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# Effects of refrigeration, freezing and replacement of milk fat by inulin and whey protein concentrate on texture profile and sensory acceptance of synbiotic guava mousses

Flávia C.A. Buriti [a], Inar A. Castro [b], Susana M.I. Saad [a,*]

[a] Universidade de São Paulo, Faculdade de Ciências Farmacêuticas, Departamento de Tecnologia Bioquímico-Farmacêutica, Brazil
[b] Universidade de São Paulo, Faculdade de Ciências Farmacêuticas, Departamento de Alimentos e Nutrição Experimental, Brazil

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ABSTRACT

The effects of refrigeration, freezing and substitution of milk fat by inulin and whey protein concentrate (WPC) on the texture and sensory features of synbiotic guava mousses supplemented with the probiotic, *Lactobacillus acidophilus* La-5, and the prebiotic fibre oligofructose, were studied. The frozen storage (−18 ± 1 °C), followed by thawing at 4 °C before the analyses, and the complete replacement of the milk fat by inulin plus WPC, led to significant differences in the instrumental texture parameters of mousses ($P < 0.05$). Nonetheless, these changes did not affect the sensory acceptability of the products studied. The frozen storage may be employed to extend the shelf-life of synbiotic guava mousses. Additionally, to obtain a texture profile similar to the traditional product, the simultaneous addition of inulin and WPC is recommended only for the partial replacement of milk fat in refrigerated and frozen mousses, and the total proportion of both ingredients together should not exceed 2.6%.



## 1. Introduction

A broad range of ready-to-eat dairy desserts is available to the consumer, offering a wide variety of textures, flavours and appearances, and are regarded as attractive vehicles for the incorporation of probiotic cultures and other functional ingredients (Cardarelli, Aragon-Alegro, Alegro, Castro, & Saad, 2008). Nowadays, consumer interest in products that contribute to decreased risks of chronic-degenerative diseases encourages the development of dairy desserts containing functional ingredients, especially those that can also be employed as fat replacers, e.g. the prebiotic fibre inulin and whey protein ingredients isolated from bovine milk (Surh, Ward, & McClements, 2006; Tárrega & Costell, 2006).

Probiotics are live microorganisms that, when administered in adequate amounts, confer a health benefit on the host (FAO/WHO, 2001). Prebiotics are selectively fermented ingredients, that allow specific changes, in both the composition and/or activity of the gastrointestinal microbiota that confer benefits upon host wellbeing and health (Gibson, Probert, Van Loo, Rastall, & Roberfroid, 2004), and can be combined with a probiotic to comprise a synbiotic food product (Buriti, Cardarelli, Filisetti, & Saad, 2007). Inulin-type fructans (inulin and oligofructose) have been the most studied prebiotics (Franck, 2008). Other ingredients, such as whey protein concentrate (WPC), may promote the growth and stability of probiotic bacteria in food products, improving their viability during shelf-life (Akalın, Gönç, Ünal, & Fenderya, 2007).

Amongst the different kinds of dairy desserts, mousses are emerging as interesting food systems in which to study the effects of the incorporation of probiotic cultures and functional ingredients (Aragon-Alegro, Alegro, Cardarelli, Chiu, & Saad, 2007). Nonetheless, the industrial production of mousse is delicate, requiring knowledge about the formation and stabilization of foam, and the use of emulsifiers and stabilizers (Cardarelli, Aragon-Alegro, et al., 2008). In this manner, inulin and whey protein ingredients may contribute to the manufacture of probiotic mousse with low-fat content, due to their excellent properties as texture and foaming agents (Franck, 2008; Herceg, Režek, Lelas, Krešić, & Franetović, 2007). Also, milk-based mousses allow the addition of several flavouring agents and can be stored under both refrigeration and freezing (Buriti, Castro, & Saad, 2010). In Brazil, guava (*Psidium guajava*), a typical fruit of tropical and subtropical regions, seems to be an excellent flavouring agent for dairy desserts, due to its large production and consumption (Zietemann & Roberto, 2007).

Frozen foods have an excellent overall record of safety and illnesses associated with frozen foods are rare (Archer, 2004). Probiotic cultures may present good viability throughout frozen storage,

* Corresponding author. Address: Av. Prof. Lineu Prestes, 580, 05508-000 São Paulo, SP, Brazil. Tel.: +55 11 30912378; fax: +55 11 38156386.
*E-mail address:* susaad@usp.br (S.M.I. Saad).

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as reported for probiotic ice-creams (Cruz, Antunes, Sousa, Faria, & Saad, 2009). Although freezing is used to extend the shelf-life of mousses, the stability of foam may be affected during storage and thawing. A study of texture profile and sensory features might be useful for evaluating such changes, particularly for mousses with reduction and substitution of fat. The present study aimed to verify the effects of refrigeration, freezing and replacement of milk fat by inulin and WPC on the texture profile and sensory features of synbiotic guava mousses containing the probiotic strain, *Lactobacillus acidophilus* La-5, and the prebiotic fibre oligofructose.

## 2. Materials and methods

### 2.1. Experimental design and guava mousse manufacture

Seven pilot-scale guava mousses-making trials were prepared according to Table 1, using a *simplex-centroid* design, for which part of the milk fat from milk cream ($x_1$) or the whole amount of it was replaced by inulin ($x_2$) and/or WPC ($x_3$). Different combinations of the ingredients: commercial sterilised milk cream (25% fat, Nestlé, Araçatuba, Brazil), prebiotic fibre inulin (Beneo® HP-Gel, Orafti, Oreye, Belgium) and WPC (WPC 80, Kienast & Kratschmer, Santo André, Brazil) were used. All trials were performed using the probiotic culture of *L. acidophilus* La-5 (Christian Hansen, Hørsholm, Denmark) and the prebiotic fibre, oligofructose (FOS) (Beneo® P95, Orafti). The proportion of 6% FOS in all trials was chosen, according to the amounts of fructans needed to confer prebiotic benefits (Gibson et al., 2004) and to compose a synbiotic food. The complete list of ingredients used for the production of the different guava mousses and the total solids provided by the sum of all components are described in Table 2.

