Current Journal of Applied Science and Technology

40(34): 14-21, 2021; Article no.CJAST.77712
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Evaluation of the Chemical Quality of Milk Powder Sold in Open Markets in Aba, Abia Atate, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2021/v40i3431565
Editor(s):
(1) Dr. Orlando Manuel da Costa Gomes, Lisbon Accounting and Business School (ISCAL), Lisbon Polytechnic Institute, Portugal.
Reviewers:
(1) Amal Mohamed Kamal El Safty, Cairo University, Egypt.
(2) Rosario Almanzar, Instituto Tecnologico de Santo Domingo, Dominican Republic.
Complete Peer review History, details of the editor(s), Reviewers and additional Reviewers are available here: https://www.sdiarticle5.com/review-history/77712

Original Research Article

Received 20 September 2021
Accepted 23 November 2021
Published 27 November 2021

ABSTRACT

Background: Cow's milk is frequently recognized as the most nearly perfect nourishment for humans [1]. On the one hand, its tremendous nutritional value could affect human health [2]. Milk, on the other hand, is an ideal microbial culture medium [3] and is easily contaminated [1]. Milk quality and safety are commonly causes of anxiety because milk quality can be compromised during processing, shipping, storage, and marketing [4], particularly in underdeveloped nations with ineffective quality monitoring. Furthermore, uniformed traders expose milk to adverse environmental conditions due to ignorance.

Objective: This study investigated some chemical parameters of milk powder sold in Aba market.

Materials and Methods: A total of six (6) brands of milk powder, namely: Peak, Three Crown, Loyal, Cow Bell, Jago, and Dano milk, packaged in affordable sachets, were purchased from the new market (Abia Ohuru) in Aba town, Abia State. The samples were emptied from the sachet into sterile plastic containers, coded, sealed and transported to the laboratory immediately for analysis. Proximate, mineral, and vitamin compositions were determined using standard methods. ANOVA was used to separate the means and a significant difference was judged at $p<0.05$.

Results: The obtained values for almost all parameters were not significantly different (p) among the samples examined. However, the obtained values were slightly lower than the values written on

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the labels. The obtained values and the values on the labels were not significantly different from the CODEX Alimentarius and NFDAC set standards for milk powder, except for vitamin A values for almost all the samples.
Conclusion: The quality of milk powder sold in the Aba market can be considered to be good enough for human consumption, although slight quality degradation was found in protein, carbohydrates, fat, and especially in the vitamin A and B content of the samples. Exposure to harsh conditions during storage and retailing processes could be a possible reason.
Recommendations: Strict and legal measures should be adopted to ensure that the quality and safety of milk in the open markets is preserved.

Keywords: Evaluation; nutrient composition; milk powder; open market.

1. INTRODUCTION

For decades, milk and dairy products have been consumed in numerous parts of the world where cattle rearing is a way of life [4]. For instance, in Nigeria, the northerners who raise cattle have traditionally enjoyed fresh milk and locally produced milk products for many decades [5]. Milk and dairy product consumption has increased throughout the world as a result of economic and trade globalization, [6] as well as exposure to Western education (Akinyoseye, 2004). Milk consumption, which was not formerly a part of the food consumed in southern Nigeria, is now becoming an increasingly regular part of most southern Nigerians' daily menus. Thus, Nigerians of all ages and ethnic groups now consume milk and dairy products that are either produced locally or imported from other parts of the world. According to a survey, consumption of various types of imported milk and milk products is highest in the south eastern geopolitical zone (Akinyosoye, 2004). The bulk of milk imported into the country is powdered milk. Milk powder may be whole or skim milk powders (SMPs). Skim milk powder has a maximum shelf life of 3 years, while whole milk powder has a maximum shelf life of about three months [7].

Dehydration or drying is used to reduce bulk for easier transportation and to minimize water activity to limit the growth of microorganisms, extending the shelf life of the product [8]. Thus, milk powder is the product of dehydration of fluid milk to about 97% solids [9].

Although milk powder has low microbial load and low water activity, milk powder is not sterile. Under certain conditions, the quality of milk changes, and this changes its health effects.

In developing countries, subjecting milk powders to extreme weather conditions is prevalent. Prolonged storage at high temperatures and exposure to ultraviolent rays cause quality deterioration. For instance, milk sugar and milk proteins under prolonged storage at high temperatures interact, resulting in a complex sequence of chemical reactions known as the non-enzymatic browning or Millard reaction. This can result in the loss of lysine and a change in the nutritional content of milk proteins [10]. Milk fat rancidity has been linked to prolonged storage and exposure to light. Furthermore, storage of milk powders at room temperature causes a noticeable alteration in color and flavor. High temperatures and high water activity accelerate microbiological spoilage of milk powder [10].

