

Labeling, Microbiological and Physicochemical Analyses of Brazilian Fermented Dairy Products

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Rec date: Sep 22, 2014, Acc date: Oct 13, 2014, Pub date: Oct 15, 2014

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Abstract

The quality control of dairy products is important to ensure the population health, thus, the chemical composition of these products should be constantly assessed due to the minimum standards required by current law. Due to the functional appeal of these products, their nutritional importance as source of protein, minerals, vitamins and fats, and the increasing purchasing power of the population, the consumption of fermented dairy products has increased significantly in Brazil, specifically in the northeastern region. In this context, the present study aims to evaluate the quality of Brazilian fermented dairy products. For this, labeling, microbiological and physicochemical analyses of 42 samples (yogurts and fermented milk drinks) were performed and the results were compared taking into account the current Brazilian legislation, the distinct mesoregions where samples were collected and the type of inspection registration of the product. The findings suggest poor quality of Brazilian fermented dairy products with regard to microbiological, labeling and physicochemical parameters, and varying quality regarding the mesoregion of origin and inspection registration of products.

Keywords: Fermented dairy drinks; Yogurt; Food quality; Labeling; Food safety

Introduction

The yogurt and dairy drinks consumption is growing due to health claims, therapeutic values and taste, especially in emerging countries by the increased purchasing power of most of the population, the emerging middle class. In Brazil, this consumption has been growing at an average rate of 5% per year [1].

The intake of products containing lactic bacteria can increase the digestibility and nutritional food value, in addition to increase the B complex and amino acids levels, improve lactose absorption, immune system modulation, reduce the carcinogenic potential, the enhance the intestinal micro flora metabolic activity. Besides, lactic bacteria promote digestive tract hygiene and decrease the symptoms related to bowel infections [2,3].

Milk and dairy products are important sources of protein, calcium, phosphorus, iodine, riboflavin and vitamins A and B₁₂ [4]. Typically, dairy drinks show reduced contents of saturated fat and cholesterol compared to whole milk, while yogurt shows higher fat content and greater consistency. Moreover, these products are the most studied, especially due to the functionality appeal, when consumed in sufficient amounts, because they are primary carriers of probiotics and/or prebiotics, and also due the therapeutic properties of milk fat for containing conjugated linoleic acid (CLA) and short and medium chain fatty acids [5,6].

The raw milk quality is critical to the dairy industry success worldwide. Besides the scientific information showing the effect of the microbiological and physicochemical characteristics on the pasteurized milk and dairy products quality, social and economic aspects have caused major changes in dairy industries worldwide. The global offer of food and increased demand of consumers for safe food have led to large investments in research and implementation of quality programs to enhance competitiveness in the market, reliability and product safety. However, the milk production chain in some developing regions still faces many challenges related to the raw milk quality and safety to meet the legislation and the needs of consumers [7].

The inspection registration is a Brazilian control system that certifies the quality of animal source foods in their sanitary and technological aspect. The inspection level: federal, state or municipal concerns the level of industry marketing. Therefore, products must comply with the specific laws of each commercialization area, which usually features different quality parameters.

Researches from Araujo and Araujo [8] with 27 dairy products fortified with vitamin D, calcium and iron, marketed in Brazil, revealed that 23% of products did not meet the statutory requirements with respect to nutritional information and labeling, and 22% used attributes not specified in the legislation. As the work developed by Smith and Almeida-Muradian [9] that identified irregularities in the labeling of UHT milks and milk powders, and results obtained by Grandi and Rossi [10] showed that 97.4% of yogurt labels and 100% of fermented milk beverage labels were incomplete, deleting or erroneously presenting one or more mandatory information. The

identification of these irregularities allow the competent authorities to remove the products from commerce and imposes fines to fraudulent companies, since they expose consumers to the risk of allergies and diseases because of the lack of important information on the label.

