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Influence of the storage conditions on physicochemical parameters of infant formula

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Abstract

The authors studied the changes in total dry matter and moisture content, solubility, titrable acidity and scorched particle content undergone by infant formula (IF) on storage for 18 months (throughout the product's shelf life) at room temperature and 15°C (the maximum limit stipulated by the Romanian regulations). The physico-chemical parameters of the samples were assessed after obtaining and at 3, 6, 9, 12, 15 and 18 months of storage.. The results shows an increase of the titrable acidity and moisture content with a decrease of the total dry matter during storage of infant formula at both temperature set-up. No significant changes were observed with solubility and scorched particle content during storage under these conditions.

Keywords: infant formula, storage conditions, physicochemical parameters

1. Introduction

According to CODEX STAN 72-1981, infant formula means a breast-milk substitute specially manufactured to satisfy, by itself, the nutritional requirements of infants during the first months of life up to the introduction of appropriate complementary feeding. The product is so processed by physical means only and so packaged as to prevent spoilage and contamination under infant formula [7].

Milk powders are hygroscopic: they tend to attract water readily from humid atmospheres. When moisture levels are excessive, milk powders may become sticky, caked or lumpy, and exhibit reduced flowability and solubility. These changes affect the ease of use of the product, requiring grinding for example, and may affect the flavor, but do not represent a health or safety problem [3].

The insolubility is generally attributed to the *Maillard* reaction, which involves reducing sugars and proteins. Storage studies of dried milk products have shown that the products stored in a variety of conditions could exhibit slight changes of solubility.

In some studies, the pH of milk powders stored at room temperature was shown to decrease. The pH change can also be attributed to the bonding of amino groups by lactose in the *Maillard* reaction [4].

Milk powders contain relatively high concentrations of lactose and protein high in lysine (an amino acid) content. In the presence of moisture, these components readily participate in the *Maillard* reaction. This interaction may result in changes in protein quality that is accompanied or followed by undesirable color changes.

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Typically both the temperature and humidity of storage conditions have an effect on the *Maillard* reaction [2].

Scorched particles are generally accepted to be a measure for any deposits in the drying chamber having been exposed to high temperatures thus getting scorched, discoloured and at the same time insoluble. However, it is not only the dryer that contributes to the scorched particles, as even the raw milk may contain some dirt or sediment, and if not clarified in a separator these will be found in the powder. Also from the evaporator brown, insoluble, jelly lumps may contribute to the scorched particles, if deposits have been formed in the tubes due to insufficient coverage of the tubes, or insufficient cleaning [6].

The aim of this study was to assess the influence of storage conditions on infant formula stability by the following:

- physicochemical parameters determination and their comparison with maximum/minimum admitted limits by the plant standard;
- evaluation of the effect of temperature and storage time on physicochemical parameters;
- identification of some possible correlations between physicochemical parameters.

2. Materials and Method

Infant formula taken in study is an instant product with 24% of fat.

Samples were taken from a local milk plant after obtaining and were codified with IF1 in the case of infant formula stored at room temperature and with IF2 in the case of infant formula stored at 15°C temperature.

Physicochemical parameters like moisture and total dry matter, solubility and titrable acidity (which is an indicator of freshness) were followed at infant formula samples after obtaining and after 3, 6, 9, 12, 15 and 18 months during storage at different temperature: room temperature and 15°C temperature.

The amount of scorched particles in a powder is determined by comparison with the ADMI chart: Scorched Particle Standards for Dry Milk. This method is used for milk powder and all other dried dairy products.

The results are compared with the original ADMI standard chart. The comparison is visual. The standard chart is divided into a scale from A-D. If a sample is classified as being between two standards it is always set at the highest value. [5].Titrable acidity, moisture content and total dry matter were run in triplicate for each infant formula sample, solubility in duplicate and scorched particle content in a single run. The average values in reproducibility conditions were taken in discussions.Statistical analysis of the data was performed with Two-way ANOVA and Correlation, using GraphPad Prism version 3.00 for Windows, GraphPad Software, San Diego California USA, www.graphpad.com.

3. Results and Discussion

The limits for physicochemical parameters are: maximum 3% for moisture content, minimum 98% for solubility, maximum 8°T for titrable acidity and maximum disc B for scorched particle content.

Moisture content was maintained until the 6th month of storage, after that registered an increase until the 12th month of storage, then a decrease until the 15th month of storage and again an increase until the 18th month of storage almost to the moisture content from 12th month (Figure 1). Lactose from milk powders has the capacity to absorb humidity from the atmosphere, at which point passing through amorphous to crystalline stage. To determination of moisture content by oven-drying method the water of hydration is partially removed [1].

In this way is explained moisture content decrease from the 12th month to 15th month of storage. Moisture content variation is due first to the hydroscopic nature of lactose and second to his transition from amorphous to crystalline stage.

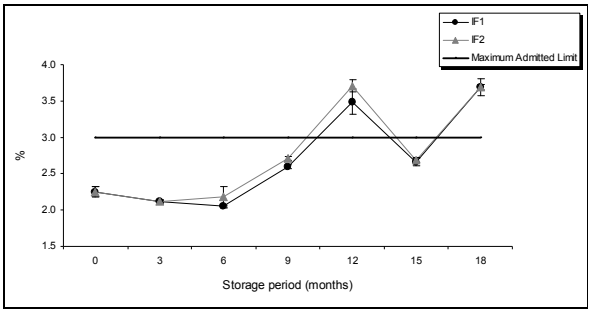

Figure 1. Moisture content evolution (%) during infant formula storage

IF1 - infant formula stored at room temperature
IF2 - infant formula stored at 15°C temperature

In terms of dry matter content, its behavior was in the mirror one from that of moisture because is calculated based on moisture content (Figure 2).

