

Jaboticaba (Myrciaria cauliflora) peel extract increases bioactive compounds in petit-suisse cheese

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Abstract

Food supplementation with natural dyes and extracts has been steadily increasing, and this is done to add value to food products, improve food quality and present technological attractions. The present work aimed to evaluate the effects of adding inulin:oligofructose 1:1 (w/w) and natural dye (0 to 3.0% of *jaboticaba* peel extract) on physicochemical and sensory characteristics of *petit-suisse* cheese during 28 days of storage. It was found that anthocyanins, phenolic contents and antioxidant activity increased with increasing concentrations of *jaboticaba* peel extracts, but anthocyanins content decreased along the storage time. Antioxidant activity remained stable throughout the storage time. All formulations were well accepted by panellists in sensory evaluation. In conclusion, the addition of inulin:oligofructose mixture and a natural dye into *petit-suisse* cheese have been demonstrated to provide an attractive colour to it and did not change its basic characteristics.

Keywords

Myrciaria cauliflora
Anthocyanins
Phenolic compounds
Prebiotics
Cheese
Colour

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Introduction

Petit-suisse is unripened cheese obtained by milk coagulation with rennet and/or specific enzymes and/or specific bacteria. It can also be added with other foodstuffs such as fruits and fruit products. It is a highly moist cheese with abundant viable lactic bacteria (Gambelli *et al.*, 1999; Brasil, 2000, 2001). Prebiotics are compounds in food that support the growth or activity of beneficial microorganisms such as bacteria and fungi. Among the many types of prebiotics is inulin. Inulin has been used in the food industry to replace sugar or fat without increasing the caloric content of food products and act as a dietary fibre (Franck, 2002). Several studies have investigated the effect of adding inulin and/or oligofructose in low-fat products such as milk drinks, yogurts, fresh cheeses, creams, sauces and dairy desserts (Franck, 2002; Akalin *et al.*, 2008; de Castro *et al.*, 2009; Guggisberg *et al.*, 2009; Meyer *et al.*, 2011; Mittal and Bajwa, 2012).

The use of natural dyes in food products has also been extensively studied as the use of synthetic dyes has been increasingly restricted. A good source for natural dye is *jaboticaba (Myrciaria cauliflora)* which is a popular Brazilian fruit with attractive

colouring. This fruit is a major dietary source for polyphenols which are present in higher contents in the peels as compared to the pulps. Polyphenols can have one or more aromatic rings bearing more than one hydroxyl group. These phenolic compounds can be divided into several sub-groups and those commonly found in plants can be categorised as: phenolic acids, flavonoids and non-flavonoids (Zhang and Tsao, 2016). Dietary phenolic compounds can enhance human health by lowering the risk of degenerative diseases such as cancers, cardiovascular diseases and metabolic disorders (Costa *et al.*, 2013; Zhang and Tsao, 2016) besides exerting influence on inflammation and are potent antioxidants. According to Croft (2016), antioxidant activity of polyphenols is given by the phenolic structure and those compounds that have catechol-like moieties and the ability to delocalise unpaired electrons have the strongest activity.

Jaboticaba is a good source for anthocyanins which are bioactive pigments of flavonoid groups featuring remarkable antioxidant, anticarcinogenic and antiviral activities (Zheng and Wang, 2001; Lima *et al.*, 2011; Costa *et al.*, 2013; Wu *et al.*, 2013). *Jaboticaba* peel is commonly discarded as waste, and with the seeds account for approximately 50%

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of the fruit weight. Therefore, the incorporation of *jaboticaba* peel or peel extract in food formulations can add value to both the fruit and the food product thereby reducing waste.

There have been reports on the use of fruit and vegetable-derived pigments in various food products including jams, cookies, ice creams, yogurts and cheeses (Wallace and Giusti, 2008; El-Samahy *et al.*, 2009; Dessimoni-Pinto *et al.*, 2011; Junqueira-Goncalves *et al.*, 2011). Therefore, the present work aimed to incorporate *jaboticaba* peel extract (natural pigment and antioxidant) and prebiotic (inulin:oligofructose) into *petit-suisse* cheese, and measure the physicochemical and sensory characteristics of the produced cheeses throughout storage, as well as the maintenance of the bioactive compounds and their antioxidant activities.

