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Estudo comparativo entre queijos animais e vegetais similares: aspectos físico-químicos, microbiológicos e sensoriais

Comparative study between animal cheese and similar vegetable: physicochemical, microbiological and sensory aspects

Estudio comparativo entre queso animal y vegetal similar: aspectos fisicoquímicos, microbiológicos y sensoriales

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Resumo

O queijo Minas Frescal tem ampla aceitação e faz parte da dieta típica de muitos brasileiros. No entanto, observou-se um aumento na busca por produtos similares de origem vegetal, devido a problemas de saúde relacionados ao consumo de laticínios. Esta pesquisa teve como objetivo avaliar a potencial substituição do queijo Minas pelo similar queijo vegetal - tofu. Duas marcas de queijo Minas Frescal (MC) e duas de produtos vegetais similares (VS) (tofu) foram avaliadas com base em parâmetros microbiológicos, físico-químicos e sensoriais. Todas as amostras analisadas estavam de acordo com os padrões microbiológicos da legislação brasileira. O pH estava em torno de 6,0. As amostras MC1 e MC2 apresentaram altos níveis de acidez e lipídios, enquanto as amostras VS1 e VS2 apresentaram altos níveis de proteína. As amostras com alto teor de umidade também foram as menos firmes (VS1 e MC1). A aceitação geral dos atributos foi satisfatória para as amostras MC1 e MC2, que seriam compradas e consumidas, enquanto o contrário ocorreu com VS1 e VS2. Todas as amostras foram consideradas com um nível de sal abaixo do nível ideal. As amostras MC1 e VS1 avaliadas foram menos firmes que o nível ideal, enquanto as amostras MC2 e VS2 foram mais firmes que o nível ideal. O tofu não foi aceito como substituto do queijo Minas Frescal pelos consumidores. Requer otimização da textura e do nível de sal para cumprir esse objetivo. No entanto, o Tofu apresentou uma vantagem em relação ao seu baixo nível de gordura e alto nível de proteína.

Palavras-chave: Tofu, Laticínios, Aceitabilidade, Físico-Químico, Microbiologia**.**

Abstract

Minas Frescal cheese has wide acceptance and it is part of many Brazilians' typical diet. However, it was observed that there is an increase in the search for similar products of vegetable origin, due to health problems related to the intake of dairy products. This research aimed to evaluate the potential replacement of Minas cheese by the similar vegetable cheese -

tofu. Two brands of Minas Frescal Cheese (MC) and two of similar vegetable product (VS) (tofu), were assessed based on microbiological, physicochemical and sensory parameters. All samples are in accordance with the microbiological standards of Brazilian law. The pH was around 6.0. The samples MC1 and MC2 had high levels of acidity and lipids, while the VS1 and VS2 had high levels of protein. Samples with high moisture content were also the least firm (VS1 and MC1).The general acceptance of attributes was satisfactory for samples MC1 and MC2, which would be bought and consumed, while the opposite was true with VS1 and VS2. All samples were considered to have a salt level below the ideal level. The samples MC1 and VS1 assessed were less firm than the ideal level, while samples MC2 and VS2 were firmer than the ideal level. Tofu was not accepted as a substitute for Minas Frescal Cheese by consumers. It requires optimization of texture and salt level in order to fulfill this purpose. However, Tofu presented an advantage in relation to its low fat level and high protein level.

Keywords: Tofu, Dairy, Acceptability, Physicochemical, Microbiology.

Resumen

El queso Minas Frescal tiene una amplia aceptación y es parte de la dieta típica de muchos brasileños. Sin embargo, se observó que hay un aumento en la búsqueda de productos similares de origen vegetal, debido a problemas de salud relacionados con la ingesta de productos lácteos. Esta investigación tuvo como objetivo evaluar la posible sustitución del queso Minas por el queso vegetal similar: el tofu. Se evaluaron dos marcas de queso Minas Frescal (MC) y dos de productos vegetales similares (VS) (tofu) en base a parámetros microbiológicos, fisicoquímicos y sensoriales. Todas las muestras están de acuerdo con los estándares microbiológicos de la ley brasileña. El pH fue de alrededor de 6.0. Las muestras MC1 y MC2 tenían altos niveles de acidez y lípidos, mientras que VS1 y VS2 tenían altos niveles de proteína. Las muestras con alto contenido de humedad también fueron las menos firmes (VS1 y MC1). La aceptación general de los atributos fue satisfactoria para las muestras MC1 y MC2, que se comprarían y consumirían, mientras que lo contrario fue cierto con VS1 y VS2. Se consideró que todas las muestras tenían un nivel de sal por debajo del nivel ideal. Las muestras MC1 y VS1 evaluadas fueron menos firmes que el nivel ideal, mientras que las muestras MC2 y VS2 fueron más firmes que el nivel ideal. El tofu no fue aceptado como sustituto del queso Minas Frescal por los consumidores. Requiere la optimización de la textura y el nivel de sal para cumplir este propósito. Sin embargo, el tofu presentó una ventaja en relación con su bajo nivel de grasa y alto nivel de proteína.

