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Determining the concentrations of some essential elements in powdered infant formula in the Al-Khums region of Libya

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A B S T R A C T

Background: Milk is a rich source of protein, fats, and essential minerals, and is considered an ideal food for humans. For infants, breast milk is usually the sole source of nutrition during the first four months of life. The best way to feed an infant is through exclusive breastfeeding for the first six months, followed by breastfeeding with the introduction of complementary foods after six months. In pharmacies, parents have complete faith in the nutritional claims printed on infant formula cans.

Amis: This study aimed to verify whether the contents of the cans matched these claims by determining the concentrations of certain essential elements in five brands of powdered infant formula sold in pharmacies in Al-Khums, Libya in 2025, and their compliance with international standards.

Methods: Subjected five brands to rigorous testing, going beyond visual inspection to include the use of stringent analytical techniques. These techniques ranged from drying and burning to assess physical stability to flame spectroscopy and titration to determine mineral content.

Results: Despite the stable physical structure, with a moisture content of 4.90% and an ash content of 2.90%, the electrolyte analysis revealed a concerning imbalance. A severe and persistent potassium deficiency was observed, accompanied by sharply elevated sodium levels exceeding acceptable limits.

Conclusion: Although calcium and iron levels remained within acceptable ranges, this electrolyte imbalance poses a hidden risk to the infants' kidney health, necessitating immediate regulatory intervention and an update to laboratory testing procedures.

Keywords: *food safety, mineral content, electrolytes, label compliance, and powdered infant formula (PIF)*

1. Introduction

Infant formula is not merely a food; it is a complete biological support system during the most rapid growth phase of human life. Because of this crucial role, international organizations such as ESPGHAN and the Codex Alimentarius Commission have established strict, non-

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negotiable standards [1, 2]. Since these regulations demand absolute precision, any tampering or labeling error becomes a serious public health issue [3]. Maintaining quality means mastering the balance between moisture and ash content. Excess water in the powder allows bacteria to grow and leads to Maillard reactions, which spoil the product [4]. Ash content, on the other hand, acts as a mirror to the integrity of the minerals when cow's milk is modified for human consumption [5]. While the legally permissible margin of error is between 10% and 20% [6]. Exceeding this limit is a clear indication of quality control failure. Potassium (K) deficiency can lead to heart and muscle problems [7]. While excess sodium (Na) puts a baby's fragile kidneys under severe stress [8]. Recognizing that the accuracy of calcium (Ca) and iron (Fe) ratios is just as important for building bones and blood [9]. This study examined five brands in Al-Khums city in 2025 to see how well their reality matched their claims.

Aims:

This study aimed to determine the concentrations of some essential elements in five types of powdered infant formula sold in pharmacies in Al-Khums city, Libya in 2025 and their compliance with international standards.

2. Methods

2.1. Sample Collection and Preparation

The field study by collecting samples from various pharmacies in Al Khums, Libya at the end of 2025. Five infant formula brands, one sample of each formula brand (intended for infants aged 0-6 months), were randomly selected. Data for each sample were meticulously documented. Relevant information including: brand name and expiration date, were recorded before transferring the samples to a dry, Sealed environment for laboratory analysis. All containers were verified to be factory-sealed to ensure accuracy.

Table 1: Brand names and country of origin of the selected infant formula samples.

Sample. No	Brand Name	Country of Origin
1	Mamilac	Poland
2	Milucky	Belgium
3	Cutebaby	Denmark
4	Babelac	France
5	Bevamil	Holland

2.2. Methods of Analysis

The tests were conducted in the Inorganic Chemistry Laboratory, Department of Chemistry, Faculty of Science. The researchers followed the strict scientific recommendations of the International Organization for Accreditation of Chemicals (AOAC International, 2020).

Statistical Analysis: the analysis of each sample was performed in triplicate. The results were analyzed using Microsoft Excel and the results obtained were presented as the mean values ± standard deviation.

Determination of moisture content (%): We adopted the oven drying method, subjecting the samples to temperatures up to (105°C ± 2°C) until the weight stabilized, to accurately measure the amount of material lost [10].

Determination of ash content (%): Our study used the dry incineration technique; the organic materials were completely thermally oxidized inside a muffle furnace at a temperature approaching 550°C for approximately four hours until the residue was carbon free and appeared grayish-white [11].

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Measurement of mineral salts (sodium and potassium): The present study employed a Flame Photometer (Model 410, Sherwood Scientific Ltd, Cambridge, UK), A technique that relies on the excitation of alkali metal atoms by the heat of a flame, then measuring the intensity of the emitted light, which is directly proportional to the concentration of the element within the sample [12].

Determination of calcium (Ca): We applied the titration method with the EDTA complex, which is a volumetric analysis process characterized by the neutralization of magnesium ion interference at a high pH, resulting in the formation of a stable complex between calcium and EDTA. To visually determine the endpoint, the murexide reagent (ammonium purpurate) was used, which provides conclusive colorimetric evidence of the reaction's completion. The color transition from pink-red to deep violet indicates the successful complexation of calcium ions with EDTA [13].

