EVALUATION OF THE QUALITY OF REPACKED WHOLE MILK POWDER AVAILABLE IN KHARTOUM MARKET, SUDAN

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المستخلص

أجريت هذه الدراسة بغرض التقييم النوعي للبن المجفف كامل الدسم معاد التعبئة الذي يباع في اسواق الخرطوم. شملت الدراسة جمع عدد ٢٧ عينة من اللبن من ثلاث أصناف في ثلاث دفعات مختلفة وفقا لزمن أخذ العينات (جمعت العينات في الدفعة الأولي في شهر اكتوبر، وفي الدفعة الثانية في شهر نوفمبر، وفي الدفعة الثالثة في شهر ديسمبر)، وأخضعت العينات للتحليل الكيميائي والميكروبيولوجي. أظهرت النتائج أن الدهون والحموضة العيارية لم تختلف معنويا بين الأصناف، بينما كان البروتين والرطوبة أعلي في الصنف B والرماد أعلي في الصنف C. لم يؤثر زمن أخذ العينة معنويا علي الدهون والرطوبة والحموضة العيارية، بينما كان البروتين أعلي في الدفعة الثانية وكان الرماد أعلي في الدفعتين الثانية والثالثة. أثر الصنف معنويا علي العد الكلي للبكتيريا الحية وبكتيريا القولون والخمائر والعفن، بينما لم تكن هناك اختلافات معنوية بين الأصناف الثلاث في البكتيريا المحللة للدهون والبكتيريا المحللة للبروتينات. أظهر زمن أخذ العينة تأثيرا معنويا علي العد الكلي للبكتيريا الحية وبكتريا القولون والبكتيريا المحللة للدهون، ولكن لم يلاحظ تأثير معنوي لزمن أخذ العينة علي البكتيريا المحللة للبروتينات والخمائر والعفن في الأصناف الثلاث.

Keywords: Whole milk powder, repacking, chemical, microbiological, quality, market.

Abstract

This study was carried out to evaluate the quality of whole milk powder repacked and sold in the market of Khartoum State, Sudan. The study involved the collection of 27 samples of repacked whole milk powder from three brands in three different batches according to sampling time (batch 1 samples were collected in October, batch 2 samples were collected in November and batch 3 samples were collected in December). The samples were then subjected to chemical and microbiological analysis. The results showed that fat and titratable acidity were not significantly different between the brands, while the protein and moisture were higher in brand B and the ash was high in brand C. Time of sampling did not significantly affect fat, moisture and titratable acidity, while the protein content was high in batch 2 and ash content was high in batches 2 and 3. The brand significantly affected total viable bacterial, coliform bacterial and yeasts and moulds counts, and there was no significant variation in lipolytic and proteolytic bacteria between the three brands. Sampling time had a significant effect on total viable bacteria, coliform bacteria and lipolytic bacteria. However, no significant effect of sampling time was observed in proteolytioc bacteria and yeasts and moulds in the three brands.

Introduction

The seasonal fluctuation in milk production or in market demand as well as the need to supply milk to locations where there is shortage of fresh milk have created a demand for milk which can be kept for extended periods of time at low storage costs. Drying the milk is an efficient method of preservation, which greatly reduces the volume of the milk, having an advantage for long distance shipping and extended storage (Deeb *et al*., 2010). The quality of whole milk powder is affected by the quality of raw milk used in its manufacture, and the shelf life can be extended from six months at room temperature to more than 12 months if

the powder is packed under vacuum or with nitrogen which lead to decreasing oxygen levels (Chen *et al*., 2003). Different researchers agree that the hygienic conditions under which raw milk is produced are the main factors affecting powder quality. Raw milk used for powder manufacture should be of good microbiological quality, and therefore, some dairy industries have set their own standards on the quality of raw milk purchased for processing (Fernandez De Oliveira *et al*., 2000).