Materials and methods

The *petit-suisse* cheeses were produced using refrigerated raw milk directly provided by farmers; *jaboticaba* peel and sucrose were obtained from the local market (Alegre, Espírito Santo, Brazil); mesophilic lactic starter culture (Choozit MA 16 LYO 125 DCU, Danisco, Brazil), inulin (ORAFTI (Beneo) GR) and oligofructose (ORAFTI (Beneo) P95) were provided by Clariant S. A. (Brazil); red fruit flavouring (TECGEM AA 211 101) were obtained from Gemacom Tech, Brazil); and potassium sorbate was obtained from Vetec (Brazil).

Preparation of *jaboticaba* extract

Jaboticaba fruits were washed, cleaned and peeled. Peels were removed and soaked (1:5, w/v) in 50% ethanol (pH 2.0, adjusted with citric acid) for 12 h at $8 \pm 2^\circ\text{C}$ in the dark. The obtained extract was vacuum-filtered and concentrated in a rotary evaporator under reduced pressure at 38°C until a soluble solid content of 32.5°Brix was reached. The concentrated *jaboticaba* peel extract was immediately stored at $-18 \pm 2^\circ\text{C}$ in a foil-wrapped amber container to prevent light denaturation until incorporation into the cheese. The percent yield of *jaboticaba* concentrated extract was 10%.

Preparation of the *petit-suisse* cheese

Raw milk was pasteurised at 63°C for 30 min. After cooled to $25 - 28^\circ\text{C}$, the lactic starter culture was added and the liquid was allowed to rest for 12 h at $28 \pm 2^\circ\text{C}$. The mass was collected when its acidity reached 52-55 °Dornic. Syneresis took place after 12 h at $8 \pm 2^\circ\text{C}$, and then the ingredients of the formulation (sugar - 5%, inulin:oligofructose 1:1

mixture - 5%, red fruit flavour - 0.08%, potassium sorbate - 0.01%) were added. *Jaboticaba* peel extract was subsequently added at varying percentages. Finally, the cheeses were stored at $8 \pm 2^\circ\text{C}$. The natural dye concentrations used in the present work relied upon previously published studies (Prudencio *et al.*, 2008; Manoharan *et al.*, 2012), as well as preliminary tests in our laboratories. Five *petit-suisse* cheese formulations were studied namely: (i) control cheese (without *jaboticaba* peel extract) and cheeses added with (ii) 1.5%; (iii) 2.0%; (iv) 2.5%; and (v) 3.0% of *jaboticaba* peel extract.

pH

The pH's of *petit-suisse* cheese formulations were determined in accordance with the Analytical Standards of the Adolfo Lutz Institute (1985) by direct insertion of the electrode in sample.

Total anthocyanins

Briefly, 1.5 N ethanol:HCl (85:15 v/v) extraction solution was used at a cheese:solution ratio of 1:4 (v/v). The mixture was then centrifuged (Thermo Scientific Heraeus Megafuge 16R, Waltham, MA, USA) for 40 min at 5,175 g and 11°C (Prudencio *et al.*, 2008). Next, the extracts were filtered and stored in the dark. Total anthocyanins present in *petit-suisse* cheese extracts were quantified by the spectrophotometric method proposed by Francis (1982) at 535 nm (molar extinction coefficient: 26,900 L/mol.cm; molecular weight: 449.2 g/mol). Results were expressed as cyanidin-3-glucoside (mg/g of sample) on wet basis.

Total phenolic contents

The total phenolic contents of the extracts previously prepared during the total anthocyanins measurement was determined by the Folin-Ciocalteu reagent methodology adapted from Singleton and Rossi (1965) through spectrophotometry (Bel Photonics, SP 2000 UV, São Paulo, Brazil). Briefly, 0.6 mL aliquot of the extract was mixed with 3.0 mL Folin-Ciocalteu reagent diluted in distilled water (1:10 v/v). After 3 min incubation in the dark, 2.4 mL saturated Na_2CO_3 solution (7.5% w/v) was added. The absorbance was read at 760 nm in a spectrophotometer after 1 h incubation in the dark. The total phenolic contents were determined using a standard curve of gallic acid (0-150 mg/L), and the results were expressed in mg of gallic acid equivalent per 100 g of sample (mg GAE/100 g) on wet basis.