Given the importance of fermented dairy products for nutrition, promoting well-being and health, in addition the problematic of the quality and safety of these products, it is necessary to intensify the supervision of such products by competent agencies and the scientific community to verify the compliance with legislation. Thus, this study aimed to assess the yogurts and fermented dairy drinks quality produced in Brazil.

Materials and Methods

Samples

Forty-two samples of yogurt and fermented milk beverages strawberry flavored from fourteen different Brazilian dairy industries were collected from April to August 2013 in mesoregions of northeastern Brazil with federal or state inspection registration. The mesoregions are classified as Sertão, Borborema, Agreste and Zona da Mata, with distinct characteristics: Sertão is characterized by tropical and semi-arid climate; Zona da Mata is humid with abundant rainfall; Borborema is tropical with lowlands and Agreste is tropical with mountains and plateaus [11].

The samples were composed of 18 yogurts and 24 fermented milk beverages. Samples were chosen considering their large consumption by the Brazilian population, according to the Annual per capita Survey of Household Food Acquisition, which found an annual national per capita consumption of 43.7 kg for dairy products, among them milk (38.4 kg), yoghurts, dairy beverages and fermented milks (3.12 kg) [12].

To characterize the samples quality, labeling, microbiological and physicochemical analyses were performed in triplicate.

Labeling analysis

The concordance between mandatory labeling information of milks and dairy products were verified considering the Brazilian legislation in relation to the studied products [13-17].

The analysis was conducted through a questionnaire with answers expressed in "compliance" or "non-compliance", considering the following criteria: font size; readability of texts; denomination; brand; statement of net weight/content; origin identification; additional nutritional information; ingredients list; use of additives; conservation mode; conservation mode after opening packaging; expiration date; expiration date after opening packaging; manufacture date; batch identification; registration number; Federal or State Inspection Service Stamp; manufacturer's data; expression "contains gluten" or "Contains No Gluten"; phrases relating to the use of artificial coloring; nutritional table; figures, symbols, graphics and drawings; specific phrases of Technical Regulations; phrases not contained in Technical Regulations.

Microbiological analyses

The mandatory microbiological analyses are total and thermotolerant coliforms and *Salmonella* spp. [16,17]. Total and thermotolerant coliforms analyses were performed using the most

probable number (MPN/mL) [18]. The count of yeasts and molds, expressed in CFU/mL, and research of *Salmonella* spp. followed recommendations of the Bacteriological Analytical Manual [19]. The analysis of yeasts and molds was performed for being a sanitary quality indicator in fermented products.

Physicochemical analyses

Samples were submitted to the following analyses: nitrogen content by the Kjeldahl method; fat content by the Gerber method. Titratable acidity (%lactic acid) was determined by titration with NaOH solution 0.1 mol/l [20].

For the analysis of fatty acids, total lipids were extracted according to Folch et al. [21], followed by preparation of methyl esters [22].

Gas-chromatographic analysis used programming suggested by Kliem et al. [23]. Helium was used as carrier gas (flow rate of 1 ml/min), and injector and detector temperatures maintained at 250°C and 260°C, respectively. Aliquots of 1.0 µL esterified extract were injected into Split/Splitless injector of gas chromatograph (Varian 430-GC, California, USA) equipped with flame ionization detector (FID); fused silica capillary column (CP WAX 52 CB, Varian) with dimensions of 60 m×0.25 mm and 0.25 mm of film thickness. The chromatograms were recorded on Galaxie Chromatography Data System software. Fatty acids were identified by comparing the retention times of the reference methyl esters standard (FAME Mix-18919-SUPELCO). The fatty acids results were expressed as area percentage (%).

Statistical Analysis

The labeling data were expressed as percentage and the values of microbiological analyses were expressed in minimum and maximum ranges.

The data of physicochemical analyses were submitted to analysis of variance and means were compared by the Tukey test at 5% in a completely randomized design with triplicate. Statistical analyses were performed using the general linear model (GLM) from the Statistical Analysis System statistical package SAS 9.1 [24].