Milk powder is a product of lower water activity and better keeping qualities and it is produced in large scale in modern plants. The powder produced can be stored for long periods of time without significant deterioration of taste or nutritive value. Its manufacture involves the gentle removal of water at the lowest possible cost under strict hygienic conditions while retaining all the desirable natural properties of milk such as colour, flavour, solubility and nutritional value. During the manufacture of milk powder the water is removed by evaporation under reduced pressure and low temperature followed by spraying in a fine mist of air to remove further moisture (Henning *et al*., 2006; Rosenthal, 1991).
There are many types of packaging materials for milk products, the container must not only protect the food from contamination and spoilage, but it must also be convenient attractive and informative as well. Packaging plays an important role in protecting and preserving the quality of food manufacturing and distribution process, and the shelf-life of any food is limited due to the occurrence of many deteriorative processes and reactions within the food materials. These include physical, chemical and interactions between food and the ambient environment across the packaging material (Thomas *et al*., 2004; Rosenthal, 1991).
According to the Standards (Codex Stan, 1999; EAS, 2006; SDS, 2008; SVGNS, 2004), whole milk powder should contain 26% fat (minimum), 34% protein (minimum), 5% moisture (maximum), 0.18% acidity (maximum), 34% lactose (minimum) and 7.3% ash (maximum) on dry-matter basis. It should contain no more than 10 cfu/gm of coliforms and yeasts and moulds, <1 cfu/gm of *E. coli* and 50,000 cfu/gm (maximum) of

total bacteria count, and both Salmonella and *Staphylococcus aureus* should be absent in 25 gm of the product.

The consumption of whole milk powder increased in the last few years due to shortage of fresh milk. This situation encouraged some investors to import powdered milk in large size bags (25 kg) and repack into small size bags in order to be distributed in the retail market. Most plants repack the milk in aluminum bags, while some milk powders are packed in metal containers.

This study was aimed at evaluating the chemical and microbiological quality of whole milk powders repacked in Sudan and sold in the local market and to determine whether the conditions of repacking are suitable to produce a quality product.

Materials and Methods

Sample collection

A total of 27 repacked whole milk powder samples (400 gm) in aluminum foil bags were purchased from supermarkets in Khartoum State, Sudan in the months of October (batch 1), November (batch 2) and December (batch 3) 2007, each batch consisting of three samples. Three different brands were studied from three different repacking plants designated as A, B and C. The samples were transported to the Department of Dairy Production, Faulty of Animal Production, University of Khartoum for analysis. The samples were aseptically opened and immediately subjected to microbiological and chemical analysis.

Chemical composition

Fat content was determined by Gerber method according to AOAC (2000). Protein content was determined by Kjeldahl method as total nitrogen content which was converted to total protein using 6.38 as a conversion factor (AOAC, 2000). Moisture content was determined by oven drying method according to AOAC (2000). Ash content was

determined by incineration of the sample at 550°C according to AOAC (2000). Titratable acidity was determined according to AOAC (2000).

Microbiological examination

The contents of milk powder were thoroughly mixed and 11 gm sample was aseptically withdrawn and mixed in a flask containing 99 ml sterile distilled water to make 10^{-1} dilution, then 1 ml was transferred to 9 ml sterile distilled water. This procedure was repeated to make serial dilutions (10^{-1}, 10^{-2}, 10^{-3} …etc). From each appropriate dilution, 1 ml was transferred into a sterile Petri dish (in duplicate) followed by addition of the appropriate culture medium (at 45±1°C) mixed gently, left to solidify and incubated in an inverted position. Total viable bacterial count was determined using plate count agar (PLA), and plates were incubated at 32^{o}C for 48 hrs (Houghtby *et al*., 1992). Coliform bacterial count was determined on MacConkey agar (MA), and the plates were incubated at 37^{o}C for 24 hrs (Christen *et al*., 1992). Proteolytic bacterial count was determined using standard plate count agar medium plus 10% sterile skim milk and the plates were incubated at 37^{o}C for 72 hrs (Frank *et al*., 1992). Lipolytic bacterial count was determined using nutrient agar medium and the plates were incubated at 37°C for 72 hrs. The lipolytic colonies were identified using copper sulphate (20%) flooded after incubation. Yeasts and moulds count was determined using yeast extract agar medium and the plates were incubated at 25^{o}C for 5 days (Frank *et al*., 1992).