Antioxidant activity

The anti-free radical activity of the extracts

was determined using the 2,2'-azinobis-(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS reagent) as described by Re *et al.* (1999) with modifications. The radical ABTS^{•+} was prepared by mixing 10 mL 7 mM ABTS and 10 mL 2.45 mM potassium persulphate solution. The mixture was then incubated in the dark for 16 h. The absorbance was corrected to 0.700 at 734 nm using a spectrophotometer with the addition of 80% ethanol (v/v). Afterwards, 3.5 mL ABTS^{•+} was added to 0.5 mL extract, and the spectrophotometric reading was performed after 90 min of reaction. The antioxidant activity was determined using a standard curve of Trolox (0-150 mM), and the results were expressed in Trolox equivalents (mM Trolox/g) on wet basis.

Colourimetry

The colour was analysed by direct reflectance readings of the rectangular coordinate system L* (lightness), a* (red-green intensity) and b* (yellow-blue intensity). The CIELAB colour scale was used to observe the samples in a colorimeter (Konica Minolta, CM-5, Ramsey, NJ, USA), with a D65 illuminant and a 10° angle. The h* (hue angle) and c* (colour saturation) values were calculated using Equations 1 and 2.

$$c * = \sqrt{(a *)^2 + (b *)^2} \quad (1)$$

$$h * = \tan^{-1} b * / a * \quad (2)$$

Dietary fibres

The fibre content was determined through the enzymatic-gravimetric method described by AOAC Official Methods of Analysis (AOAC, 1997). Briefly, defatted sample was submitted to enzymatic hydrolysis, by action of thermoresistant α -amylase and protease, and finally by the addition of the enzyme amyloglucosidase. The residue was filtered and washed successively with ethanol and acetone solutions. After filtration, the residues were dried, and the ash and protein contents determined. For insoluble fibre determination, the enzymatic hydrolysis procedure was conducted, and the soluble fibre was removed from the sample by filtration and washing. The residue was washed using water, 95% ethanol and acetone, dried, weighed, and the ash and protein contents determined. For the determination of the soluble fibres, the filtrate was washed with 78% ethanol, its residues were weighed and the ash and protein contents were determined.

Microbiological analysis

Prior to sensory evaluation, *petit-suisse* cheeses were assessed by the most probable number (MPN) method for coliforms (Downes and Ito, 2001).

Sensory evaluation

Petit-suisse cheese formulations (except for the 0%, control) were subjected to sensory acceptance and buying intention analyses. The acceptance test was divided into two sessions: blind test and test with information about the product. The sensory analysis was carried out in individual booths, under white illumination, with untrained panellists, in two sessions and in different days: 5 and 7 d of storage.

Blind acceptance and buying intention tests

Four *petit-suisse* cheese formulations were used in the first session of the acceptance test (after 5 d of storage). Untrained panellists (potential consumers of the product) received the samples randomly and individually, in 50 mL plastic cups along with disposable spoons and drinking water. Each cup was assigned a 3-digit number. The test was carried out blindly. Panellists were asked to wash their mouth with water between samples which were tested using a structured 9-point hedonic scale ranging from 1 (extremely dislike) to 9 (extremely like) (Reis and Minim, 2010). The colour, flavour, texture and overall impression were assessed. Additionally, the panellists also indicated their buying intention for each formulation using a 5-point scale structured with the following terms: (i) would certainly buy; (ii) would probably buy; (iii) might/might not buy; (iv) would probably not buy; and (v) would certainly not buy.

Acceptance tests with information about the product

The *petit-suisse* cheese formulation that was most accepted by the panellists in the blind test (as indicated by statistical treatment of the data obtained) was further tested after 7 d of storage. The panellists of the two sessions were the same. This sample was evaluated as to buying intention using a 5-point scale as well as to acceptance using the structured 9-point hedonic scale. The same sensory attributed were considered. At this point, the sample was offered to the panellists along with the nutritional information which read "the *petit-suisse* cheese that you are receiving has been prepared with the addition of natural colorant obtained from *jabuticaba* peel which is a good source of pigments and compounds with antioxidant activity. The prebiotics inulin and oligofructose were also added in the cheese. These compounds are dietary fibres that have various

beneficial functions in the body such as enhancing the immune system and improving intestinal function". Then, the panellists were asked to judge the sample taking into account the information provided.