Palabras clave: Tofu · Lácteos · Aceptabilidad · Fisicoquímico · Microbiología.

1. Introduction

Cheeses are fermented dairy products from the milk of limited number of mammals. They have a great diversity of flavors, textures and shapes which originate due to variations in the raw material, the ingredients added in processing techniques and the aging time, which unleashes dynamic biochemical processes in cheeses.

According to the Brazilian agency responsible for the regulation of this product - Ministry of Agriculture, Livestock and Supply (MAPA) - the milk used in cheese production must be pasteurized and then coagulated by the action of enzymes, bacteria or specific organic acids, used isolated or in combination. Cheese designation is reserved for cheese products whose base does not contain milk fat and/or protein from different sources (BRASIL, 1996).

The production of cheese is distributed worldwide, with more than 1000 known types, 400 of which are produced in France (PERRY, 2004). Brazil is the third largest producer of cheese, after the European Union and the United States, growing at an average rate of 5% per year. According to the Brazilian Association of Cheese Industries, Brazil produced 700,000 tons of this product in 2009, and the Minas Frescal cheese takes fourth place among the varieties produced most in the country (ABIQ, 2010).

The Minas Frescal cheese presents sensory acceptance and comprises a large part of the daily diet of the many Brazilians. It is obtained by enzymatic coagulation of milk casein, usually using chymosin and pepsin and can be added specific lactic acid bacteria. It is a cheese with a medium fat level (25.0 to 49.9%) and a very high moisture content (>55.0%) which must be consumed fresh and stored at a temperature below 8°C. It presents the main sensory characteristics of: soft consistency, whitish color, smooth or slightly acid taste, characteristic odor, should not possess a crust and if this occurs, it should be fine and eventually there could be some mechanical holes (BRASIL, 2004).

However, due to health problems related to the intake of dairy products, in regard to lactose intolerance and high cholesterol, there is an increased interest in searching for similar foods of vegetable origin, such as tofu.

Tofu is considered a very nutritious food and is usually produced from soy, which is part of the traditional diet of Asian countries (Jayasena, 2010). It is obtained by precipitation of soy proteins by the coagulating action of acids or salts to produce gels resulting in the

formation of a protein system with water retention, lipids and other constituents. Tofu presents a smooth, soft and elastic texture (Ciabotti, 2009).

Products used as a substitute for the cheese must have similar sensory characteristics. Studies have been necessary to verify the potential of the consumption of these products in place of cheese by comparing the sensory, physical, chemical and microbiological characteristics.

The purpose of this study was to evaluate the Minas Frescal cheese potential replacement by similar vegetable-Tofu, by comparing the physicochemical, microbiological, and acceptability of both products in order to verify that similar vegetable products could be an alternative for the diet of people with health problems related to ingestion of milk and dairy products.

2. Materials and methods

2.1 Samples

Two different brands of Minas Frescal cheese (MF), with Federal Inspection and two different brands of vegetable similar product (VS) - Tofu, commercialized in Fortaleza /CE, were obtained at the Department of Food Technology, Federal University of Ceara for evaluating microbiological, physicochemical and sensory characteristics.

Samples of Minas Frescal cheese and Tofu were vacuum packed in polyethylene film of low density. The other Tofu sample was packaged in a polystyrene tray covered with high density polyethylene.

The samples were aseptically divided into eight servings, four of which were used for microbiological evaluations and four were designated for physical-chemical evaluations.

2.2 Microbiological analysis

Samples of Minas Frescal cheese (MF) and similar vegetable product (VS) were evaluated for determination of coliforms at 45ºC by the Most Probable Number (MPN/g) technique. Three tubes were used, *Staphylococcus* coagulase positive (CFU/g), *Salmonella* and *Listeria monocytogenes* in 25g sample for detection, as established by the Brazilian legislation for cheeses of very high moisture, through RDC Resolution No. 12 of the National Agency for

Sanitary Surveillance (ANVISA) from January 2, 2001 (BRASIL, 2001a). Microbiological analyses were performed according to methods described by APHA (2001).

2.3 Physicochemical determinations

The samples were mashed and subjected, in triplicate, to the acidity, protein, moisture and ashes analysis according to AOAC (2005). The pH was determined using a potentiometer (Quimis, model Q.400.A), calibrated with buffer solutions of pH 4.0 and 7.0. The total lipid content was determined by the Gerber method whose reading was determined on the graduated scale of butyrometer for milk. The firmness and texture were analyzed using a digital penetrometer counter (SoilControl Agrisearch and Equipment model DD - 200 PBDF - 0/20kgf).

The quantification of total protein was determined by the Kjeldahl method (AOAC, 2005) in which the total nitrogen value obtained was multiplied by 6.25. The moisture determination was performed by gravimetric drying at 105°C for 16 to 24 hours. Ash was also found by the gravimetric drying method, where the sample was subjected to incineration in a muffle furnace at 550°C.

2.4 Sensory evaluation

Initially, a questionnaire about demographics (age, gender, income, and level of instruction), liking of cheese products, the frequency and form of cheese consumption, the incidence of problems related to the intake of milk and dairy products, and consumption of alternative products to cheese. The acceptability tests were carried out in individual booths, using 100 untrained subjects.