Statistical analyses

Statistical analyses were performed using the Statistical Analysis Systems (SAS, ver. 9). General Linear Models (GLM) were used to determine the effect of brand and batch on the quality of whole milk powder. Means were separated by Duncan multiple range test at $P \leq 0.05$.

Results

Chemical composition of repacked whole milk powder

Samples of repacked whole milk powder taken from the three brands (A, B and C) revealed that fat content and titratable acidity showed no significant difference between the brands, however, the protein and moisture contents were highest ($P<0.05$) in samples from brand B. The ash content was high in brand C ($P<0.05$) (Table 1). Time of sampling (batch number) did not significantly affect fat, moisture and titratable acidity, while the protein content was high in samples collected during November and ash content was high in samples collected during November and December (Table 2). Sampling time did not significantly affect the fat, protein contents and titratable acidity in the three brands. However, moisture and ash contents in brands A and B were affected by sampling time, while no effect was found in brand C (Table 3).

Microbial quality of repacked whole milk powder:

The brand of milk powder significantly affected total viable bacterial count ($P<0.01$), coliform bacterial ($P<0.05$) and yeasts and moulds ($P<0.05$) counts, with the lowest total viable bacterial count being in brand C, while brand B had the lowest coliform bacterial count and brand A had the lowest yeasts and moulds counts. There was no significant variation in lipolytic and proteolytic bacterial counts between the three brands (Table 1). Sampling time (batch number) had a significant effect on total viable bacteria ($P<0.05$), coliform bacterial ($P<0.01$) and lipolytic bacterial counts ($P<0.01$). Samples collected during November had the lowest total viable bacterial count; while samples collected during October had the lowest coliform bacterial count and samples collected during December had the lowest lipolytic bacterial count. However, no significant effect of sampling time was observed in proteolytioc bacterial and yeasts and moulds counts (Table 2). Batch number significantly affected total viable bacterial count in brand A ($P<0.001$), coliform bacteria in brand B ($P<0.001$), lipolytic bacteria in brands B and C ($P<0.05$) and proteolytic bacteria in brand A ($P<0.05$). However, there was no significant effect of batch number on yeasts and mould counts in the three brands (Table 4).

Table 1. Chemical composition (%) and microbiological quality (Log_{10} cfu/gm) of three brands of repacked whole milk powder (mean of three monthly batches)

Parameter	**Brand[1]**			**S.L**
	A	**B**	**C**	
Fat	26.62±0.208[a]	26.52±0.208[a]	26.61±0.208[a]	N.S
Protein	25.08±0.196[b]	26.40±0.196[a]	26.20±0.196[a]	*
Moisture	5.04±0.99[b]	5.97±0.99[a]	4.96±0.99[b]	*
Ash	6.01±0.079[ab]	5.67±0.079[b]	6.18±0.079 [a]	*
Acidity	0.14±0.002[a]	0.15±0.002[a]	0.14±0.002[a]	NS
Total viable bacteria	4.12±0.038[a]	3.52±0.038[ab]	3.25±0.038[b]	**
Coliform bacteria	2.35±0.037[a]	2.03±0.037[b]	2.19±0.037[ab]	*
Lipolytic bacteria	2.28±0.022[a]	2.43±0.022[a]	2.39±0.022[a]	N.S
Proteolytic bacteria	2.34±0.007[a]	2.26±0.007[a]	2.32±0.007[a]	N.S
Yeasts and moulds	2.38±0.001[b]	3.52±0.001[a]	3.25±0.001[ab]	*

Means within each row bearing the same superscripts are not significantly different P>0.05)
[1]Brands A, B and C refer to the three different repacking companies
** = P< 0.01
* = P< 0.05
N.S = Not significant
S.L = Significant level

Table 2. Chemical composition (%) and microbiological quality (Log_{10} cfu/gm) of three monthly batches of repacked whole milk powder