Determination of iron (Fe): The process begins by reducing iron to its divalent form (Fe^{2+}), then reacting it with an organic reagent (such as 1,10-phenanthroline) to form a highly colored compound. By comparing the absorption of this compound at 510 nm with a standard curve prepared from a high-purity material such as Mohr's salt, we were able to determine the amount of iron with an accuracy of up to mg/100 g using visible and ultraviolet spectroscopy [14].

3. Results and Discussion

The tables presented summarize the results of laboratory analysis of the five powdered infant formula samples, compared to the values stated on their labels (mg/100g).

Table 2: Physicochemical Parameters (Moisture and Ash %)

Sample	Moisture (%)	Ash (%)
1	4.90 ± 0.08	2.86 ± 0.04
2	4.85 ± 0.07	2.91 ± 0.05
3	2.80 ± 0.04	2.94 ± 0.03
4	1.87 ± 0.03	2.90 ± 0.05
5	2.83 ± 0.05	2.88 ± 0.04

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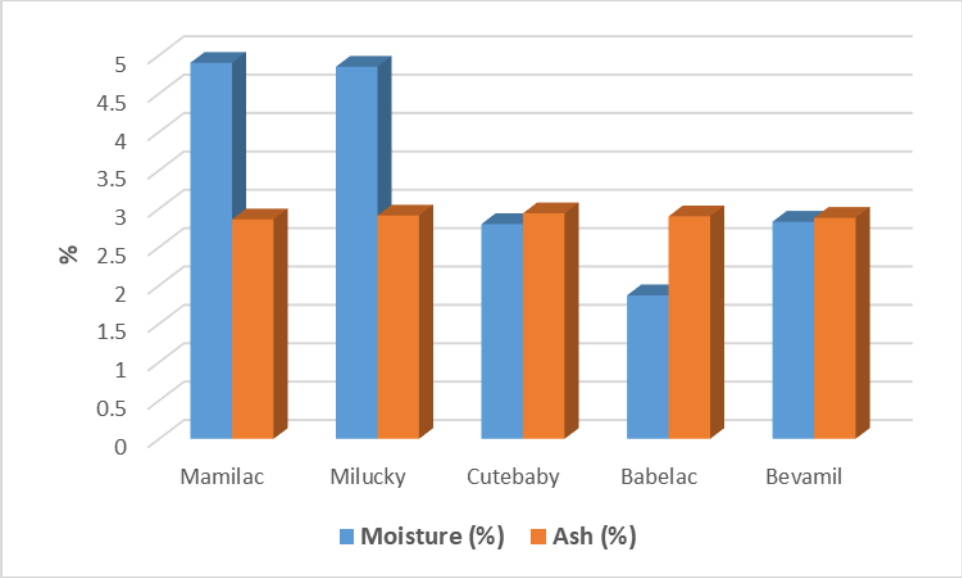

Figure 1: Physical and chemical parameters (moisture and ash %).

Table 3: Comparison of measured and named concentrations of some minerals in (mg/100g).

Sample	Na (In Sample)	Na (On Label)	K (In Sample)	K (On Label)	Fe (In Sample)	Fe (On Label)	Ca (In Sample)	Ca (On Label)
1	176.9±1.2	150	343.82 ±2.5	500	4.75 ±0.15	5.1	387.4 ±3.1	370
2	147.5±1.1	158	320.89 ±2.1	511	3.56 ±0.12	3.3	407 ±3.5	425
3	196.7±1.5	150	369.03 ±2.8	520	4.27 ±0.18	4.2	410 ±2.9	380
4	167.2±1.0	159	334.65 ±2.3	517	3.26 ±0.11	3.9	442 ±3.8	448
5	186.0±1.3	185	311.73 ±2.0	500	4.75 ±0.14	4.2	500.5 ±4.2	485

Note: All mineral concentrations are expressed (mg/100g).

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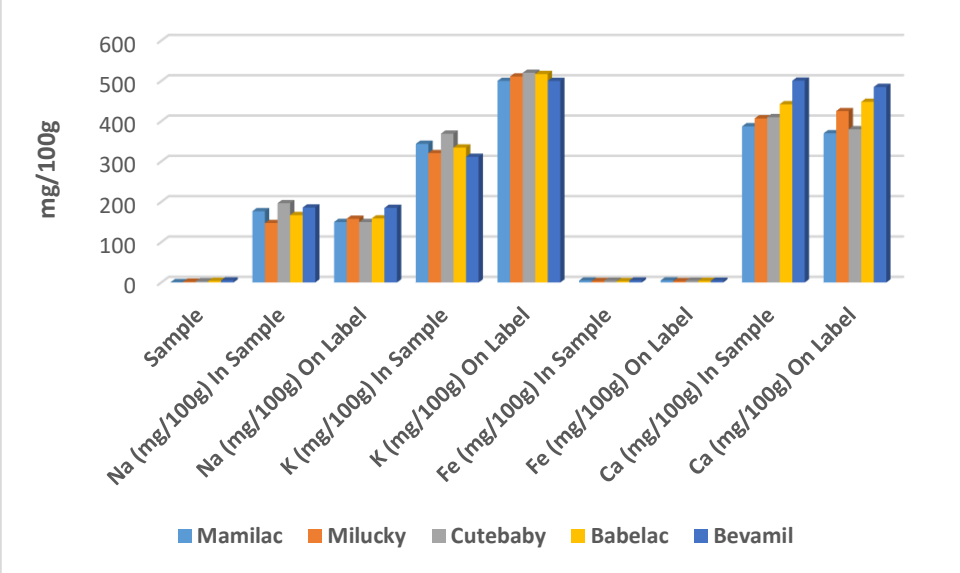