Results and Discussion

Labeling quality

Only one label was fully in accordance with legislation, while others showed at least one type of noncompliance. The overall compliance was 84% and 89% for yogurts and dairy drinks, respectively, showing higher quality of information on labels of dairy drinks; however, not fully in accordance with current legislation, not presenting significant information that should clarify the consumers.

The mesoregion showing the highest labeling quality for yogurts (Figure 1a) was Zona da Mata. For dairy drinks (Figure 1b), the mesoregions showing greater compliance were Zona da Mata, Agreste and Borborema. From these results, it could be inferred that there are differences in the labeling quality, depending on the origin mesoregion of products. All mesoregions showed unsatisfactory labeling quality, being far beyond the quality required by legislation, and Sertão was the mesoregion with the highest number of non-compliances for both products.

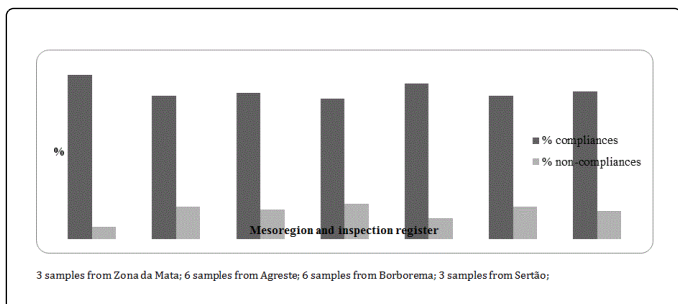


Figure 1a: Labeling compliance for yogurt expressed in percentage.

The non-compliances percentage was higher for products with federal inspection for both yogurts as dairy drinks, showing differences in the labeling quality of yogurts with state and federal inspection register, allowing inferring that products with federal inspection undergo closer inspection than those with state inspection, and thus have higher labeling quality. These results indicate supervision lack by competent agencies and reinforce the need for more adequate inspections to ensure compliance of labels with legislation and inform consumers with clarity and fidelity.

Figure 2 shows that the highest irregularities percentage detected on labels was 47% for item use of additives, that is, nearly half of labels analyzed used some type of additive not allowed by legislation for this product. For example, the use of dye red Bordeaux is not on the additives list allowed by the Technical Regulations for Dairy Drinks and Fermented Milk [16,17]; however, its presence was verified on labels, and some samples did not show the additives used on labels, representing a potential health risk to consumers.

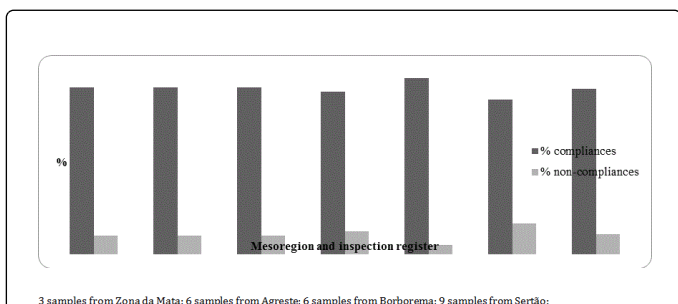


Figure 1b: Labeling compliance for dairy drink expressed in percentage

In about 35% of labels analyzed, nonconformities were observed in the ingredients list, such as absence of dye specification used and missing ingredients. The item "readability" also showed 35% of irregularities and concerns mainly to inadequate label cut, omitting or making the reading of information difficult, label discoloration and also inadequacy of letter contrast with the label background, making the information unreadable.

Other irregularities found were expiration date, batch and manufacturing date unreadability; absence of specific phrases provided in the Technical Regulation, such as "this product is not yogurt" in the case of dairy drinks; incorrect product denomination; font size less than 1 mm; lack of "artificially colored" phrase; lack of information such as household measurement and units in the nutrition table.