Parameter	**Batch**[1]			**S.L**
	1	**2**	**3**	
Fat	26.89±1.062[a]	26.64±1.062[a]	26.34±1.062[a]	N.S
Protein	26.09±1.062[a]	26.29±1.062[a]	25.29±1.062[b]	*
Moisture	5.14±0.059[a]	4.97±0.059[a]	5.07±0.059[a]	N.S
Ash	5.78±0.085[b]	6.04±0.085[a]	6.03±0.085[a]	*
Acidity	0.15±0.002 [a]	0.14±0.002[a]	0.14±0.002[a]	N.S
Total viable bacteria	4.76±0.048[a]	4.45±0.048[b]	4.59±0.048[ab]	*
Coliform bacteria	2.03±0.130[b]	2.31±0.130[a]	2.23±0.130[ab]	**
Lipolytic bacteria	2.36±0.021[a]	2.44±0.021[a]	2.28±0.021[b]	**
Proteolytic bacteria	2.33±0.032[a]	2.24±0.032[b]	2.24±0.032[b]	N.S
Yeasts and moulds	2.30±0.021[a]	2.32±0.021[a]	2.34±0.021[a]	N.S

Means within each row bearing the same superscripts are not significantly different (P>0.05)

[1] Batches 1, 2 and 3 were collected in October, November and December respectively

** = P< 0.01

* = P< 0.05

N.S = Not significant

S.L = Significant level

Table 3. Chemical composition (%) of repacked whole milk powder in three brands collected in three monthly batches (Mean±SE)

Brand [1]	Batch [2]	Chemical composition (%)				
		Fat	**Protein**	**Moisture**	**Ash**	**Titratable acidity**
A	**1**	26.27±0.287[a]	26.40±0.322[a]	4.97±0.922[b]	5.67±0.126[a b]	0.14±0.004[a]
	2	26.94±0.287[a]	26.22±0.322[a]	5.25±0.922[b]	5.35±0.126[b]	0.15±0.004[a]
	3	27.10±0.287[a]	25.89±0.322[a]	5.99±0.922[a]	5.98±0.126[a]	0.14±0.004[a]
	S.L	N.S	N.S	*	*	N.S
B	**1**	26.42±0.612[a]	26.22±0.190[a]	5.92±00.132[a]	6.10±0.126[a b]	0.15±0.004[a]
	2	26.77±0.612[a]	25.95±0.190[a]	3.99±00.132[c]	5.70±0.126[b]	0.13±0.004[a]
	3	26.50±0.612[a]	25.81±0.190[a]	5.03±00.132[b]	6.18±0.126[a]	0.14±0.004[a]
	S.L	N.S	N.S	*	*	N.S
C	**1**	26.32±0.276[a]	26.64±0.287[a]	5.21±00.217[a]	6.07±0.172[a]	0.14±0.004[a]
	2	26.95±0.276[a]	26.16±0.287[a]	5.11±00.217[a]	6.28±0.172[a]	0.15±0.004[a]
	3	26.32±0.276[a]	26.39±0.287[a]	4.89±00.217[a]	6.18±0.172[a]	0.14±0.004[a]
	S.L	N.S	N.S	N.S	N.S	N.S

Means in each column bearing similar superscripts are not significantly different (P>0.05)
* = P<0.05
N.S = Not significant
S.L = Significance level
SE = Standard error of means
[1]Brands A, B and C refer to the three different repacking companies
[2]Batches 1, 2 and 3 refer to the batches collected in October, November and December respectively

Table 4. Microbiological quality (Log_{10} cfu/gm) of repacked whole milk powder in three brands collected in three monthly batches (Mean±SE)