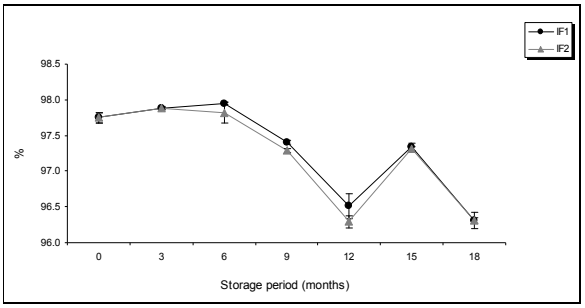

Figure 2. Total dry matter (%) evolution during storage

The solubility index was maintained constantly during the entire period of storage (Figure 3).

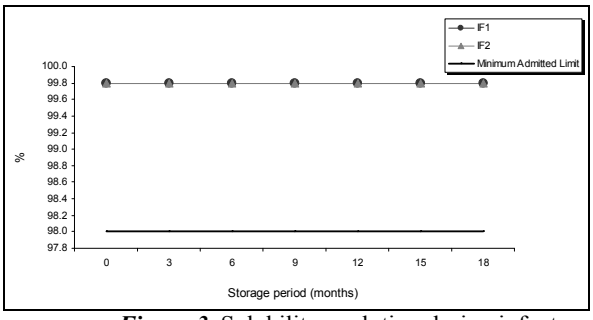

Figure 3. Solubility evolution during infant formula storage

During storage, titrable acidity registered small variations until the 15th month of storage, after that registered an increase in the last month of storage, the 18th month (Figure 4). Titrable acidity is due to formation of phosphates, citrates, CO_2 and also to the formation of lactic acid. Thus, we can hypothesize that the products titrable acidity until the 15th months of storage is due to the formation of lactic acid and the sudden increase of titrable acidity from the 15th month of storage is due to the formation of CO_2 by Maillard reactions.

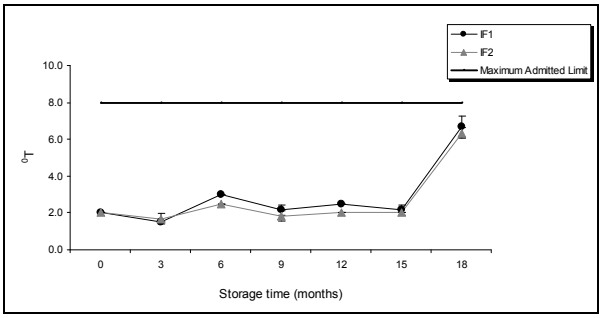

Figure 4. Titrable acidity evolution during infant formula storage

Scorched particle content do not exceeded disc A in infant formula samples in neither of two different storage conditions during the shelf-life.

The effects of storage temperature and time on physicochemical parameters of infant formula are shown in table 1 and correlations between them in table 2.

Table 1. Two-way ANOVA test for infant formula

Parameter	Temperature effect			Time effect		
	F	P	S	F	P	S
Titrable acidity	6.271	0.0463	*	178.7	<0.0001	***
Total dry matter	4.677	0.0738	NS	242.5	<0.0001	***
Moisture content	4.677	0.0738	NS	242.5	<0.0001	***
Solubility	-	1.0000	NS	-	1.0000	NS

F –F ratio; P –probability; Significance of effect (S): NS not significant, P>0.05; *significant P≤0.05; **very significant P≤0.01; ***extremely significant P≤0.001

Table 2. Correlation coefficients for infant formula

Correlations between		IF1				IF2			
		r	R^2	P	S	r	R^2	P	S
Moisture	Solubility index	-	-	-	-	-	-	-	-
Moisture	Titrable acidity	0.681	0.464	0.091	NS	0.582	0.338	0.170	NS
Titrable acidity	Solubility index	-	-	-	-	-	-	-	-

r – coefficient of correlation; R^2 – coefficient of determination; P – probability;Significance of effect (S): NS not significant, P>0.05; *significant P≤0.05; **very significant P≤0.01; ***extremely significant P≤0.001

IF1 - infant formula stored at room temperature

IF2 - infant formula stored at 15°C temperature

4. Conclusion

Storage temperature had no significant effect on physicochemical parameters, excepting the titrable acidity. Instead, storage time had an extremely significant effect in the case of titrable acidity, total dry matter and moisture content and no significant effect on solubility. Between the physico-chemical parameters was not found any significant correlation.

Scorched particle content does not registered modifications during storage, which means that is not influenced by the storage temperature or processing conditions.

Moisture and titrable acidity were increased during storage; the biggest value of moisture was registered in the 12^{th} month of storage and titrable acidity in the 18^{th} month of storage.

Moisture content was the parameter which not corresponded to plant standard limit. The moisture content exceeded the maximum admitted limit in the 12^{th} month of storage, which makes the product shelf-life to be reduced from 18 to 12 months. To avoid this, we recommend to study different type of packaging which could offer a better protection of the product in terms of its safty and quality preservation against environmental conditions (humidity, oxygen, light, etc.) that could interfere with the physicochemical parameters by affecting infant formula matrix.

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IF1 - infant formula stored at room temperature
IF2 - infant formula stored at 15°C temperature