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Development of cheese bread with the addition of guar gum and xanthan gum as a substitute for partial fat

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Abstract

Cheese bread *(pão de queijo)* is a traditional Brazilian product that is consumed widely in Brazil. There is also currently a trend towards exportation to foreign markets. Cheese bread dough is gluten-free and consequently it represents an alternative for people suffering from celiac disease. The aim of this study was to develop cheese breads with added guar gum and xanthan gum as partial fat substitutes to produce low-calorie bread, with reduced up to 55% of soybean oil and to evaluate the physicochemical characteristics of frozen and baked cheese bread. Xanthan gum, guar gum, and a mixture of both gums in various proportions (0.25%, 0.5% and 0.75%), as well as reduced soybean oil of standard, were added. The analysis of the moisture, pH, specific volume and density of the frozen and baked cheese bread dough was performed. The addition of xanthan gum resulted in better characteristics than guar gum or a mixture of both gums. The formulations containing xanthan gum had higher moisture retention and better texture in the frozen dough, as well as higher volume and lower density, which are desirable characteristics in baked bread. The treatments with the addition of xanthan gum and 55% reduction of partial fat (soybean oil) provided better moisture, density and specific volume to the baked bread and offer the possibility of developing low-calorie bread with much of the fat content of standard commercial formulations replaced.

Introduction

Cheese bread *(pão de queijo)* is traditional product from the Brazilian state of Minas Gerais which is sold all over Brazil and is currently being marketed abroad. The dough is gluten-free and therefore cheese bread is an alternative for people suffering from celiac disease, who are allergic to the wheat proteins that are used in many baked goods. Cheese bread is often eaten as a snack to accompany drinks like coffee and tea and it is tasty and nutritious (Clareto *et al*., 2006; Aplevicz, 2006).

Cheese bread is produced from a mixture of starches (sweet, sour, or a mixture of both), eggs, milk, fat, cheese and salt. It does not have an established quality standard, so there are various types of cheese bread available in the market (Machado and Pereira, 2010; Rosa and Flores, 2011). The starch (of cassava) is the main ingredient, its classification for sweet and sour, the starch sweet is the cassava starch native through the process of separation of the fibers and drying, and the sour when fermentation occurs before drying, being a product modified by oxidation of cassava starch (Pereira *et al*., 2004; Andrade, 2012).

The increased consumption of cheese bread has given rise to new investments that are designed to improve product quality and to meet the relevant legislation. The commercialization of baked bread is complicated by the rapid decrease in product quality after baking. Quick freezing of cheese bread dough has greatly expanded the market; it is easy to prepare, provides longer storage of the product, and is convenient for consumers (Silva *et al*., 2009; Andrade, 2012). Guar gum is a polysaccharide produced endosperm of *Cyamopsis tetragonolobus* beans, has a high viscosity at low concentrations and used to prevent syneresis in frozen foods. Xanthan gum is an extracellular polysaccharide produced by *Xanthomonas campestris*, soluble in both hot and cold water as low cost. The gums have higher moisture retention functions, volume increase in the baking and fat substitutes. The mixture of these gums provides greater synergistic effect of gelling and viscosity (Munhoz *et al*., 2004; Matuda, 2008; Borges and Vendrusculo 2008; Andrade, 2012; Cortez-Vega *et al*., 2013).

Modified starches and other food additives have been shown to be stable when they are subjected to cycles of freezing, thawing and retrogradation; they provide better texture and water retention. Gums

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are natural polymers; they are hydrocolloids with water-soluble gelling properties, and they reduce the calorific value of foods. They have been increasing used for the technology of baking in recent years (Benassi *et al*., 2001; Munhoz *et al*., 2004; Andrade, 2012).