Besides, adulterants like soap, acid, starch, table sugar, and chemicals are often added to milk either to increase its shelf-life or to increase the profit of the producer [11]. Poor storage conditions and adulterants lower the quality of milk and milk products. Milk quality degradation is very common globally. Lack of routine quality control, the perishability nature of milk and efforts to bridge the gap between demand and supply are some of the possible reasons behind milk quality degradation [12].

To ensure that consumers are always offered good quality milk in developed countries, strict monitoring is done routinely until good quality milk gets to the consumers. Such strict monitoring is lacking in developing countries.

1.1 Aim of the Study

The aim of the study was to evaluate the chemical quality of milk obtained from the open market and to compare the quality with standard quality and the values written on the label of each sample.

2. MATERIALS AND METHODS

2.1 The Study Area

2.1.1 Aba metropolis

The study was carried out in Aba, a strategically selected site in the south-eastern geopolitical zone of Nigeria.

Businessmen and women who are engaged in importation, production, processing, and marketing businesses dwell in Aba. Milk powder is one of the commodities imported into Aba. Processing of milk powder into dairy products also goes on in Aba at micro or macro levels. Hawkers, retailers in the various markets in Aba, supermarkets, fast foods, and restaurants all market milk and milk products.

The majority of Aba residents consume milk and dairy products marketed in Aba, particularly children and young adults. High-calorie, salty, fatty, and sugary foods, as well as a sedentary lifestyle, are popular among Aba residents, as they are with many other urban dwellers in Sub-Saharan Africa [13]. And as a result, diet and lifestyle-related diseases are major health concerns for Aba residents [13], (Ogah, 2013).

2.1.2 Procurement of dried milk samples

Six (6) of the most commonly consumed dried milk powder were purchased from the new market (Ahia Ohuru), a purposefully selected market in Aba. The samples of milk were labeled, put inside a sterile plastic container and transported immediately to the laboratory for analysis. Peak, Three Crowns, Jago, Loyal, Cowbell milk, and Dano milk were the dried milk powders purposefully chosen.

2.2 Chemical Quality

2.2.1 Proximate analysis

The AOAC [14] methods were used to determine the: moisture, crude protein, fat, crude fiber and ash content of the dried milk powder. The oven method was used for moisture determination, The Kjeldahl method was used to calculate crude protein, and The AOAC [14] soxhlet extraction method was used to determine the fat content. Oven drying, digestion and extraction methods were used to determine the crude fiber, ash content was determined by weighing, incinerating, cooling and re- weighing. According to FAO, (2012) the carbohydrate content was determined by difference: % Carbohydrates = (% moisture + % fat + % ash + % protein + % crude fiber) – 100. The calorific content of the sample was calculated using the values obtained for protein, fat, and carbohydrate. Determination of Minerals: The AOAC [14] method was used to evaluate the mineral contents of the milk samples. The minerals include iron, calcium, potassium, zinc was determined using an atomic absorption spectrophotometer (Hitachi model A-1800) and flame atomization. The sodium content of dried milk powder was determined using the AOAC flame photometry process. The colorimeter was used in accordance with the AOAC [14] procedure to determine vitamin A level. The AOAC [14] scalar analyzer method was used to assess thiamine, riboflavin amount and vitamin C levels. The solid non-fat content was calculated using the difference method (SNF). The reduction method was used to calculate lactose.

2.2.2 Data analysis

Data was entered, organized and analyzed using Statistical Package for Social Scientists SPSS Inc., Chicago, Illinois, USA) Version15.0. Numerical data obtained from the various analyses were expressed as means and standard deviation. Statistical differences between the mean of the milk samples were tested using ANOVA.