The presence of these irregularities omits important information that should enlighten consumers about the product and exposes them to food safety risks by the use of non-legal ingredients. Given that children are the main consumers of milk products, manufacturers should be extremely careful to avoid failures like these. The labeling information recommended by Brazilian legislation are important both for the standardization of information on labels and to inform the consumer; therefore, the absence of such information induces to errors and represents a risk to consumer health. The intensification of surveillance by health authorities and access to nutrition education are needed to improve the labeling quality in Brazil.

Microbiological quality

The results for total and thermotolerant coliforms showed that 87% of dairy drinks samples were within the standards required by Brazilian legislation (max. 100 MPN/mL for total coliforms and max. 10 MPN/mL for thermotolerant coliform) [16]. Yogurt samples showed 94% and 89% of compliance for total and thermotolerant coliforms, respectively, indicating better microbiological quality, while due to their greater amount of whey, a byproduct from cheese production, dairy drinks showed lower microbiological quality.

In the counting of yeasts, all yogurt and dairy drink samples showed growth of molds and yeasts, but current legislation does not require this type of analysis in these products.

The presence of yeasts, filamentous fungi and coliforms in yogurt and fermented dairy drinks are indicative of poor sanitary practices during manufacturing or packaging, process failure or post-process contamination, shortening the product shelf life [25,26]. Absence of *Salmonella* spp. was detected in all samples, as recommended by Brazilian legislation. The absence of *Salmonella* is mandatory because these bacteria can cause serious food poisoning known as salmonellosis.

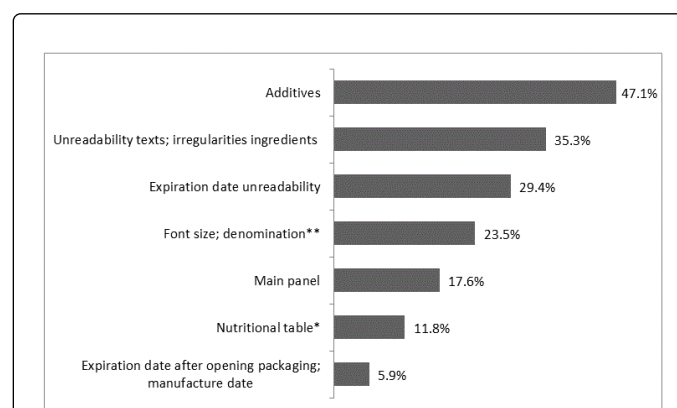


Figure 2: Nonconformities irregularities of yogurt and dairy drinks labels expressed as percentage (%). *Nutritional table and information's not provided in the Technical Regulation; **Font size; Denomination; unread ability manufacture date; unread ability batch; specific phrases of Technical Regulations.

In dairy drinks, samples from Zona da Mata showed coliforms growth above 2400 MPN/mL, revealing contamination above the maximum allowed by law. These results suggest differences in the microbiological quality of fermented milk products depending on the mesoregion product of origin, pointing inadequate microbial quality

for some samples and failure in the hygiene and sanitary aspect during production.

Regarding the inspection registration, samples of both products with state inspection registration showed microbiological contamination above levels established by law for total and thermo tolerant coliforms, possibly for being submitted to less stringent inspections and lack of adequate sanitation during production and/or storage. The growth of molds and yeasts suggests inadequate hygienic and sanitary conditions, reinforcing the need to increase sanitary surveillance. Belli et al. [27] showed values below the limit for all microbiological parameters of commercial yogurts samples regarding their low acidity, which results are not in agreement with those found in this study, in which non-conformities were found with respect to the microbiological standards required, leading to food safety risks for consumers.