Several sources of fat substitutes promote a significant reduction in fat content and the energy value of foods, without being detrimental to manufacture and consumption. The replacement of fat can be partial or total, and the use of gums to replace fat has been widely used in low-calorie products because they have a low calorific value (Monteiro *et al*., 2006; Luvielmo and Scamparini, 2009; Santos, 2009; Menezes *et al.,* 2012). The tendency for substitutes fat began in the 80s, due to the concern of consumers in relation to health, the growth of chronic diseases and obesity in the population by the consumption of foods with a high fat content. Current Brazilian legislation (ANVISA Resolution No. 54 of November 12, 2012 and Ordinance No. 27 of January 13, 1998) states that a minimum reduction of 25% of any ingredient of a formulation means that a product can be considered to be 'low-calorie' (Brasil, 2012).

The aim of this study was to develop cheese breads with added xanthan gum and guar gum as partial fat replacements to obtain a low-calorie product and to analyze the physicochemical characteristics of frozen and baked bread dough.

Materials and Methods

Sweet and sour cassava starch (Amafil®), pasteurized full fat milk (Polly-Confepar®), soybean oil (Soya®), dextrin (Cargill®) and gums (Relva Verde®) were used to prepare the cheese bread; the other ingredients were purchased in a local supermarket in Londrina, PR, Brazil. The preparation of the dough followed the steps shown in the production flow diagram (Figure 1).

The treatments consisted of 18 formulations (Table 1). All formulations related to standard (100%) used were 35% sweet starch, 8% sour starch, 10% milk, 16% soybean oil and 12% Minas-type cheese, which included the addition of different gums (0.25%, 0.5% e 0.75%) and the combination of both gums (xanthan gum, guar gum and mixtures of both) and reduced soybean oil (16%) related to the standard. The values of the percentage of gum were added based on the studies of Andrade (2012), and according Brazilian law, maximum 1% addition gum (Brasil, 2010). The experiment was conducted according to a completely randomized design with three replications.

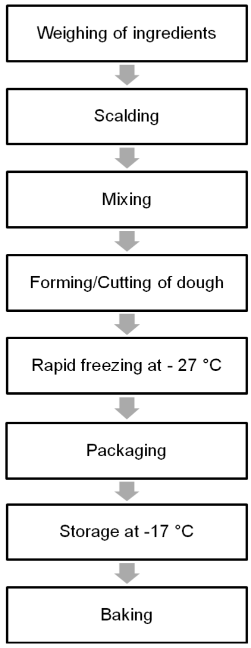

Figure 1. Flowchart of the production of the cheese bread added with different concentrations of guar gum and xanthan gum and with partial fat reduction

Processing of the cheese bread

To obtain the bread dough all the ingredients were first weighed. The sweet and sour starches, water, salt and gum were mixed in an industrial mixer and then scalding was performed at the boiling temperature of milk (65°C – 70°C) with soybean oil. After 15 minutes, the eggs were added, which had their whites and yolks mixed prior to their addition. During 30 minutes of mixing in the blender, the modified starch (dextrin) and the Minas-type cheese were slowly added and mixing continued for a further 3 minutes. The cheese bread dough was cut and placed into molds (circular format, 25 g/bread) using standard industrial equipment and it was then frozen in tunnels in a cold chamber at -27°C for 1 hour. The dough remained frozen for 30 days, after which the physicochemical characteristics of the frozen dough and baked breads were evaluated. The breads were baked at 180°C for 20 min in a preheated electric oven.

Physicochemical characteristics

Moisture

The breads were thawed in an oven with forced air circulation at 65°C for 1 h and then the samples were placed in an oven with air circulation at 105°C for 3 hours and the moisture was determined by weight difference in samples dried to constant weight (IAL, 2008).

pH

Ten grams of sample of the frozen dough and

Table 1. Coding of formulations of cheese bread containing added gums and reduction of partial fat (Soybean oil)

Percentage of gum and fat (Soybean oil) in the formulations	Code of treatment
1. Xanthan gum (0.25%) and -20% S.Oil	X120
2. Xanthan gum (0.5%) and -20% S.Oil	X220
3. Xanthan gum (0.75%) and -20% S.Oil	X320
4. Xanthan gum (0.25%) and - 30% S.Oil	X130
5. Xanthan gum (0.5%) and -30% S.Oil	X230
6. Xanthan gum (0.75%) and -30% S.Oil	X330
7. Guar gum and xanthan gum (0.25%) and -30% S.Oil	GX130
8. Guar gum and xanthan gum (0.5%) and -30% S.Oil	GX230
9. Guar gum and xanthan gum (0.75%) and -30% S.Oil	GX330
10. Xanthan gum (0.25%) and -50% S.Oil	X150
11. Xanthan gum (0.5%) and -50% S.Oil	X250
12. Xanthan gum (0.75%) and -50% S.Oil	X350
13. Xanthan gum (0.25%) and -55% S.Oil	X155
14. Xanthan gum (0.5%) and -55% S.Oil	X255
15. Xanthan gum (0.75%) and -55% S.Oil	X355
16. Guar gum and xanthan gum (0.25%) and -55% S.Oil	GX155
17. Guar gum and xanthan gum (0.5%) and -55% S.Oil	GX255
18. Guar gum and xanthan gum (0.75%) and -55% S.Oil	GX355

baked bread were weighed and diluted with 100 mL of distilled water. The pH was subsequently determined using a previously calibrated pH meter, introducing the electrode into the mixture (IAL, 2008).

Volume

The volume of the frozen and baked cheese bread was measured by the displacement of millet seeds method. In this analysis, millet seeds were placed into a 2 liter plastic container. The volume of the product was calculated from the difference between the fixed volume occupied by millet seeds in the container without the cheese bread, and the volume occupied by the seeds with the cheese bread. The difference was evaluated by placing the seeds in a 500 mL beaker. The specific volume was calculated by the ratio between the volume of baked bread and its weight, which was obtained by using an analytical balance (Machado and Pereira, 2010). The following equation was used:

$$SV = V/m$$

Where: SV = specific volume (mL/g), V = volume of cheese bread (mL), m = mass of cheese bread (g)

Density

The absolute density of the frozen and baked cheese bread was determined by the ratio between the mass (g) and the volume (cm^3).

Statistical analysis

The data were subjected to analysis of variance (ANOVA) by Tukey's test at 5% probability of error using the SISVAR statistical program (Ferreira, 2000).

Results and Discussion

The averages for moisture, pH, volume and density of the samples of frozen cheese bread dough, with different treatments of gum and fat reduction, and the standard, are shown in Table 2. The average moisture for frozen dough and cheese bread when thawed at 65°C was 20%. Table 2 shows that the moisture values of the bread varied in all the treatments and that the samples with higher concentrations of gum had the highest moisture contents. The gums are polysaccharides of linear chain and with residues in side chain, when added in solutions with water and starch retains quickly higher moisture and consequently provide greater moisture and improve the texture of the dough in baked products (Munhoz *et al*., 2004; Santos, 2009). Andrade (2012) studied cheese bread, with added xanthan gum and carrageenan used as stabilizers. He observed that moisture levels increased in line with increases in the concentration of gum, which

Table 2. Average values of moisture, pH, volume and density of frozen cheese bread dough