3. RESULTS

3.1 Proximate Composition of Dried Milk

Table 1 shows the proximate composition of dried milk. Moisture content was highest (4.05^a) in Three crown milk and lowest (3.08^b) in Dano milk. The protein content of the samples ranged (20.41%) in Dano milk to (23.97%) in Three Crown milk. The obtained protein values were lower than the values written on the label of each sample and the standard value of 24%. Fat was highest (28.39%) in Three crown milk and slowest (25.79%) in Peak milk. The obtained values were lower than the values on the labels of each sample, but higher than the stipulated 24% fat. Also, ash content was highest (5.78%) in Dano milk and lowest (4.97%) in Three crown milk. The values obtained were lower than the standard protein value of 6.5%. Not all the samples had ash content written on their labels. Similarly, carbohydrate was highest (40.71%) in Dano milk and lowest (36.45%).Furthermore, protein content of the entire samples except in cowbell milk (24.07%) was lower than the recommended minimum value of not less than 24% (NAFDAC, 2019) and of minimum of 34% of CODEX [15] and also was lower than what is written in the label (26 g, 32g, 23.5g, 25g, and 23.5g 23.6 g in loyal, Dano, Jago, Peak, Three crown and cowbell milk respectively.

3.2 Mineral Composition of Milk samples

Table 2 shows Mineral Composition of Milk samples. Calcium ranged from (572 mg) in cowbell milk to (867 mg) in loyal milk. The values obtained are similar to the values written on the labels, but slightly lower than the standard value of 950 mg/100 g.The values obtained for sodium ranged from (37.03 mg) in Jago milk to (44.02 mg) in Cowbell Milk. Not all the samples had sodium value written on its label. The obtained values differed from the standard value of 37 mg/100 g.The potassium content obtained for the samples was highest (1320 mg) in loyal milk and lowest (1257 mg) in three crown milk. The values obtained were lower than standard value for potassium (133 mg/100 g). Not all the samples have the potassium content written on the label. Zinc value raged from (2.57 mg) in three crown to (2.90 mg) in cowbell milk. The values were lower than the standard value for zinc of 3.1mg/100g for. Not all the samples had zinc value written on the label.

3.3 Vitamin Composition of Milk Samples

Table 3 shows vitamin composition of Milk samples. The vitamin A content obtained ranged from (579$i\mu$) in Dano milk to (2475^{b} $i\mu$) in cowbell milk. The values obtained were lower than the values written on the label of each sample. The obtained values, the values written on the labels and the standard value for vitamin A all differed significantly (P<0.05). Vitamin B_1, was highest (0.89 mg) in peak milk, lowest (0.09 mg) in cowbell milk. The values differed significantly from the standard value for vitamin B_1, of (0.26 mg). Not all the milk samples had the vitamin B_1

Table 1. Proximate composition of dried milk samples

Brand (%)	MC (%)	CP (%)	FAT (%)	CF (%)	ASH (%)	CHO (%)	EV (%)
Three crown	4.05^{ab}	23.97^{ab}	28.39^{ab}	0.165^{ab}	4.99^{ab}	38.55^{ab}	516.65^{ab}
Dano milk	3.98^{b}	20.41^{bc}	27.55^{bc}	0.340^{bc}	5.78^{bc}	40.71^{bc}	487.21^{b}
Jago	4.12^{cb}	23.66^{cb}	26.87^{c}	0.165^{a}	5.13^{c}	37.58^{a}	492.34^{c}
Cowbell milk	4.03^{ab}	23.07^{ab}	27.54^{bc}	0.110^{c}	5.62^{a}	36.45^{c}	502.20^{a}
Peak milk	4.11^{ca}	23.81^{a}	25.79^{a}	0.105^{a}	5.31^{c}	39.62^{b}	482.67^{c}
Loyal	3.52^{b}	23.96^{c}	27.52^{b}	0.080^{c}	5.52^{b}	38.54^{a}	499.67^{ab}
S value	4.00	24.00	24.00	0	6.5	38	496
LSD:	0.08	0.21	0.085	0.065	0.095	0.20	0.07

Values are given as the mean and L.S. D.; Mean scores having different superscript letters on the same column differ significantly at 5% significant level

Footnote: moisture content (MC), crude protein (CP), crude fiber (CF), carbohydrate (CHO), energy value (EV)
The abbreviation ab, b, bc, a, c, ca, show that there was no definite pattern of difference (p<0.05) in the proximate composition of the dried milk samples