Physicochemical aspects

With respect to protein content, yogurts showed higher contents (Table 1), but lower than values found by Akalin et al. [28], who

observed protein levels ranging around 5%, which shows the low protein quality of Brazilian yogurts. Among mesoregions, the values for yogurts were similar but below the minimum required by law, with differences ($P < 0.05$) between Zona da Mata and Sertão mesoregions, while for dairy drinks, Sertão mesoregion stood out with higher protein content and Agreste and Borborema mesoregions showed protein contents lower than those set by legislation [16]. Yogurt samples with state inspection registration had higher protein content, while dairy drinks showed no difference ($P < 0.05$), which is due to the greater manipulation of dairy drinks, making it a more uniform product. However, the results for yoghurt samples were below the minimum values required by law, suggesting poor protein quality of yogurts and dairy drinks, which could be indicative of fraud and lack of inspection [17].

SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid.

Product		Protein ¹	Fat ¹	Titratable acidity ²	SFA ³	MUFA ³	PUFA ³
Yogurt	Mesoregion						
	Agreste	2.47 ^{ab}	1.82 ^{ab}	0.71 ^a	66.49 ^a	30.47 ^a	3.04 ^a
	Borborema	2.61 ^{ab}	1.57 ^b	0.68 ^{ab}	68.64 ^a	27.80 ^a	3.56 ^a
	Sertão	2.79 ^a	2.30 ^a	0.66 ^{ab}	66.27 ^a	30.80 ^a	2.91 ^a
	Zona da Mata	2.27 ^b	1.67 ^{ab}	0.55 ^b	61.44 ^a	32.33 ^a	6.23 ^a
	Register						
	Federal	2.10 ^b	1.02 ^b	0.56 ^b	68.27 ^a	28.32 ^a	3.41 ^a
	State	2.76 ^a	2.18 ^a	0.72 ^a	65.08 ^a	30.66 ^a	4.25 ^a
	Mean	2.54 ± 0.11	1.79 ± 0.17	0.67 ± 0.04	66.33	29.95	3.72
	Legislation	Min. 2.80	3.00-5.90	0.60-1.50	*	*	*
Dairy drink	Mesoregion						
	Agreste	1.60 ^c	0.85 ^c	0.47 ^b	75.91 ^a	19.69 ^b	4.30 ^a
	Borborema	1.60 ^c	0.42 ^d	0.48 ^b	62.99 ^a	24.22 ^{ab}	12.73 ^a
	Sertão	2.28 ^a	1.92 ^a	0.63 ^a	65.88 ^a	30.64 ^a	3.48 ^a
	Zona da Mata	1.98 ^b	1.22 ^b	0.60 ^a	67.45 ^a	28.52 ^{ab}	4.02 ^a
	Register						
	Federal	1.95 ^a	1.22 ^a	0.53 ^b	69.60 ^a	25.92 ^a	4.28 ^a
	State	1.86 ^a	1.16 ^a	0.58 ^a	69.66 ^a	26.97 ^a	3.74 ^a
	Mean	1.90 ± 0.07	1.19 ± 0.14	0.55 ± 0.02	67.86	26.03	6.06
	Legislation	Min. 1.70	Min. 2.00	*	*	*	*

Table 1: Mean values of physicochemical variables of yogurts and dairy drinks. ¹g/100g; ²%; ³area %; Min: minimum; *There is no specification of values for the parameter; Means followed by different lowercase letters in the same row indicate significant differences according to Tukey's test at a 5% significance level.

As expected, the fat content found for yogurt (1.79 g/100 g) was higher than that found in dairy drinks (1.19 g/100 g), where despite differences, the values were similar. It is noteworthy that this study analyzed yogurts and dairy drinks produced with whole milk; therefore, the fat content of these products should be above 3 g/100 g and 2 g/100 g, respectively (minimum established by legislation) [16,17]. Discrepant values were obtained by Alkalin et al. [28] for yogurts, ranging from 2.99 to 3.10 g/100 g. This suggests lack of identity and standardization of products by Brazilian companies, milk fat poor quality, being indicative of fraud and lack of inspection. Sertão was the mesoregion that showed the highest fat contents in products. Yogurt samples with federal inspection registration showed lower fat contents, indicating lower levels of surveillance. Regarding dairy drinks, all mesoregions differed, with the lowest value found for drinks from Borborema mesoregion, and these differences show the lack of identity and standardization of these products.