Sample	Moisture (%)	pH	Volume (mL/g)	Density (g/mL)
Standard	30.71±0.48^{e}	6.49±0.16^{gh}	1.57±0.01^{a}	0.29±0.01^{g}
X120	18.48±0.08^{h}	6.81±0.01^{abcde}	1.57±0.01^{a}	0.3±0.02^{f}
X220	18.53±0.02^{h}	6.79±0.07^{abcde}	1.57±0.01^{a}	0.31±0.01^{e}
X320	19.75±0.07^{h}	6.76±0.00^{abcde}	1.57±0.01^{a}	0.32±0.01^{d}
X130	40.54±0.13^{a}	6.71±0.03^{bcdef}	1.57±0.01^{a}	0.33±0.00^{c}
X230	40.71±0.16^{d}	6.68±0.02^{cdefg}	1.57±0.01^{a}	0.33±0.00^{c}
X330	40.84±0.09^{a}	6.67±0.14^{defg}	1.57±0.01^{a}	0.35±0.00^{a}
GX130	22.15±0.33^{g}	6.92±0.01^{ab}	1.57±0.01^{a}	0.31±0.01^{e}
GX230	23.56±0.73^{f}	6.89±0.01^{ab}	1.57±0.01^{a}	0.31±0.01^{e}
GX330	23.82±0.34^{f}	6.88±0.01^{abc}	1.57±0.01^{a}	0.32±0.01^{d}
X150	34.80±0.55^{cd}	6.52±0.01^{fgh}	1.57±0.01^{a}	0.3±0.01^{f}
X250	36.04±0.31^{bc}	6.52±0.16^{fgh}	1.57±0.01^{a}	0.3±0.02^{f}
X350	36.87±1.17^{b}	6.48±0.00^{gh}	1.57±0.01^{a}	0.33±0.02^{c}
X155	35.85±2.98^{c}	6.68±0.04^{defg}	1.57±0.01^{a}	0.29±0.01^{g}
X255	33.20±0.15^{d}	6.66±0.00^{defg}	1.57±0.01^{a}	0.3±0.01^{f}
X355	33.93±0.56^{d}	6.41±0.05^{h}	1.57±0.01^{a}	0.31±0.02^{e}
GX155	22.24±0.07^{g}	6.93±0.00^{a}	1.57±0.01^{a}	0.3±0.02^{f}
GX255	22.99±0.61^{g}	6.91±0.04^{ab}	1.57±0.01^{a}	0.33±0.01^{c}
GX355	23.50±0.53^{f}	6.88±0.00^{abc}	1.57±0.01^{a}	0.34±0.01^{b}

Treatment of samples: X1: 0.25% xanthan gum; X2: 0.5% xanthan gum; X3: 0.75% xanthan gum; GX1: 0.25% xanthan gum and guar gum; GX2: 0.5% xanthan gum and guar gum; GX3: 0.75% xanthan gum and guar gum. Different lowercase letters in the same column indicate significant differences between samples by Tukey's test at 5%.

was due to the greater presence of hydroxyl in the formulation, which led to water penetration that gave levels of around 40% moisture to the bread.

The addition of xanthan gum to the treatments with 30% and 50% soybean oil reduction showed more moisture than the standard and the other treatments. Xanthan gum promotes the retention of water in gluten-free bread; it imparts improved texture, reduces the syneresis of gel during freezing cycles, extends the shelf life of products, and is mainly used in low-calorie products (Botelho, 2012; Menezes *et al*., 2012). Silva *et al.* (2009) found values of over 40% moisture in frozen cheese bread stored in polyethylene bags at -18°C for 120 days, with increased moisture retention over the period of freezing.

The pH for the cheese bread doughs is presented in Table 2. The pH of the dough with added gums and soybean oil reduction showed a pH that was higher than the standard (6.49), except for the treatments X350 and X355. These results are similar to those found by Silva *et al.* (2009) and Pereira *et al.* (2005), who studied frozen cheese bread dough of supermarket of Minas Gerais, Brazil (values of 5.5 up to 6.46). According to Aplevicz (2006), pH values greater than 6.0 are due to the fact that the product contains a higher concentration of sweet starch; when the product contains the pH values are lower than 6.0 due to the higher acidity, hydrolysis and oxidation of starch performed during the fermentation process for the production of fermented cassava starch or starch modified (Ladeira and Pena, 2011; Machado *et al.*, 2012).

The volume presented by the frozen cheese bread dough (Table 2) for all the treatments was equal to the standard; all the treatments were prepared using the same mold and all the dough was cut using standardized equipment. The density (Table 2) varied in all the treatments for the cheese bread dough. This was due to the fact the density was related to changes in the viscosity and weight conferred by the substitution of fat by macromolecules in the formulations (Esteller and Lannes, 2005; Debiagi *et al*., 2010). All the treatments showed higher density than the standard (0.29 g/mL). There is little information in the literature regarding the density of breads with added gum. Guarda *et al.* (2004) state that the hydrocolloids have a greater ability to

Table 3. Average values of moisture, pH, volume and density in baked cheese bread