Experimental design and statistical analyses

The experiment was conducted in a split plot, in which different *jaboticaba* extract concentrations (0 – 3%) were the plots and storage time (0 – 28 d) were the subplots. Three repetitions were performed in duplicates, following a completely randomised design. pH, total anthocyanin content, total phenolic content, antioxidant activity and colour were analysed at days 0, 7, 14, 21 and 28. Fibres were quantified, after 28 days of storage, in the cheese that showed the greatest antioxidant activity. Data obtained in the sensory evaluation were analysed using Analysis of Variance (ANOVA) and Tukey's test to compare the mean values. The data acquired at further storage times were analysed using ANOVA and kinetic studies. Statistica software, version 7.0, was used for calculations, whereas the kinetic models were fitted using the SigmaPlot software, version 11.0.

Ethical aspects

The present work has been approved by the Ethics Committee on Human Research of the Centre for Health Sciences, Federal University of Espirito Santo, Brazil (protocol number 282,865, May 2013).

Results and discussion

pH

Figure 1 shows that the higher the *jaboticaba* extract concentration, the lower the pH of the *petit-suisse* cheese. Similar result was found by Alves (2011) when adding *jaboticaba* peel flour into yogurt. This also indicates that the natural dye influenced the pH of the product. This result was expected because the natural dye was in acidic conditions (pH 2.0) prior to their addition to the formulations. This condition was a consequence of the extraction method. Furthermore, the extract might have been used as a substrate by the starter culture. The low pH observed for the *petit-suisse* cheese denotes an important parameter since it assists in the stability of the pigment in a way that maintains the red

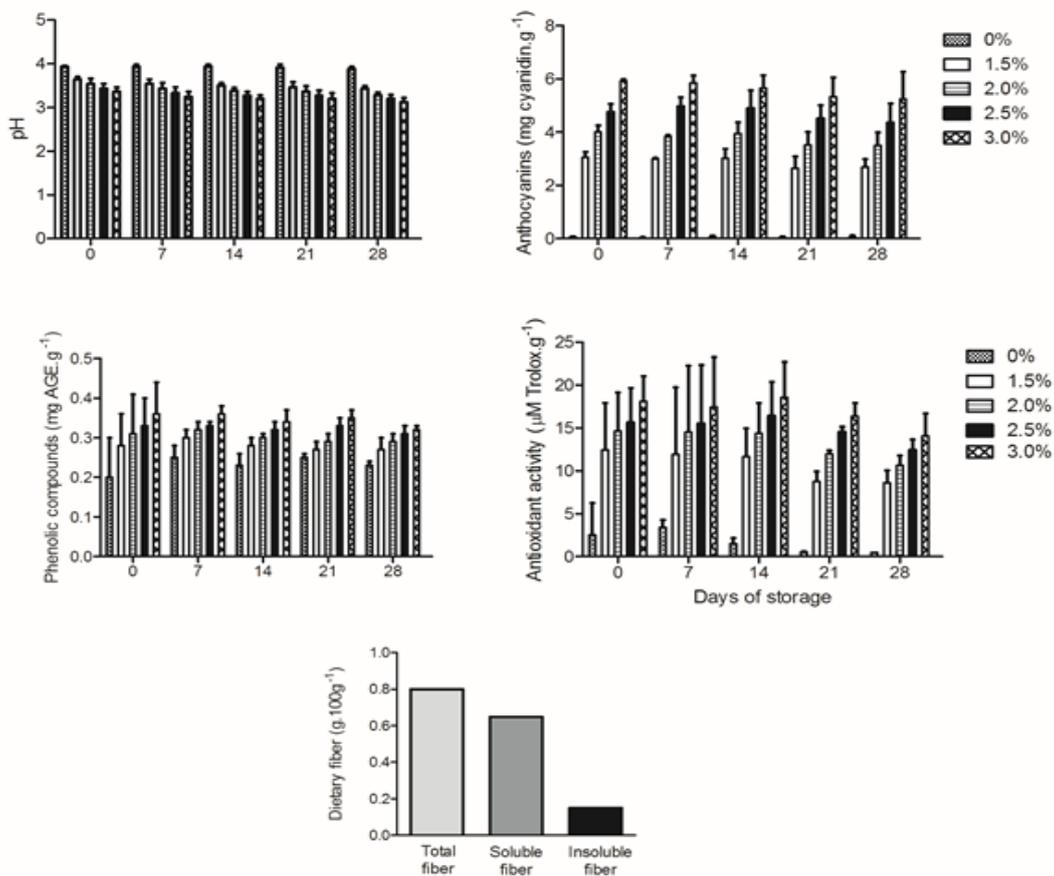


Figure 1. pH, anthocyanin, phenolic contents and antioxidant activity of *petit-suisse* cheeses incorporated with different *jaboticaba* peel extract concentrations at different storage times. Dietary fibres of *petit-suisse* cheese incorporated with 3.0% *jaboticaba* peel extract at 28 days of storage