Table 2. Mineral composition of dried milk samples

Brand	Ca mg/100 g	Na mg/100 g	K mg/100 g	Fe mg/100 g	Zn mg/100 g
Three cr	805.22^{ab}	38.45^{ba}	1257^{ac}	0.515^{d}	2.57^{a}
Jago	833.37^{bc}	37.03^{bc}	1281^{cb}	0.530^{d}	2.71^{b}
Dano	806.02^{c}	39.04^{b}	1321^{c}	0.360^{d}	2.66^{c}
Peak	834.55^{a}	37.92^{c}	1284^{cb}	0.420^{d}	2.73^{b}
Cowbell	843.85^{b}	44.02^{a}	1281^{cb}	0.585^{d}	2.90^{e}
Loyal	867.61^{c}	41.62^{b}	1320^{c}	0.490^{d}	2.85^{e}
Std value	950mg/100g	37mg/100g	1330mg/100g	0.50mg/100g	3.1mg/100g
LSD	0.685	0.485	0.495	0.5	0.125

Values are given as the mean and L.S. D.; Mean scores having different superscript letters on the same column differ significantly at 5% significant level Footnote: calcium (Ca), sodium (Na), potassium (K), Iron (Fe), zinc (Zn)

Table 3. Vitamin composition of dried milk

Brand	Vitamin A (1U) ((mg)/100g)	Vitamin B_1 (1U) (mg)/100g)	Vitamin B_2 (1U) (mg)/100g)	Vitamin B_3 (1U) (mg)/100g)	Vitamin C (1U) (mg)/100g)
Three Crown	741^a	0.85^a	0.79^a	0.210^a	0.61^a
Cowbell	$2475^b(\boldsymbol{i\mu})$	0.09^b	0.72^b	0.20^b	0.64^a
Jago	662^c	0.18^c	0.75^c	0.23^b	0.69^c
Loyal	2480^d	0.10^d	1.44^d	0.27^c	0.81^d
Peak	735^e	0.89^e	0.85^e	0.25^c	0.87^e
Dano	579^f	0.76_f	1.42^c	0.22^b	0.81^f
Std value	11091/100g	0.26g	1.45mg	0.68mg/100g	2.2mg100g
LSD:	**0.08**	**0.215**	**0.085**	**0.055**	**0.065**

Values are given as the mean and L.S. D.; Mean scores having different superscript letters on the same column differ significantly at 5% significant level

Table 4. Nutritional composition of sampled milk powder from the labels

	Loyal	Peak	Dano	Three crown	Cow bell	Jago
Energy	507kcal	490kcal	500kcal	520kcal	516	520
Fat	28g	26g	28	28	30	30
Protein%	24g	24g	22g	23.5	23.6g	32
Carb	39g	40g	41g	39.9g	37.9g	40
Lactose	NS		36g	37.8g	NS	NS
Vita A	2500iu/RE	753μg	600/2000 iu	753mg/2500 iu	2500 iu	735
D_3	350	9mg	10/400$i\mu$	8.9mg/350m	200mg	10mg
E	NS	0.53mg	NS	12.6mg	4.5 μg	NS
K	3mg	NS	NS	NS	12 μg	NS
Folic	6mg	88mg	NS	20mg	200mg	8mg
Calcium	870	.84g	800mg	800mg	580	NS
Dietary fiber	NS	0	NS	NS	NS	NS
Vita $_C$	7mg	88mg	NS	NS	18	15mg
B_1	0.13mg	0.99mg	NS	.93mg	0.1mg	NS
B_2	1.5mg	0.91mg	NS	NS	1mg	NS
B_{12}	2.5mg	3.9mg	NS	2.5mg	1.6	NS
Phosphorus	620	NS	NS	620mg	750mg	NS
Zinc	2.5mg	NS	2.5mg	2.5mg	1.8mg	NS
Moisture	3g	NS	NS	NS	< 3%	4g
B_3	0.3mg	NS	NS	NS	200	NS
Sodium	240	NS	NS	NS	180	NS

Footnote: NS; not stated

content written on the label. Vitamin B_2 was highest (1.44 mg) in loyal milk and lowest (0.72 mg) cowbell milk. The values obtained were lower than the standard value of 1.45 mg. Not all the sample had to vitamin B_2 content writhen on the label. The vitamin B_3 content obtained ranged from (0.20 mg) in cowbell milk to (0.27 mg) in loyal milk. The values obtained were lower than the standard value of 0.68mg/100. Not all the sample had the value of vitamin B_3 written on the label. Vitamin C content ranged from (0.61 mg) in three crown milk to (0.87 mg) in peak milk. The values obtained were lower than standard value of 2.2 mg/100 g for vitamin C. Not all the samples had vitamin C content written on the labels.