**Table 1**
Simplex-centroid experimental design employed in the present study.

| Trials | Proportion of each ingredient in the mixture ($x_1$, $x_2$, $x_3$) | Amounts of each ingredient (g) in 100 g of mousse | | |
|---|---|---|---|---|
| | | Milk fat MF ($x_1$) | Inulin I($x_2$) | WPC ($x_3$) |
| MF (control) | (1, 0, 0) | 4 | 0 | 0 |
| I | (0, 1, 0) | 0 | 4 | 0 |
| WPC | (0, 0, 1) | 0 | 0 | 4 |
| MF-I | (½, ½, 0) | 2 | 2 | 0 |
| MF-WPC | (½, 0, ½) | 2 | 0 | 2 |
| I-WPC | (0, ½, ½) | 0 | 2 | 2 |
| MF-I-WPC | (⅓, ⅓, ⅓) | 1.33 | 1.33 | 1.33 |

Guava mousses were produced in batches of 6 kg (for sensory evaluation) and 4 kg (for the other analyses) with commercial skimmed milk (Paulista, Divisão de Beneficiamento da Danone, Guaratinguetá, Brazil, ultra high temperature [UHT]), skimmed powdered milk (Molico, Nestlé, Araçatuba, Brazil), sucrose (União, Coopersucar-União, Limeira, Brazil), pasteurised and frozen guava pulp (*Psidium guajava*; Icefruit-Maisa, Icefruit Comércio de Alimentos, Tatuí, Brazil), lactic acid (85% food-grade solution, Purac Sínteses, Rio de Janeiro, Brazil) and emulsifier (Cremodan® Mousse 30-B, Danisco, Cotia, Brazil).

For the manufacture of mousse, skimmed powdered milk, FOS and WPC (for mousses WPC, MF-WPC, I-WPC and MF-I-WPC) were incorporated previously in the skimmed milk one day before the production, so as to dissolve these powdered ingredients completely, and maintained under refrigeration at 4 ± 1 °C, until mixing with the further ingredients took place. One portion of around 40 ml of this pre-mixture was sterilised and employed on the following day, for the fermentation of the probiotic culture at 37 °C for 150 min. Meanwhile, the further ingredients were mixed and heated during approximately 10 min, in order to achieve 85 °C in a pilot-scale universal mixture machine (Geiger UMMSK-12, Geiger, Pinhais, Brazil). Next, the temperature was reduced to 40 °C for the addition of the enriched fermented milk with the *L. acidophilus* culture. Then, the mass was cooled to 10–15 °C for aeration in a planetary beater (Amadio model 20, Irmãos Amadio, São Paulo, Brazil). In this process, the mass presented an overrun of around 80–85%, as established in a previous study (Buriti et al., 2010). Subsequently, mousses were packaged in appropriate polypropylene plastic pots for food products (68 mm of diameter, 32 mm of height, 55 ml of total volume, Tries Aditivos Plásticos, São Paulo, Brazil) with a manual dispenser (Intelimaq model IQ81-A, Intelimaq Máquinas Inteligentes, São Paulo, Brazil) and sealed with a metallic cover with varnish in a sealer (Delgo Nr. 1968, Delgo Metalúrgica, Cotia, Brazil). Each batch produced was divided into two halves: one half was stored under refrigeration (4 ± 1 °C) during 28 days and the other one was stored whilst freezing (−18 ± 3 °C) for up to 112 days.

### 2.2. Microbiological analysis of mousses

Coliforms and *Escherichia coli*, DNA-se positive *Staphylococcus*, and yeasts and moulds were analysed in triplicate samples during the manufacture process (day 0) and weekly throughout refrigerated and frozen storage (up to 28 and 112 days, respectively). Duplicate samples of mousses, maintained at −18 ± 3 °C, were tested for the presence of *Bacillus cereus* and *Salmonella* spp. once after storage. Except for the investigation of *Salmonella* spp., 25 g

**Table 2**
Ingredients used for the production of the guava mousse trials studied, according to the experimental design described in Table 1, including the total solids provided by the sum of all components.

| Ingredients (%) | Mousses | | | | | | |
|---|---|---|---|---|---|---|---|
| | MF | I | WPC | MF-I | MF-WPC | I-WPC | MF-I-WPC |
| Skimmed milk | 47.25 | 59.25 | 59.25 | 53.25 | 53.25 | 59.25 | 55.25 |
| Sterilised milk cream (25% fat) | 16.00 | 0.00 | 0.00 | 8.00 | 8.00 | 0.00 | 5.33 |
| Inulin | 0.00 | 4.00 | 0.00 | 2.00 | 0.00 | 2.00 | 1.33 |
| WPC | 0.00 | 0.00 | 4.00 | 0.00 | 2.00 | 2.00 | 1.33 |
| FOS | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| Skimmed powdered milk | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Pasteurised and frozen guava pulp | 12.50 | 12.50 | 12.50 | 12.50 | 12.50 | 12.50 | 12.50 |
| Sucrose | 11.00 | 11.00 | 11.00 | 11.00 | 11.00 | 11.00 | 11.00 |
| Emulsifier/stabilizer | 2.80 | 2.80 | 2.80 | 2.80 | 2.80 | 2.80 | 2.80 |
| Lactic acid | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 |
| *Lactobacillus acidophilus* | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| Total solids | 35.10 | 35.10 | 35.10 | 35.10 | 35.10 | 35.10 | 35.10 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |