., Han, C., Zhou, X., Chen, X., Huang, F., Zhu, Z., “Microwave-assisted extraction and determination of dicyandiamide residue in infant formula samples by liquid chromatography-tandem mass spectrometry”, Journal of Dairy Science, 96 (11), 6877-6882, Nov 2013.

[10] Lu, Y., Chen, Y., Lu, A., Lv, J., Man, C.X., Chai, L., Jiang, Y.J., “Comparison of methods for the microbiological identification and typing of Cronobacter species in infant formula”, Journal of Dairy Science, 9 (2), 623-641, Feb 2014.

[11] Juan, C., Raiola, A., Manes, J., Ritieni, A., “Presence of mycotoxin in commercial infant formulas and baby foods from Italian market”, Food Control, 39, 227-236, May 2014.

[12] Ciesarová, S., Kukurová, K., Bednáriková, A., Morales, F.J., “Effect on heat treatment and dough formulation on the formation of Maillard reaction products in fine bakery products- benefits and weak points”, Journal of Food and Nutrition Research, 48 (1), 20-30, 2009.

[13] Capuano, E., Fogliano, V., “Acrylamide and 5-hydroxymethylfurfural (HMF): A review on metabolism, toxicity, occurrence in food and mitigation strategies”, LWT-Food Science and Technology, 44, 793-810, May 2011.

[14] Nursten, H.E., The Maillard Reaction: chemistry, biochemistry and implications, Royal Society of Chemistry, Cambridge, 2005.

[15] Somoza, V., “Review: five years of research on health risk and benefits of Maillard reaction products: An update”, Molecular Nutrition & Food Research, 49, 663-672, Jul 2005.

[16] Delgado-Andrade, C., Rufián-Henares, J.A., Morales, F.J., “Optimised Procedure to Analyse Maillard Reaction-Associated Fluorescence in Cereal-Based Products”, Czech Journal of Food Sciences, 26 (5), 339-346, 2008.

[17] Oh, N.S., Lee, H.A., Lee, J.Y., Joung, J.Y., Lee, K.B., Kim, Y., Lee, K.W., Kim, S.H., "The dual effects of Maillard reaction and enzymatic hydrolysis on the antioxidant activity of milk proteins", Journal of Dairy Science, 96 (8), 4899-4911, Aug 2013.

[18] Donnarumma, F., Wintersteiger, R., Schober, M., Greilberger, J., Matzi, V., Maier, A., Schwarz, M., Ortner, A., "Simultaneous Quantitation of Alpha-ketoglutaric Acid and 5-Hydroxymethylfurfural in Plasma by HPLC with UV and Fluorescence Detection", Analytical Sciences, 29 (12), 1177-1182, Dec 2013.

[19] Madani-Tonekaboni, M., Kamankesh, M., Mohammadi, A., "Determination of furfural and hydroxymethyl furfural from baby formula using dispersive liquid–liquid microextraction coupled with high-performance liquid chromatography and method optimization by response surface methodology", Journal of Food Composition and Analysis, 40, 1-7, Jun 2015.

[20] Er Demirhan, B., Demirhan, B., Sönmez , C., Torul , H., Tamer , U., Yentür, G., "Short communication: Determination of potential 5-hydroxymethyl-2-furaldehyde and 2-furaldehyde compounds in follow-on milks and infant formulas using the high-performance liquid chromatography method", Journal of Dairy Science, 98 (2), 818-822, Feb 2015.

[21] Code of Practice for Evaluation of Fruit and Vegetable Juices, European Fruit Juice Association (AIJN), 1999.

[22] Codex Alimentarius, Standard for Honey, FAO, Codex Stan 12-1981, revision 2001, Available:http://www.fao.org/fao-who-codexalimentarius/sh-proxy/ar/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCODEX%2BSTAN%2B12-1981%252Fcxs_012e.pdf.

[23] Council Directive 2001/110/EC of 20 December 2001 relating to honey, Available:http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:010:0047:0052:EN:PDF.

[24] Delgado-Andre, C., Seiquer, I., Haro, A., Castellano, R., Navarro, M. P., "Development of the Maillard reaction in foods cooked by different techniques. Intake of Maillard-derived compounds", Food Chemistry, 122 (1), 145-153, Sept 2010.

[25] Zhang, J., Li, J., Tang, Y., Xue, G., "Rapid method for the Determination of 5-Hydroxymethylfurfural and Levulinic Acid Using a Double-Wavelength UV Spectroscopy", The Scientific World Journal, 2013, 1-6, Aug 2013.

[26] Jackson, A., "Feeding the normal infant, child and adolescent," Medicine, 43 (2), 127-131, Feb 2015.

[27] Regione Friuli Venezia Giulia, Linee di indirizzo per l'alimentazione nei nidi d'infanzia 3 mesi-3 anni. Available: https://www.regione.fvg.it/rafvg/export/sites/default/RAFVG/salute-sociale/promozione-salute prevenzione/allegati/Linee_nidi_infanzia_2010.pdf

[28] Holdsworth, M., Madden, A., Webster-Gandy, J., Oxford Handbook of Nutrition and Dietetics, Oxford University Press, Oxford, 2006, 239-241.