Brand[1]	Batch[2]	Microbiological count (Log_{10} cfu/gm)				
		Total viable bacteria	Coliform bacteria	Lipolytic bacteria	Proteolytic bacteria	Yeasts and moulds
A	1	4.43±0.080^{ab}	2.03±0.021^{a}	2.31±0.050^{a}	2,30±0.040^{a}	2.26±0.065^{a}
	2	4.74±0.080^{a}	2.07±0.021^{a}	2.57±0.050^{a}	2.10±0.040^{b}	2.28±0.065^{a}
	3	4.38±0.080^{b}	1.98±0.021^{a}	2.17±0.050^{a}	2.31±0.040^{a}	2.22±0.065^{a}
	S.L	***	N.S	N.S	*	N.S
B	1	4.30±0.075^{a}	2.34±0.029^{a}	2.63±0.022^{a}	2.37±0.045^{a}	2.29±0.063^{a}
	2	4.20±0.075^{a}	2.33±0.029^{a}	2.32±0.022^{b}	2.30±0.045^{a}	2.31±0.063^{a}
	3	4.33±0.075^{a}	1.09±0.029^{b}	2.47±0.022^{ab}	2.28±0.045^{a}	2.38±0.063^{a}
	S.L	NS	***	*	NS	NS
C	1	5.00±0.091^{a}	1.83±0.030^{a}	2.42±0.052^{a}	2.32±0.044^{a}	2.30±0.067^{a}
	2	3.52±0.091^{a}	2.52±0.030^{a}	2.36±0.052^{a}	2.33±0.044^{a}	2.38±0.067^{a}
	3	4.51±0.091^{a}	2.60±0.030^{a}	2.04±0.052^{b}	2.36±0.044^{a}	2.44±0.067^{a}
	S.L	N.S	N.S	*	N.S	N.S

Means in each column bearing similar superscripts are not significantly different ($P>0.05$)
* = $P<0.05$
*** = $P<0.001$
N.S = Not significant
S.L = Significance level
SE = Standard error of means
[1]Brands A, B and C refer to the three different repacking companies
[2]Batches 1, 2 and 3 refer to the batches collected in October, November and December respectively

Discussion

The importation of whole milk powder will affect the local fresh milk production, beside the safety consideration other than bacterial contamination, in addition to nutritional aspects of milk powder compared to fresh milk. The investigation suggests that importation should be limited if not totally abandoned to encourage the production of fresh healthy milk. The investigation focused on whether the repacked whole milk powder sold in Khartoum State complies with Sudanese standards for milk powder or not, and how much the environment of repacking affects the quality of milk powder. The results of fat content obtained during the present study comply with the standards (SDS, 2008; Codex, 1999; EAS, 2006; SVGNS, 2004), while the protein content was lower than the value specified in the standards. Some samples (38%) comply with the standards for moisture content while others were far below. The titratable acidity complied with the standards (SDS, 2008; EAS, 2006; SVGNS, 2004). The results of fat, protein, ash and titratable acidity in this study are in agreement than those reported by Sabah El Khier and Yagoub (2009), while moisture content was higher than the reports of Sabah El Khier and Yagoub (2009) and Fernandez de Oliveira *et al.* (2000).

The results in this investigation do not conform to the standards, which stated that the total bacterial count should be less than Log_{10} 4.0 cfu/gm, yeasts and moulds count should be less than Log_{10} 1.0 cfu/gm, and the milk powder must be free from coliform bacteria (SDS, 2008; Codex, 1999; EAS, 2006; SVGNS, 2004). This high load of bacteria is an indicator of recontamination, since the imported milk powder always complies with universal standards, therefore, no bacterial growth should be observed during and after processing.

The results of TVBC reported in this study are similar to those reported by Sabah El Khier and Yagoub (2009), Deeb *et al.* (2010), Rajput *et al.* (2009) and Ahmed and Anwar (2006), slightly higher than those reported by Rajput *et al.* (2008) and higher than those reported by Fernandez de

Oliveira *et al.* (2000), while coliform bacterial count was higher than that reported by Sabah El Khier and Yagoub (2009) and Ahmed and Anwar (2006).

The recontamination could be attributed to different factors such as the recontamination during repacking, the unsanitized storage area, no aseptic conditions are observed during sack opening, the use of unsanitized equipment for repacking, no sanitary standards are used for workers, there might not be routine health check up for workers, the temperature and humidity of storage and transportation might not comply with standards.

This study recommends the consumption of fresh milk, but if necessary repacking of milk powder should be under strict sanitary conditions to ensure delivery of safe product to the consumer.

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