The design was balanced complete blocks and the samples were presented monodically. The samples were served in white plastic cups in standardized quantities (10g) at 10 ± 1°C, under refrigeration and coded with randomized three-digit numbers. Mineral water at room temperature (20 ± 2°C) and salt cracker were provided for mouth-rinsing between the sample evaluations (IAL, 2008).

The 9-point hedonic scale (1 = extremely dislike, 5 = neither like or dislike, 9 = extremely like) was used to assess the smell, salty taste, flavor, and overall acceptance (Stone, 2004; Meilgaard, 1999). The consumption intention was evaluated by 9-point food action rating scale – FACT (1 = I would eat this food every opportunity I had; 5 = I would eat this if

available but would not go out of my way; 9 = I would eat this only if I were forced to) and the purchase intention was evaluated by a 5-point scale (1 = certainly would purchase; 3 = Maybe would purchase, maybe not; 5 = certainly would not purchase) (ABNT, 1998).

The appropriateness of salty taste and firmness was verified using the 9-point just about right (JAR) scale (-4 = extremely weak; 0 = just about right; +4 = extremely strong). This procedure allows determination of how much the samples differ from the intensity of the attribute considered ideal by consumers (Meilgaard, 1999; Villegas et al.; 2010).

In order to define the sample that has the ideal salty taste and firmness, the frequencies of responses in the “too weak” and “too strong” categories of the scale were counted. In order to conclude that a specific attribute is at an optimal level, the sample must achieve at least 70% of responses on the scale corresponding to "just about right" (0-zero) and to conclude that an attribute is not at the optimum level, at least 20% of responses must fall in the "too weak” or “too strong” categories (Meullenet et al., 2007).

The research was submitted and approved by the Research Ethics Committee, through the Brazil platform, under number 1.628.994.

2.5 Statistical analysis

Quantitative data of physicochemical determinations are expressed as the mean ± standard deviation (SD). The results showing significant differences were analyzed using the Tukey’s test (Origin 7.0). Values at $P < 0.05$ were considered significant.

Based on the acceptance results obtained, frequency histograms were constructed with assigned values for each sample. The data relating to the acceptance of the four samples were also subjected to analysis of variance (ANOVA), having samples and subjects as sources of variation. Tukey’s test ($P < 0.05$) was again used for separation of means, using the software Origin version 7.0. The results of consumption intention and consumer purchase were presented in frequency histograms with stacked columns.

3. Results and discussion

3.1 Microbiological characterization

The Brazilian legislation (BRASIL, 2001a) specifies the absence of *Salmonella spp.*, *Listeria monocytogenes*, and coliforms at 45ºC and allows *Coagulase Positive Staphylococcus*

counts up to $5x10^2$ CFU/g for very high moisture cheeses. For the analysis of coliforms at 35ºC there is no specified limit of detection.

The microbiological analysis of the MF and VS samples presented conformity with current legislation standards (Table 1).

Table 1 - Microbiological analysis of Minas Frescal cheese and vegetable similar product (Tofu) commercialized in Fortaleza/CE

Analysis	**Samples**			
	MF1	MF2	VS1	VS2
Salmonella	Absence/25g	Absence/25g	Absence/25g	Absence/25g
Listeria	Absence/25g	Absence/25g	Absence/25g	Absence/25g
Estafilococcus	Absence/25g	Absence/25g	Absence/25g	Absence/25g
Coliforms at 35º C (MPN/g)*	$3,0x\ 10^2$	$3,2x10^2$	< 10	$1,8\ x\ 10^3$
Coliforms at 45ºC (MPN/g)*	1,0 x 10	< 3	< 3	< 3

MPN - most probable number. MF1 = Minas Frescal cheese brand 1; MF2= Minas Frescal cheese brand 2, VS1 = similar vegetable (Tofu) brand 1, VS2 = 2 vegetable similar (Tofu) brand 2. Table Source: BAM FDA (Food and Drug Administration)

Komatsu et al. (2010) evaluated 50 samples of Minas Frescal cheese produced in five farms in Uberlândia/MG, and verified that 88% had coagulase positive Staphylococcus counts above the standards set by currently legislation. Carvalho, and Kuaye Viotto (2007) evaluated the quality of 93 Minas Frescal cheese produced by different technological processes and detected that 34.4% of samples were contaminated by coliforms at 45°C, however *Salmonella* sp. were not detected in any of the samples. In the same study, *Listeria* spp. were found in 11.8% of the examined cheeses, of which 42.9% presented positive results for *L. monocytogenes*.

3.2 Physicochemical determinations

The results of physicochemical analysis (acidity, pH, protein, fat, moisture, ash and firmness) of MF and VS samples are shown in Table 2.

Table 2 - Physicochemical properties of Minas Frescal cheese and vegetable similar product (Tofu) samples

Analysis	Samples			
	MF1	MF2	VS1	VS2
Acidity (ºD)	40.00	43.70	9.9	6.7
pH	$5.88^{ab} \pm 0,40$	$5.93^{a} \pm 0,07$	$6.07^{a} \pm 0,06$	$6.36^{b} \pm 0,05$
Fat content (%)	$33.67^{a} \pm 0,20$	$26.80^{b} \pm 0,18$	$5.59^{c} \pm 0,03$	$7.47^{d} \pm 0,30$
Protein content (%)	$17.29^{a} \pm 1,77$	$23.31^{b} \pm 1,43$	$13.96^{a} \pm 1,18$	$42.49^{c} \pm 0,54$
Moisture content (%)	$59.50^{a} \pm 1,65$	$57.87^{a} \pm 1,70$	$87.15^{b} \pm 1,68$	$64.25^{c} \pm 0,82$
Ash content(%)	$3.16^{a} \pm 0,01$	$2.97^{b} \pm 0,06$	$1.07^{c} \pm 0,01$	$1.13^{c} \pm 0,03$
Firmness (N)	$11.85^{a} \pm 0,48$	$16.89^{b} \pm 1,45$	$1.81^{c} \pm 0,32$	$12.08^{a} \pm 1,16$

Experiments were performed in three replicates. Data are reported as the Mean ± SD except for acidity. For each parameter, means followed by the same letter are not significantly different ($P < 0.05$) by Tukey's test

MF1 = Minas Frescal cheese brand 1; MF2= Minas Frescal cheese brand 2, VS1 = similar vegetable (Tofu) brand 1, VS2 = 2 vegetable similar (Tofu) brand 2

The acidity of the MF samples was higher than the VS samples. An explanation for this fact is a result of the action of lactic acid bacteria fermenting milk lactose (Cogan & Parente, 2004), which are responsible for the increased acidity and pH reduction of Minas Frescal cheese. The bacteria continue to multiply (both mesophilic and psychrotrophic micro-organisms) producing acid during storage and distribution (Ciabotti et al., 2009), which does not occur with Tofu similar Vegetable.

The pH values found in the samples MF1 and MF2 (Table 2) are similar to those found in a study conducted by Carvalho, Viotto and Kuaye (2007) in Minas Frescal cheese when similarly processed using a direct acidification (5.85) or using a lactic culture (5.94), but differed in cheese processed by ultrafiltration (6,51). However, the Tofu samples, which in this study had pH of 6.07 (VS1) and 6.36 (VS2), differed from the values found in a study conducted by Prabhakara, and Valiyaveettil Perera (2006), which presented a pH ranging between 5.62 to 5.95, (using different types of coagulants to produce the Tofu).

MF Samples are in accordance with the terms of the Brazilian legislation with respect to moisture content, which should be more than 55% for cheeses of very high moisture content (2004). The mean values found in this study were 59.50% and 57.88% for MF1 and MF2, respectively, and no significant difference ($P < 0.05$) was observed for the Tukey test.

The VS1 sample presented a moisture content of 87.15%, similar to results verified by Ciabotti et al. (2006), where similar products to Tofu (produced with common soybean, soybean and common bleached free soybean lipoxygenase) showed values of 82.82%, 82.42% and 83.49%, respectively. For the VS2 sample, similar moisture was found to be 64.25%, appearing below the values found in the previously mentioned study, but within the standard for cheese of very high moisture content required by Brazilian law (BRASIL, 2001).

VS samples varied significantly between each other and compared with MF1 and MF2 samples for the moisture content. The high moisture content combined with high pH for the similar vegetable samples promote the development of spoilage micro-organisms, which makes it's shelf life shorter and it must be consumed quickly after opened.

The total lipid content found in Minas Frescal cheese samples ranged from 33.67% to 26.79% (MF1 to MF2), thus, the samples were according to No. 4/2004 Instruction (BRASIL, 2004), which classifies Minas Frescal cheese as a medium fat content (25 to 44.9% fat) cheese. Fat content from similar vegetable (Tofu) values were 5.59% for VS1 and 7.47% for VS2. Similar results were found by Ciabotti et al. (2006), where Tofu (made using common soybeans) presented 5.65% fat content.

The protein concentration in cheese can change according to the cheese variety, because the maturation processes performed in some cheeses are complex, involving biochemical reactions such as proteolysis - degradation of proteins by coagulating enzymes, natural milk enzymes and microbial enzymes, glycolysis of residual lactose by lactic acid bacteria, and lipolysis by lipolytic enzymes (Mcsweeney, 2004).

The Minas Frescal cheese is a product to be consumed fresh, so it's processing does not involve the maturation step, therefore transformations of proteins and lipids into aromatic compounds and flavor do not occur (Mcsweeney, 2004). However, the high moisture content of these cheeses favors microbial and enzymatic action resulting in continuous production of acid and a higher rate of proteolysis. These reactions promote increased acidity and soften the texture of the cheese during storage under refrigeration (Naldini, 2002).

The protein content found in Minas Frescal cheese samples (17.29% - MF1 and 23.31% - MF2) is consistent with the research conducted by Sangaletti et al. (2009) where values were found between 21.29 and 22.18%. Tofu samples analyzed showed higher protein

levels (13.96% - VS1 and 42.49%- VS2) compared to the values found by Ciabotti et al. (2006) for Tofu made using common soybeans (9.19%), bleached soybean (9.84%) and soybean lipoxygenase-free (9.54%). The MF1 and VS1 samples showed no significant difference ($P < 0.05$) for the protein content.