Sample	Moisture (%)	pH	Volume (mL/g)	Density (g/mL)
Padrão	18.89±0.93^{f}	6.30±0.00^{i}	3.45±0.02^{a}	0,64±0,02^{b}
X120	20.11±0.04^{cde}	6.55±0.00^{cde}	3.33±0.00^{b}	0.61±0.02^{e}
X220	20.02±0.04^{de}	6.55±0.00^{cde}	3.19±0.00^{bc}	0.61±0.02^{e}
X320	18.90±0.02^{f}	6.52±0.01^{defg}	3.08±0.01^{e}	0.61±0.02^{e}
X130	21.90±0.11^{bcd}	6.49±0.00^{fgh}	3.01±0.00^{e}	0.64±0.00^{b}
X230	20.56±0.19^{bcde}	6.48±0.01^{gh}	3.01±0.00^{e}	0.64±0.00^{b}
X330	20.80±0.20^{bcde}	6.47±0.00^{gh}	2.89±0.01^{g}	0.64±0.02^{b}
GX130	22.12±0.20^{bc}	6.56±0.00^{bcd}	3.20±0.00^{b}	0.65±0.00^{a}
GX230	20.60±0.28^{bcde}	6.55±0.00^{cde}	3.19±0.00^{b}	0.65±0.00^{a}
XG330	20.91±0.13^{bcde}	6.51±0.00^{efg}	3.17±0.00^{d}	0.65±0.01^{a}
X150	21.20±0.08^{bcde}	6.61±0.00^{a}	3.33±0.00^{b}	0.62±0.01^{d}
X250	20.19±0.04^{cde}	6.61±0.00^{a}	3.29±0.00^{b}	0.62±0.01^{d}
X350	19.50±0.28^{ef}	6.59±0.00^{abc}	3.05±0.01^{e}	0.61±0.01^{e}
X155	22.05±0.91^{ab}	6.46±0.00^{h}	3.40±0.01^{a}	0.59±0.01^{f}
X255	24.21±0.36^{a}	6.46±0.00^{h}	3.37±0.01^{a}	0.59±0.01^{f}
X355	22.76±0.13^{ab}	6.30±0.05^{i}	3.26±0.02^{bc}	0.59±0.02^{f}
GX155	21.50±0.55^{bcde}	6.59±0.00^{abc}	3.30±0.00^{b}	0,63±0,01^{c}
GX255	20.81±0.08^{bcde}	6.58±0.00^{abc}	3.00±0.00^{e}	0.63±0.01^{c}
GX355	20.20±0.08^{cde}	6.53±0.00^{def}	2.97±0.01^{f}	0.63±0.01^{c}

Treatment of samples: X1: 0.25% xanthan gum; X2: 0.5% xanthan gum; X3: 0.75% xanthan gum; GX1: 0.25% xanthan gum and guar gum; GX2: 0.5% xanthan gum and guar gum; GX3: 0.75% xanthan gum and guar gum. Different lowercase letters in the same column indicate significant differences between samples by Tukey's test at 5%.

absorb water as stabilizing solutions and they provide greater compression of stabilizers with water, and they increase density.

Dough with high density and low specific volume are negative characteristics in baked products because it is associated with high moisture content, insufficient beating and cooking, insufficient aeration, difficulties in chewing and inappropriate taste (Esteller and Lannes, 2005). The moisture content of the standard sample was lower than the bread with added gum and soybean oil reduction (Table 3). The treatments with the addition of xanthan gum and 55% reduction of soybean oil (X155, X255 and X355) showed greater moisture and volume, as well as lower density and acceptable product characteristics. However, the standard sample still had the greatest volume when compared to the other treatments, indicating that the presence of fat contributes to increased volume due to the greater elasticity conferred to the dough (Pereira *et al*., 2004; Mulser *et al*., 2009). According to Dyminski *et al.* (2000), fat substitutes that are based on carbohydrates incorporate large amounts of water into products. However, although they have similar properties, the use of fat conferred a smaller volume to the bread in the present study.