colour of anthocyanins. In addition, lowering the pH contributes to preservation of the product. It was also noticed that the pH of the *jabuticaba* peel extract-added formulations decreased throughout storage indicating that the content of free H⁺ ions in the samples varied significantly ($p < 0.05$) under the storage conditions. This pH reduction is typical of cheeses because of the natural process involving lactose fermentation by the starter culture which produces lactic and other organic acids. Furthermore, the microorganisms can also metabolise free sugars (i.e., sucrose and oligofructose) contributing to the acidification of the product (Maruyama *et al.*, 2006).

Bioactive compounds

The natural dye-added formulations showed a gradual increase in anthocyanin content depending on extract concentration (Figure 1). The formulation containing 3.0% of *jabuticaba* extract had the highest anthocyanin content (5.92 mg/g). Cyanidin-3-glucoside is the most abundant anthocyanin in *jabuticaba* (Reynertson *et al.*, 2006). The natural dye-added formulations showed decreasing anthocyanin contents throughout the storage period ($p \leq 0.05$) (Table 1). Anthocyanin degradation might have been triggered by the presence of oxygen, temperature, light and interactions with other food components (Yousuf *et al.*, 2016). The total phenolic content was significantly affected ($p \leq 0.05$) by the addition of natural dye. However, it remained stable throughout the storage period ($p > 0.05$) (Table 1) which was also observed by Moraes Filho (2013) in *petit-suisse* cheese. The highest phenolic content was found in the formulation added with 3.0% *jabuticaba* peel extract (0.35 mg GAE/g). *Jabuticaba* peel is naturally rich in phenolic compounds such as tannins, ellagic acid, rutin and quercetin (Einbond *et al.*, 2004; Reynertson *et al.*, 2006, 2008; Abe *et al.*, 2012). When working with the incorporation of acid extracts of fruits, usually the incorporation is done in small concentrations because this addition results in the increase in acidity of the resulting product. Therefore, 3% *jabuticaba* peel extract was chosen so as not to increase too much the acidity of the *petit-suisse* cheese.

The antioxidant activity of a compound is related to its bioactive components, and depends on the chemical structure and concentration of these phytochemicals in food. In the present work, the antioxidant activity increased with increasing extract contents ($p \leq 0.05$) while it was stable throughout storage time ($p > 0.05$) indicating that the product presented the same antioxidant activity from the beginning to the end of the storage period (Table 1).

The highest antioxidant activity (16.91 μ M Trolox/g) was found in the formulation added with 3.0% *jabuticaba* peel extract. The fruit source of the natural dye added to the *petit-suisse* cheeses featured a high antioxidant power which could protect the human body from naturally occurring oxidative processes and also lessen or even inhibit cell damage caused by free radicals. It was expected that the antioxidant activity would decrease over storage time because there was loss of anthocyanins throughout the storage period. However, the contrary was observed. The addition of *jabuticaba* extracts into food might result in the incorporation of other phenolic compounds that also contribute to the antioxidant activity.

Table 1. Linear equations and R^2 of the kinetic models fitted for pH, anthocyanin content, phenolic content and antioxidant activity of *petit-suisse* cheeses at different storage times and *jabuticaba* peel extract concentrations.

	Adjusted model	R^2
pH		
0%	Y=3.92 ^{ns}	-
1.5%	Y=3.3728+0.2660e ^{-0.05523 t}	0.9987*
2.0%	Y=3.2007+0.3336e ^{-0.04392 t}	0.9686*
2.5%	Y=3.1760+0.2546e ^{-0.06397 t}	0.9626*
3.0%	Y=3.1112+0.2421e ^{-0.07242 t}	0.9324*
Anthocyanin		
0%	Y=0.05 ^{ns}	-
1.5%	Y=3.0967-0.0155 t	0.7555*
2.0%	Y=4.0200-0.0187 t	0.7856*
2.5%	Y=4.9427-0.0179 t	0.5791*
3.0%	Y=5.9720-0.0266 t	0.9535*
Phenolic compound		
0%	Y=0.23 ^{ns}	-
1.5%	Y=0.28 ^{ns}	-
2.0%	Y=0.30 ^{ns}	-
2.5%	Y=0.32 ^{ns}	-
3.0%	Y=0.35 ^{ns}	-
Antioxidant activity		
0%	Y=1.68 ^{ns}	-
1.5%	Y=10.69 ^{ns}	-
2.0%	Y=13.23 ^{ns}	-
2.5%	Y=14.91 ^{ns}	-
3.0%	Y=16.91 ^{ns}	-

t = time of storage (days); *significant at $p < 0.05$; ns: not significant.

Colorimetric parameters

In the formulations added with *jabuticaba* peel extract, increased dye contents led to decreased L* values as a result of its red colouration (Figure 2). In addition, L* of the natural dye-added formulations changed slightly during the storage time ($p \leq$

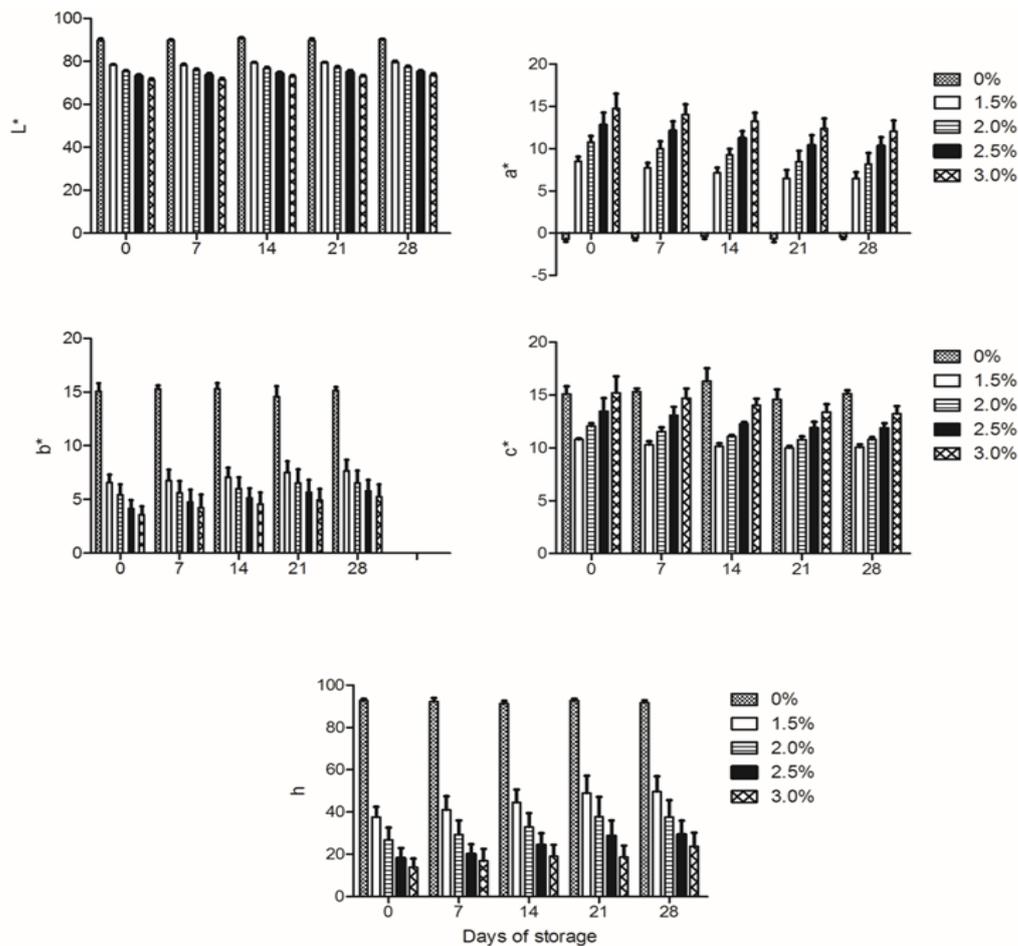


Figure 2. Colorimetric parameters of *petit-suisse* cheeses incorporated with different *jabuticaba* peel extract concentrations at different storage times.

0.05) possibly because of the degradation of some compounds (Table 2). According to the kinetic models adjusted to the variable L^* , it can be seen that there was a slight increment, but statistically significant, in the response L^* related to storage time. Natural dye-free formulation presented a constant ($p > 0.05$) a^* (mean: -0.56) value throughout the storage period (Figure 2 and Table 2). In the other formulations, time had a negative interference in colour intensity, leading to a reduced a^* ($p \leq 0.05$). This might be attributed to the correlation that a^* had with anthocyanins ($r = 0.9861$; $p \leq 0.05$) which in turn could explain the degradation of pigments during storage. Furthermore, the higher the natural dye concentration added, the greater the intensity of the red colour in the formulated *petit-suisse* cheeses. All formulations showed positive b^* values indicating the yellowish colouration of the product. As previously mentioned, the measured b^* values might have been influenced by the original colour of the cheese regardless of the addition of the natural dye. This parameter was stable over time for natural dye-free formulation, but significantly increased during storage in other formulations ($p \leq 0.05$). Chromaticity or colour saturation (c^*) is related to the visual sensation of "colour quantity",

and indicates the colour intensity or purity when compared to white (Montes *et al.*, 2005). The formulation that was not added with *jabuticaba* peel extract showed no significant difference ($p > 0.05$) in colour saturation values during storage. For the other formulations, c^* decreased throughout the storage time and reduced natural dye concentration ($p \leq 0.05$) (Figure 2 and Table 2). Hue angle (h^*) falls within the red-yellow range (0 - 90°). The natural dye-free formulation remained closer to yellow, and increasing *jabuticaba* peel extract contents resulted in h^* values closer to red.

Dietary fibres

The formulation that presented the highest antioxidant activity was characterised as to the content of dietary fibres (soluble and insoluble).

One hundred grams *petit-suisse* cheese formulation incorporated with 3.0% *jabuticaba* peel extract and 5.0% of inulin:oligofructose 1:1 (w/w) mixture yielded 0.80 g total dietary fibre and 0.65 g soluble dietary fiber (Figure 1) at a storage period of 28 days. Therefore, it is not possible to claim functional properties for this product because it did not overcome the minimum threshold to be

considered a functional product (at least 3 g dietary fibres or 3 g inulin) (Brasil, 2008).

Table 2. Linear equations and R^2 of the kinetic models fitted for colorimetric parameters of *petit-suisse* cheeses at different storage times and *jabuticaba* peel extract concentrations.

	Adjusted model	R^2
L*		
0%	Y=90.05 ^{ns}	-
1.5%	Y=78.2393+0.0526 t	0.8538*
2.0%	Y=75.5713+0.0667 t	0.9427*
2.5%	Y=73.2707+0.0747 t	0.9109*
3.0%	Y=71.1653+0.0860 t	0.9117*
a*		
0%	Y=-0.56 ^{ns}	-
1.5%	Y=5.7018+2.8329e ^{-0.05084 t}	0.9869*
2.0%	Y=5.1790+5.6062e ^{-0.02319 t}	0.9918*
2.5%	Y=8.3056+4.5637e ^{-0.03136 t}	0.9765*
3.0%	Y=8.0158+6.7946e ^{-0.01908 t}	0.9901*
b*		
0%	Y=15.09 ^{ns}	-
1.5%	Y=6.5333+0.0420 t	0.9729*
2.0%	Y=5.4020+0.0449 t	0.9495*
2.5%	Y=4.2593+0.0599 t	0.9622*
3.0%	Y=3.7000+0.0581 t	0.9781*
c*		
0%	Y=15.31 ^{ns}	-
1.5%	Y=10.0422+0.7468e ^{-0.15179 t}	0.9840*
2.0%	Y=10.5372+1.5661e ^{-0.07262 t}	0.9839*
2.5%	Y=11.1549+2.3951e ^{-0.04697 t}	0.9560*
3.0%	Y=10.7458+4.5281e ^{-0.02267 t}	0.9813*
h*		
0%	Y=92.15 ^{ns}	-
1.5%	Y=38.0360+0.4568 t	0.9674*
2.0%	Y=26.9580+0.4277 t	0.9426*
2.5%	Y=18.0167+0.4424 t	0.9602*
3.0%	Y=14.1793+0.3060 t	0.8870*

t = time of storage (days); *significant at $p < 0.05$; ns: not significant.