Figure 2: Comparison of measured and named concentrations of some minerals in (mg/100g).

Chemical and Physical Substances

Moisture measurements revealed a range between 1.87% and 4.90%, results generally consistent with international standards requiring moisture below 5.0% [1]. However, Table (2) shows that the first two samples (4.90% and 4.85%) are just above the critical limit. This means that any storage in a high-humidity environment could cause these percentages to exceed the permissible limit, accelerating quality deterioration and shortening the product's shelf life [4]. The ash content (2.86% to 2.94%) indicates stability and consistency in the mineral composition and manufacturing processes across different brands [11].

Mineral Content

We observed a discrepancy between the measured minerals and those declared in Figure (2) and Table(3) .

A. Potassium (K): Potassium is the leading intracellular element responsible for nerve impulse transmission and muscle contraction [15]. Therefore, any severe deficiency negatively impacts the infant's electrolyte balance, exposing them to health risks such as hypokalemia [7]. Potassium content of infant formulas set in Codex Alimentarius range between 60 to 160 mg/100 kcal about 399.6 to 1065.6 mg/100g. Alarmingly, all five samples showed a clear deficiency, exceeding the acceptable margin of variation (10%-20%) [6]. the scales fell to (311.73 to 369.03 mg/100g), while the labels indicated levels between 500 and 520 mg/100g.

These findings are consistent with Almeida et al [16]. who evaluated mineral compliance in infant formulas using ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometry). In their study, potassium levels ranged from 394 to 1018 mg/100g, yet they reported significant cases of non-compliance where laboratory values were lower than label claims, these discrepancies, similar to the low levels found in this study, suggest potential issues in mineral stability during storage."

B. Sodium (Na): Elevated sodium levels directly increase the renal salt load on the infant's delicate systems, raising the likelihood of

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dehydration due to hypernatremia [8]. Sodium content of infant formulas set in Codex Alimentarius range between 20-60 mg/100 kcal about 133.2 to 399.6mg/100g. Our studies have shown that the sodium content often exceeds the figures printed on the cans [16]. this was clearly evident in samples (1) and (3) with a significant difference. This consistent increase points to the accuracy of the mineral fortification processes during manufacturing [17].

C. Iron (Fe) and Calcium (Ca): In contrast to its counterparts, the iron and calcium contents showed remarkable consistency. The iron concentrations were consistent with the stated values, indicating the product's ability to fulfill its role in preventing anemia [9]. Iron contents of infant formulas set in Codex Alimentarius range between 0.3 to 1.3 mg/100 kcal about 1.99 to 8.66 mg/100g. The results, as shown in Figure 2 and Table 3, proved that the calcium values showed only slight differences from the labeled values, all within commercially permissible limits. Calcium contents of infant formulas set in Codex Alimentarius range between 50 to 140 mg/100 kcal about 333 to 932.4 mg/100g. Sample No. 5, which recorded 500.5 mg compared to the mentioned 485 mg, demonstrates the ability of manufacturers to accurately control calcium levels, calcium being an important element for bone growth in children.

4. Conclusion

Given the critical importance of infant formula as the sole source of nutrition, international organizations have established stringent standards for its composition. Our independent evaluation confirmed the effectiveness of quality control measures regarding chemical and physical stability. However, our study revealed significant variations in essential minerals, particularly a marked increase in sodium (Na) and a general deficiency in potassium (K). This dietary pattern poses a direct and serious threat to the body's mineral balance and kidney health in infants, necessitating immediate regulatory measures to ensure that products in Libya comply with international standards. Furthermore, it is crucial to emphasize that storage conditions, transportation methods, and the precision of analytical instrumentation play a pivotal role in the final quality and nutritional integrity of the milk.

ETHICAL STATEMENT:

Not Applicable.

CONFLICT OF INTEREST

There is no conflict of interest to be declared.

AUTHORS' CONTRIBUTIONS

R.E. and E.A.: organising, conducting research, composing the first draft, and editing and rewriting it. S.E.: Text formatting, editing, and revision techniques. H.A., H.B., and E.S.: Research, resources, and lab work.

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