The specific volume of the breads differed between the treatments. The treatments with xanthan gum had greater volume, as well as better texture, smoothness, firmness and elasticity (Table 3). However, the treatments with guar gum resulted in a differentiated, unacceptable texture, with little elasticity, that were dark, hardened and without standard. The treatments X155 and X255 did not differ from the standard and they had a higher specific volume compared to the other treatments. There was better moisture retention and texture observed in the dough of the formulations with xanthan gum.

Silva *et al.* (2003) studied low-calorie baked cheese breads and found specific volumes close to 3 cm^3/g and density close to 0.5 g/cm^3. Leal *et al.* (2013) compared formulations of cheese bread made with goat and sheep milk to those made with cow milk and observed that the bread made with cow milk showed desirable characteristics of lower density (0.53 g/mL) and higher specific volume (4.59 mL/g), which was directly related to the expansion index and which resulted in more aerated, light and spongy crumbs for the bread dough. These results are similar to the results in the present study relating to the treatments with the added gums and soybean oil reduction.

Increases in volume occur because of the expansion of steam and air during baking and this is an important characteristic in defining the quality of bread. The fat acts as a molecular lubricant and imparts water resistance, which increases the resistance to the outflow of gases and water vapor (Pereira *et al*., 2004; Mulser *et al*., 2009). Other changes that occur at this stage are the coagulation of proteins in the eggs, milk and cheese and the gelatinization of the starch, which develops the flavors and color changes due to the Maillard reaction between the proteins and the reducing sugars on the surface of the bread (Aplevicz, 2006).

Gluten-free dough is unable to retain the gas generated during baking, which results in bread with low specific volume, and firm, rubbery crumbs. The mixture of sour and sweet starch contributes to the expansion of the dough in gluten-free breads, as well as the hydrocolloids, gums and other additives, which increase the viscosity of the dough, improves the gas retaining capacity, prolongs shelf-life, and results in products with greater volume and crumbs with improved structural and textural characteristics (César *et al*., 2006; Capriles and Arêas, 2011).

The addition of gum, and replacing the fat in the cheese bread, produced greater moisture retention, which contributed to volume values that were close to the standard. Gums have high viscosity at low concentrations, and as a stabilizer they are compatible with starches, which make them ideal for preparing breads and other products (Munhoz *et al.*, 2004; Weber *et al*., 2008; Luvielmo and Scamparini, 2009; Botelho, 2012).

The density of the baked bread varied in the different treatments, which showed similar values to the standard; however, they differed from each other. The treatments X155, X255 and X355 differed from the others and presented lower density than the standard. The xanthan gum used to replace the fat provided lower density. Clareto *et al.* (2006) investigated cheese bread with added protein concentrate for the total replacement of fat and observed the same density value compared to the standard. However, they also found that the dough was stiff, the cheese flavor was less pronounced, and the degree of acceptability was lower.

The pH of the baked bread (Table 3) was in the range of 6.0 to 7.0 for all the treatments. The pH was higher for the treatments with added guar gum and xanthan gum compared to the control sample, indicating that different molecular interactions occurred due to the addition of hydrocolloids or other ingredients (Nikaedo *et al*., 2004; Andrade, 2012). Imamura and Madrona (2008) analyzed cheese bread with sweet starch and different concentrations of whey, and they found pH values higher than 6.0 pH, which also contributed to the good physical acceptability of the product.

Conclusion

The addition of xanthan gum, guar gum and the mixture of both gums, together with soybean oil reduction, influenced the physicochemical quality of the frozen and baked cheese bread *(pão de queijo)*. The addition of xanthan gum gave the formulations greater moisture retention and better texture for the frozen bread dough. The treatments with the addition of xanthan gum and 55% reduction of soybean oil (X155, X255 and X355) had greater humidity, density and specific volume for the baked bread, which contributed to the production of bread that was low-calorie due to the reduced fat content.

The dough of the bread with an added mixture of xanthan and guar gums had inferior texture, low elasticity, was dark, hardened and without standard. This study showed that it is possible to develop cheese bread with the partial replacement of fat by gums, which results in low-calorie bread, with similar physicochemical characteristics to standard cheese bread.

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