Acidity in fermented milk is a function of the lactose fermentation process by lactic acid bacteria, with transformation into lactic acid [29]. Dairy drinks showed lower acidity, which is consistent with results obtained by Costa et al. [30] from 0.55% to 0.61% for fermented dairy drinks. Among mesoregions, dairy drinks that showed higher acidity were from Sertão and Zona da Mata. With respect to the inspection registration of companies, those with state inspection registration showed higher acidity for both yogurts and dairy drinks. However, the values for yogurts with federal inspection registration were lower than required by law, showing unsatisfactory quality of the acidity parameter [17]. For dairy drinks, there are no limits of quality standard for this parameter. In the processing of yogurt, titratable acidity is used to assess the fermentation progress and as quality parameter of the finished product [31].

Samples from Sertão mesoregion showed better physicochemical and nutritional quality for all parameters analyzed. Despite the drought, this mesoregion remains an important dairy belt, with the largest dairy companies, which have higher concern in ensuring the quality of their products.

Observing the fatty acids profile of products studied (Table 1), it appears that they had similar lipid composition, with predominance of saturated fatty acids. These results were consistent with those observed by Serafeimidou et al. [32]. Studies have indicated that saturated fatty acids are associated with increased low density lipoprotein (LDL), increasing exposure to cardiovascular diseases; polyunsaturated fatty acids have the opposite effect [32,33]. However, the concept that milk fat is harmful to health is changing over time through studies that have shown the beneficial effects of fatty acids present in milk fat. During the past decades, medical and nutritional recommendations promoted a decline in the consumption of saturated fatty acids; however, current discussions question these recommendations, as with the decrease in saturated fat, an increase in the consumption of other nutrients such as simple carbohydrates was observed, and this can have a major impact in increasing the risk of cardiovascular disease and diabetes, which are higher than those brought by the consumption of saturated fat [34].

The physicochemical and microbiological quality of yogurts and fermented dairy drinks varied among mesoregions, possibly by the variation in the raw material composition, the milk, which may vary according to animal breed, climate, season, animal health, among others factors that affect the final quality of the product. Besides other factors like different ingredients, manufacturing techniques, fermentation, which influence the final characteristics of the products

and alter the physicochemical and microbiological composition, influencing differently in health and well-being of consumers. One should take into account that the northeastern region of Brazil has been through the second consecutive year of drought, and that this prolonged weather event has affected livestock and animal feed, directly influencing the milk and derivatives quality. Moreover, values below those required by legislation found in this study suggest fraud of products, causing damage to consumers.

Variations in the quality of these products with respect to the inspection registration of companies was also observed, suggesting different nutritional and microbiological characteristics depending on the place the product will be marketed and inspection parameters at state or federal level, also indicating the existence of differences in the inspections flexibility, and products with lower or higher quality due to the varying quality standards are offered to the population.

Brazilian legislation does not require physicochemical analysis of products to be included in the nutrition label and it is possible to formulate a table of nutritional information from references such as: chemical composition table of food or food database, i.e., nutritional information contained in labels are approaches reported in literature, not necessarily being the reality of the product [35]. Comparing the physicochemical results with the nutritional information on labels, all values were different, suggesting credibility lack of nutritional information on the products labels.

Conclusion

The overall quality of yogurt and fermented dairy drink samples analyzed in this study was unsatisfactory with respect to labeling, microbiological and physicochemical parameters, not meeting the minimum requirements set by Brazilian law.

The labeling, physicochemical and microbiological characteristics were influenced by the product (yogurt and fermented dairy drink), the geographic area of origin of the products (Zona da Mata, Agreste, Sertão e Borborema) and the inspection registration (state or federal) type, showing a variable quality profile of Brazilian dairy products.

Acknowledgments

The authors are grateful to CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brazil) for financial support.

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