Regarding the analysis of physical firmness, the samples that present higher moisture content were also those that had lower firmness (VS1 and MF1) and there was no significant variation ($p < 0.05$) between MF1 and VS2 samples.

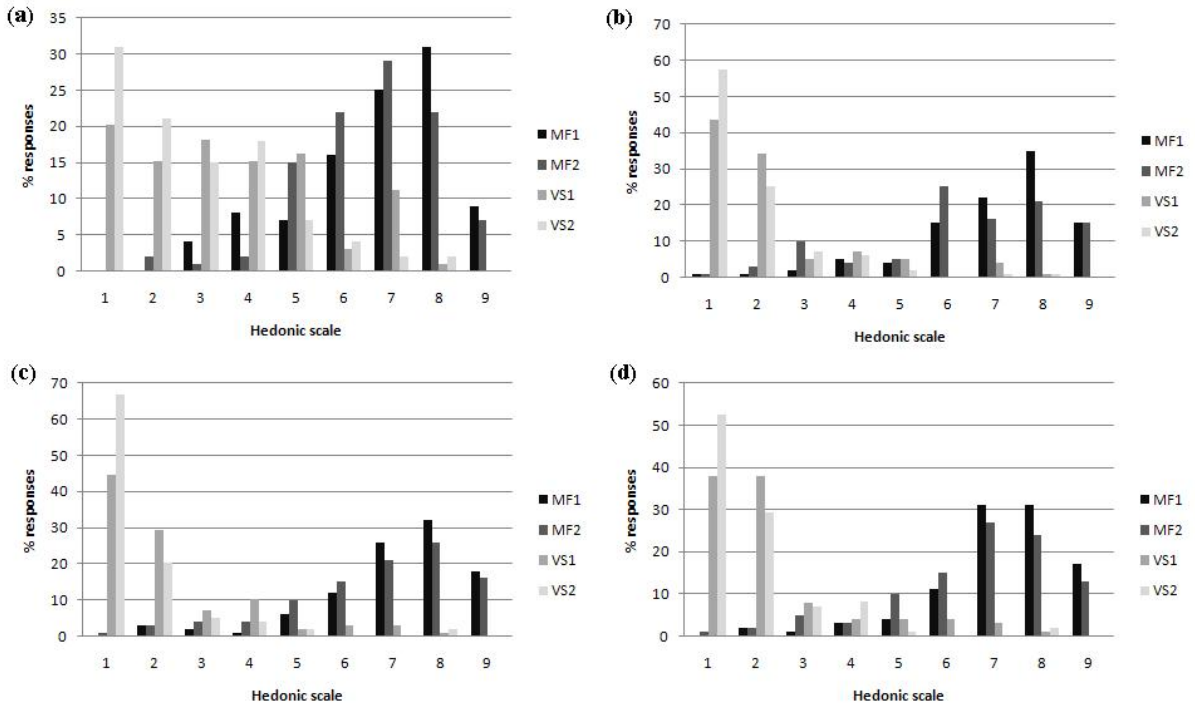
3.3 Sensory analysis

The 100 subjects that evaluated the acceptability of MF and VS samples were 79% women with incomplete higher education (69%) and the predominant age group was 19-25 years (67%). The majority of the consumers (94%) liked Minas Frescal cheese, and 66% extremely liked it. Regarding the frequency of consumption, 34% of the subjects consumed it a few times a week, 28% fortnightly and 29% monthly. Only 1% reported having some problem related to the intake of dairy products, such as lactose intolerance. However, 45% reported consuming alternative products to cheese, citing cream cheese, soy cheese and soy-based beverages.

Considering that the highest values of the hedonic scale (6-9) are equivalent to liking the sample, it can be noted that in relation to the assessment aroma, salty taste, flavor and overall acceptance (Figure 1) the MF1 and MF2 obtained higher frequency of responses within these levels, with percentages between 70% and 90%. However, the VS1 and VS2 accumulated 15% of the maximum response between those levels, indicating rejection.

Galante et al. (2017) evaluated the sensory acceptance of cholesterol-reduced cheese. The samples had similar sensorial characteristics to the cheese without treatment.

Figure 1 - Frequency of notes of hedonic scale for the assessment of acceptance of the attributes smell **(a)**, salty taste **(b)**, flavor **(c)** and overall **(d)** of commercial samples of Minas Frescal cheese and similar vegetable (Tofu)



MF1 = Minas Frescal cheese brand 1; MF2= Minas Frescal cheese brand 2, VS1 = similar vegetable (Tofu) brand 1, VS2 = 2 vegetable similar (Tofu) brand 2

All averages of acceptance (Table 3) for MF1 and MF2 were significantly different ($P < 0.05$) from the means of VS1 and VS2 samples.