4. DISCUSSION

4.1 Proximate Analysis of Dried Milk Samples

The moisture content within normal ranges found in this study is not consistent with the findings of Khalid et al., [16] who reported lower moisture content in dried milk sampled in Sudan. Low moisture content implies low water activity levels, which does not permit microbial growth but might cause changes to occur in milk powders after production. It is the lipids and the non-lipid constituents of milk which undergo such changes.

Normally, the rates of such reactions are accelerated with the elevation of storage temperature and oxygen.

Furthermore, the milk fat and milk protein of most of the samples were found to be slightly lower than the fat content written on the label of each sample. This agrees with the findings of Ahmad et al., [17,18], who discovered quality depreciation in dried whole milk, but disagrees with the findings of Kajal et al., (2012), who discovered protein and fat content within normal ranges in dried milk samples from Mymensingh, Bangladesh.

Protein quality degradation was also found. Protein quality deterioration manifests as the Millard reaction. This reaction leads to nutritional quality reduction [17]. Loss of nutritive value after production primarily concerns loss of available lysine due to Millard reactions. Storage at 20°C temperature, at normal water content does not cause an appreciable loss. Extensive Millard reactions can cause a decrease in protein digestibility and the formation of weak mutagens [17,19].

The digestibility of protein and the accessible lysine content of milk powders have been reported to decrease after manufacture and while in storage. The moisture content, storage period, and storage temperature all influence these reductions. Higher moisture levels and longer storage times at high temperatures have been found to hasten degradation. Because storage temperatures in tropical markets are high and unmanaged, the observed decline in the quality of dried whole milk samples necessitates increased supervision and education of the marketers. The mineral and vitamin content of dried milk samples declined as well, according to the results of the vitamin and mineral study. The nutritional quality of milk powder is affected when it is stored in adverse conditions during transportation, storage and distribution. All of the samples showed a considerable loss in vitamin A content, as well as a modest fall in vitamin B1, B2, B3, and C content, which agrees with the finding of Akpanyung (2006). The decrease in mineral content is also similar with the findings of Akpanyung (2006), who observed an average calcium concentration of 11,108 mg/kg in powdered milk samples purchased from Nigerian local markets. The mean Fe content in this study, ranging from (0.36 mg/100 g to 0.58 mg/g), is higher than that reported by Semaghiul et al., [20] (21.73 ppm), Salah et al., [21] (20.41 ppm) and Perween et al., [22] (4.33 mg/l). Akpanyung (2006) reported a mean Zn content of 126.1mg/kg, which is similar to that obtained in this study. But it is significantly higher than that reported by Semaghiul et al., [20] of 3.24 ppm.

The higher values written on the label of all the milk samples, compared to the values obtained for vitamin A and water-soluble vitamins in this study, are an indication of quality deterioration. High temperature storage affects water-soluble vitamins [23] FAO, 2013, www.usdec.org,2001, Fischer et al., 2003 causing a reduction in thiamin, vitamin B12, and vitamin B_{12}. According to DT-6 lesson 42 [19], exposure of milk powders to high temperatures and light causes vitamin and mineral losses. Also, exposure of milk powders to sunlight causes vitamin A destruction by the ultraviolent rays of sunlight.

Protecting milk powders against high temperatures and light helps to minimize loss of light-sensitive vitamins, in particular riboflavin. Tropical market places are characterized by high temperatures and the exposure of milk powder to light. Milk powders stored under conditions (no light, minimal oxygen, low moisture) will likely have minimal loss of vitamins. It is suggested that to protect light-sensitive vitamins, exposure of powders to such conditions should be avoided [19]. Besides, periodic monitoring of milk at the various distribution chains is paramount.

5. CONCLUSION

The quality of milk powder sold in the Aba market can be considered to be fairly good for human consumption, although slight quality degradation was found in protein, carbohydrates, fat, and especially in the vitamin $_A$ and $_B$ content of the samples. Exposure to harsh conditions (high temperatures and exposure to ultra violet light) during storage and retailing processes could be the possible reason. Milk powder in the market places in tropical zones like Nigeria should be marketed in a more conducive condition. Milk powder marketed in a cool, dry environment will not have an appreciable nutrient loss.

6. RECOMMENDATIONS

1. Strict and legal measures should be adopted to ensure that the quality and safety of milk in the open markets is preserved.
2. Regulatory organizations should monitor milk in the marketplace on a regular basis.
3. And also ensure that labels clearly reflect the whole nutritional value of milk powder.

4. Milk industries should organizing periodic training of the milk handlers in the market place: the distributors and sellers.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/77712