The supplementation with prebiotics was initially considered sufficient to meet the Brazilian legislation criteria for claiming functional properties. Fibres might have been lost when the storage period ended. It is noteworthy that the *jabuticaba* extract experienced an acidic condition from the beginning and pH dropped even more during storage ($p \leq 0.05$). Probably, the greater acidification of the medium might have contributed to the possible depolymerisation of fructan chains (Leonel *et al.*, 2006). In extremely acidic conditions (pH<4), the $\beta(2-1)$ bonds between fructose units can be partially hydrolysed after storage, possibly leading to losses of physicochemical and functional properties (Charalampopoulos and Rastall, 2012). A way of overcoming the hurdle of incorporating these prebiotics into new products of acidic nature (e.g., extracts containing natural pigments) is to incorporate them in greater proportions so that the product can achieve the threshold of functional property throughout its shelf life.

Microbiological analysis

All the formulations were of satisfactory sanitary conditions ($< 5.0 \times 10^3$ thermotolerant coliform per gram of cheeses of very high moisture content; Brasil, 2001). All the formulations presented counts of < 3.0 MPN per gram for coliforms.

Sensory evaluation

The *petit-suisse* cheeses were submitted to two sessions of sensory evaluation, blind test and test with information about the product. The first session involved the participation of 100 untrained panellists, 64 women and 36 men, aged between 20 – 40 years, with most of them were students and staff from the Federal University of Espírito Santo, Brazil. The overall duration of the sensory analysis was about two hours. Colour was the only attribute that showed a significant difference ($p < 0.05$) between the tested formulations (Table 3). The formulations added with 2.5% and 3.0% *jabuticaba* peel extract presented the highest hedonic averages for colour, possibly due

Table 3. Average scores for the sensory attributes and buying intention of *petit-suisse* cheese formulations incorporated with different *jabuticaba* peel extract concentrations.

Sample	Colour	Flavour	Consistency	Overall impression	Buy intention
1.5%*	5.7 ^a	6.6 ^a	7.1 ^a	6.6 ^a	3.3 ^a
2.0%*	6.8 ^b	6.4 ^a	7.1 ^a	6.5 ^a	3.4 ^a
2.5%*	7.4 ^c	6.2 ^a	7.0 ^a	6.6 ^a	3.4 ^a
3.0%*	7.8 ^{cA}	6.1 ^{aA}	7.3 ^{aA}	6.7 ^{aA}	3.3 ^{aA}
3.0%**	8.3 ^B	6.5 ^A	7.7 ^B	7.1 ^A	3.5 ^A

*Acceptance blind test. **Acceptance test with information. Means followed by at least the same lower case or upper case do not differ by Tukey's test at 5% of probability ($p > 0.05$).

to visual similarity to the commercial *petit-suisse* cheese. Colour fell within the hedonic terms "like moderately" and "like very much". The averages scores for flavour, texture and overall impression fell between the terms "like slightly" and "like very much".

To verify whether the acceptance and buying intention of *petit-suisse* cheese were improved after nutritional information was provided; the formulation containing 3.0% *jabuticaba* peel extract was used in the second sensory session. This session involved 85 panellists, 64 women and 21 men, aged between 20 – 40 years. Colour and texture were the only attributes whose acceptance was modified after providing information regarding the product (Table 3). These attributes had a higher acceptance ($p < 0.05$) in the second session (information provided) than in the first one (blind test). This might be due to the fact that the panellists had associated the addition of *jabuticaba* peel extract with a value-added product, and thus considering the colour more attractive because of the natural source of pigments. Regarding texture, the panellists might have associated the product with the informed addition of dietary fibres, indicating that they observed improved texture as soon as they were told the ingredients used in the formulation. The *petit-suisse* formulation containing 3.0% *jabuticaba* peel extract, when submitted to the analysis of buy intention, was classified between "might/might not buy" and "would probably buy" (scores varying from 3.3 – 3.5, Table 3). Based on this result, a valuable recommendation for future studies is to make some improvements in the formulation of the product, in order to reach best scores for the buying intention.

Conclusion

The incorporation of *jabuticaba* peel extract into *petit-suisse* cheese was efficient, since both the bioactive compounds and the antioxidant activity were maintained throughout the storage period assessed. Also, the *jabuticaba* peel extract provided a reddish colouring that is typical of the natural dye anthocyanin, and the formulation added with 3.0% *jabuticaba* extract presented the best antioxidant activity and sensory outcomes. Relying upon the data obtained in the present work, one might conclude that the use of extracts from natural sources for food colouring purposes is potentially beneficial and also contributes to consumers' health due to their high antioxidant capacities. Furthermore, the use of peel is regarded as an important contribution to lessen the agricultural waste and to achieve the maximum utilisation of *jabuticaba*.

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Conflict of interest

Authors declare no conflict of interest.

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