The highest acceptance means (Table 3) were obtained for MF1 and MF2 samples, being close to 7 ("like moderately") for all attributes. No significant difference ($P < 0.05$) was observed between the means of these samples for smell or flavor. VS1 and VS2 samples presented, for all attributes evaluated, average values between 1 ("extremely dislike") and 3 ("moderately disliked") and a significant difference ($P < 0.05$) it was also observed between the two VS samples for smell and flavor acceptance.

Table 3 Average acceptance of commercial samples of Minas Frescal cheese and similar vegetable products (Tofu)

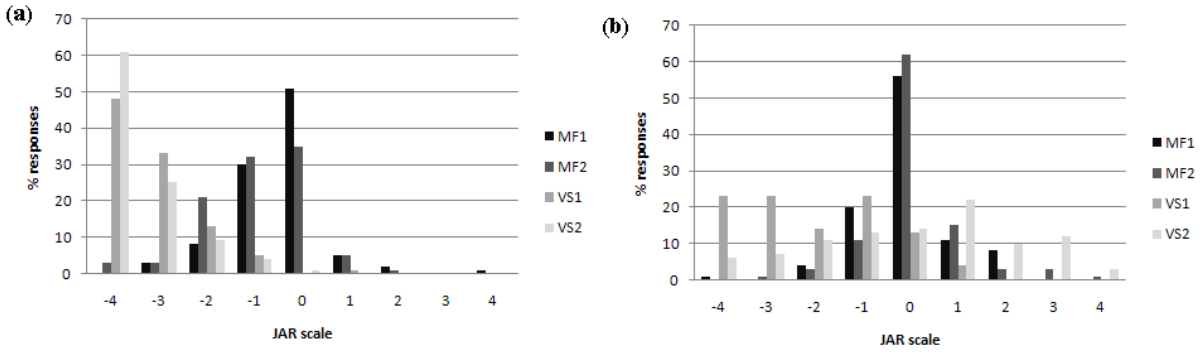
Attributes	Samples			
	MF1	MF2	VS1	VS2
Smell	$6.79^{a} \pm 1.57$	$6.64^{a} \pm 1.43$	$3.51^{b} \pm 1.96$	$2.79^{c} \pm 1.75$
Salty taste	$7.08^{a} \pm 1.63$	$6.43^{b} \pm 2.01$	$2.17^{c} \pm 1.61$	$1.79^{c} \pm 1.29$
Flavor	$7.18^{a} \pm 1.60$	$6.74^{a} \pm 1.88$	$2.22^{b} \pm 1.64$	$1.65^{c} \pm 1.30$
Overall	$7.23^{a} \pm 1.47$	$6.70^{b} \pm 1.78$	$2.27^{c} \pm 1.64$	$1.86^{c} \pm 1.32$

Data are reported as the Mean ± SD. For each attribute, means followed by the same letter are not significantly different ($P < 0.05$) by Tukey's test

MF1 = Minas Frescal cheese brand 1; MF2= Minas Frescal cheese brand 2, VS1 = similar vegetable (Tofu) brand 1, VS2 = 2 vegetable similar (Tofu) brand 2

In the salty taste and firmness evaluation, none of the samples presented the optimal intensity for the attributes (Figure 2) because they did not achieve a minimum of 70% of responses at the "just about right" range.

Figure 2 - Frequency of responses by category of the JAR scale for salty taste **(a)** and firmness **(b)** of commercial samples of Minas Frescal cheese and similar vegetable (Tofu)



MF1 = Minas Frescal cheese brand 1; MF2= Minas Frescal cheese brand 2, VS1 = similar vegetable (Tofu) brand 1, VS2 = 2 vegetable similar (Tofu) brand 2

The salty taste of all samples was considered weak (Figure 2), because the MF1, MF2, VS1 and VS2 samples achieved the largest accumulation of responses between the scale

levels corresponding to "too weak" with 41%, 59%, 99% and 99%, respectively. The salty taste of the MF1 and MF2 samples were considered 'slightly weak' because of the higher percentage of responses in this category, while VS1 and VS2 samples were 'extremely weak' in view of the greater quantity of -4 notes.

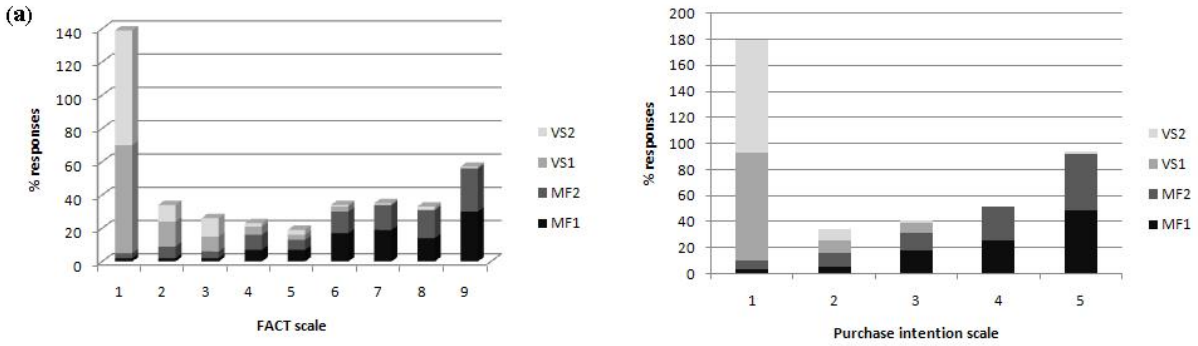
The firmness of the samples was not considered just about right (Figure 2) because VS1 and MF1 samples presented an accumulation of 25% and 83% of responses among the categories corresponding to "too weak". The VS2 and MF2 samples presented 22% and 47% of responses, respectively, among the categories relating to "too strong". However, the sample MF1 was considered "slightly weak" and the samples VS2 and MF2 were considered "slightly strong". The VS1 was evaluated suboptimally firm, since it had the highest percentage of responses corresponding to "moderately", "very", and "extremely weak".

The sensory results of firmness were consistent with the data of firmness measured by the penetrometer (Table 2). Samples with higher instrumental firmness values were considered "too strong" while the samples that presented lower values for this parameter were evaluated as "too weak".

The MF2 presented the highest percentage of zero responses ("just about right") reaching close to 70%. Therefore, the sample with greater instrumental firmness is closer to the firmness tasters considered just about right. The explanation could be that the Coalho cheese, classified as semi-hard (BRASIL, 2001b), is one of the most consumed and appreciated cheeses in Fortaleza. According to research made by SEBRAE-CE (2005) approximately 26.4% of the Fortaleza population and 27.7% in the state of Ceará consume the Coalho cheese daily.

The answers to the consumption intention (Figure 3a) showed that MF1 and MF2 samples would be consumed because they accumulated 80% and 71% of responses, respectively, among the categories of the sensory scale indicating consumption. These samples had a higher frequency of responses in the 9 category, corresponding to "I would eat this only if I were forced to". However, the VS1 and VS2 samples would be not consumed because they accumulated 94% and 92%, respectively, of answers between categories that indicate negative consumption intention.

Figure 3 - Frequency of responses by category of attitude scales to consumer attitude (a) and purchasing behavior (b) in relation to commercial samples of Minas Frescal cheese and similar vegetable (Tofu)



MF1 = Minas Frescal cheese brand 1; MF2= Minas Frescal cheese brand 2, VS1 = similar vegetable (Tofu) brand 1, VS2 = 2 vegetable similar (Tofu) brand 2

Regarding consumers' intention to purchase (Figure 3b), a situation similar to the consumption intention was observed. The MF1 and MF2 samples would be bought because they accumulated 74% and 69% of responses, respectively, among the categories of the scale that indicate the purchase. However, VS1 and VS2 samples would not be bought because they accumulated 92% and 96% of responses between categories of the scale that indicate not buy the product.

4. Conclusions

The Minas Frescal cheese and similar vegetables (Tofu) commercialized in Fortaleza/CE and evaluated in this study presented satisfactory sanitary conditions, according to standards established by the current legislation.

MF samples presented higher acidity values than VS samples. The VS samples showed lower percentages of total lipids and higher moisture content. Regarding protein content, VS2 sample presented higher than VS1 sample.

Commercial samples of Minas Frescal cheese (MF1 and MF2) had satisfactory smell, salty taste, flavor and overall acceptance, while samples of vegetable similar product (Tofu) had high rejection for both the specified attributes and generally.

All the samples were considered to have a weak salty taste. Regarding firmness, the MF2 sample was considered firmer and its firmness was closer to the just about right for the consumers.

The commercial samples of Minas Frescal cheese would be consumed and purchased by the subjects, while the vegetable similar product (Tofu) would not be consumed or purchased. They were not accepted as substitutes as Minas Frescal cheese, regarding the sensory characteristics. Despite the low acceptance of Tofu, they presented an advantage over Minas Frescal cheese due to its low fat and high protein content. However, this food needs optimization regarding the firmness and salty taste.

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References

American Public Health Association (APHA) (2001) Compendium of methods for the microbiological examination of foods. Washington DC, 676 p

Association of Official Analitical Chemistry (AOAC) (2005) Official Methods of Analysis of the Association of Official Analytical Chemistry. 16 ed. Washington DC, 1141p

Associação Brasileira das Indústrias de Queijos (ABIQ) (2010) Carta Leite: Aumenta o consumo de queijo no Brasil, p. 2. Disponível em: <http://www.bovinos.ufpr.br/100921_Aumenta_o_consumo_de_queijo_no_brasil_def.pdf >. Acessed in: mar 20 2012

Associação Brasileira de Normas Técnicas (ABNT) (1998) NBR 14141: Escalas utilizadas em análise sensorial de alimentos e bebidas. Rio de Janeiro.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Portaria nº 146 de 07 de março de 1996. Aprova os Regulamentos Técnicos de Identidade e Qualidade dos Produtos

Lácteos. Diário Oficial da União, Brasília, DF, 11 de março de 1996, seção 1, p. 3978-3986

BRASIL. Ministério da Saúde. Agência Nacional de Vigilância Sanitária - ANVISA. Resolução RDC no. 12, de 2 de janeiro de 2001. Regulamento técnico sobre os padrões microbiológicos para alimentos. Diário Oficial da República Federativa da Brasil, Brasília, DF, 10 jan. 2001a. Seção 1. p. 45.

BRASIL. Ministério da Agricultura e do Abastecimento. Secretaria de Defesa Agropecuária. Instrução Normativa nº 30, de 26 de junho de 2001. Aprova os Regulamentos Técnicos de Identidade e Qualidade de Manteiga da Terra ou Manteiga de Garrafa; Queijo de Coalho e Queijo de Manteiga, conforme consta dos Anexos desta Instrução Normativa. Diário Oficial [da] República Federativa do Brasil, Brasília, DF, 2001b.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Instrução Normativa nº 04, de 01 de março de 2004. Altera a Resolução MERCOSUL GMC nº 44/98 que corrige a Resolução GMC N° 145/96 "Regulamento Técnico MERCOSUL de Identidade e Qualidade do Queijo Minas Frescal". Diário Oficial da União, Brasília, DF, 05 de março de 2004

Carvalho JDG, Viotto WH, Kuaye AY (2007) The quality of Minas Frescal cheese produced by different technological processes. Food Control 18(3):262-267

Ciabotti S, Barcelos MFP, Cirillo MA, Pinheiro ACM (2009) Sensorial and technologic properties of product similar to tofu obtained with whey and soymilk addiction. Food Sci Tech 29(2):346 – 353

Ciabotti S, Barcelos MFP, Mandarino JMG, Tarone AG (2006) Avaliações químicas e bioquímicas dos grãos, extratos e tofus de soja comum e de soja livre de lipoxigenase. Ciênc Agrotec 30(5):920 – 929

Cogan TM, Parente E (2004) Starter Culture: general aspects. In: Fox et al. Cheese: Chemistry, Physics and Microbiology, vol. 1, 3rd ed., London, Elsevier.

Galante, M.; Pavon, Y.; Lazzaroni, S.; Soazo, M.; Costa, S.; Boeris, V.; Risso, P.; Rozycki, S. (2017). Effect of cholesterol-reduced and zinc fortification treatments on physicochemical, functional, textural, microstructural and sensory properties of soft cheese. International Journal of Dairy Technology, 70: 1-9.

Instituto Adolfo Lutz (IAL) (2008) Normas Analíticas do Instituto Adolfo Lutz. v. 1: Métodos químicos e físicos para análise de alimentos. 466/IV - Queijo - Determinação de gordura utilizando butirômetro para leite. 4ª. ed. 1ª edição digital, São Paulo. <http://www.gipescado.com.br/arquivos/met_fis-qui_ial/cap27.pdf>. Acessed in: feb 22 2012

Jayasena V, Khu WS, Nasar-Abbas SM (2010) The development and sensory acceptability of lupin-based Tofu. J Food Qual 33:85–97

Komatsu RS, Rodrigues MAM, Loreno WBN, Santos KA (2010) Ocorrência de *Staphylococcus* coagulase positiva em queijos minas frescal produzidos em Uberlândia-MG. Biosci J 26(2):316-321

Mcsweeney PLH (2004) Biochemistry of cheese ripening: introduction and overview. In: Fox et al. Cheese: Chemistry, Physics and Microbiology, vol. 1, 3rd ed., London, Elsevier, 617p.

Meilgaard M, Civille GV, Carr BT (1999) Sensory evaluation techniques. 3rd ed. Boca Raton: CRC, 309p.

Meullenet JF, Xiong R, Findlay CJ (2007) Multivariate and probabilistic analyses of sensory science problems. Ames: IFT Press, Blackwell.

Naldini MCM (2002) Comportamento diferencial de *Listeria monocytogenes* em queijos Minas Frescal elaborados pelo método convencional e por acidificação direta. 72p. Dissertação de Mestrado – Faculdade de Engenharia de Alimentos, UNICAMP, Campinas

Prabhakaran MP, Perera CO, Valiyaveettil S (2006) Effect of different coagulants on the isoflavone levels and physical properties of prepared firm tofu. Food Chem 99:492-499

Perry KSP (2004) Queijos: aspectos químicos, bioquímicos e microbiológicos. Quimica Nova 27(2):293-300

Sangaletti, N.; Porto, E.; Brazaca, S. G. C.; Yagasaki, C. A.; Dalla A, R. C.; Silva, M. V. (2009). Estudo da vida útil do queijo Minas Frescal. Ciência e Tecnologia de Alimentos, Campinas, 29 (2): 262 – 269, abr.- jun., 2009.

Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (SEBRAE) (2005) Lages V, Lagares L, Braga C. Valorização de produtos com diferencial de identidade e qualidade: indicações geográficas e certificações para competitividade nos negócios. 227p.

Stone H, SIDEL J (2004) Sensory evaluation practices. 3nd ed. Academic Press, London, 408 p.

Villegas B, Tárrega A, Carbonell I, Costell E (2010) Optimising acceptability of new prebiotic low-fat milk beverages. Food Qual Prefer 21(2):234-242

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