Feasibility of utilising ricotta cheese whey in chocolate ice cream

Viabilidade de utilização do soro de queijo ricota em sorvete de chocolate

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ABSTRACT
The purpose of this study was to evaluate the feasibility of the application of Ricotta Cheese Whey (RCW) in ice creams by assessing the impact of this addition on different quality factors. Five samples of chocolate ice cream were developed with a difference between the formulations only regarding the proportion of RCW (25, 50, 75, and 100% (w/w)) in the ice cream mix. The sample developed only with whole milk (WM) was also analysed. The ice creams were subjected to several proximate composition, physico-chemical properties, microbiological quality, and sensory analysis. The results showed that the increase in the level of RCW caused a decrease in the nutrient content and that their application in ice cream significantly reduced the fat content. A small change in the texture and instrumental colour of the ice cream, which indicated more hardness and greater colour intensity, did not negatively affect the sensory tests. In addition, the experimental ice creams showed greater resistance to melting (no desorption signals) when incorporating RCW in the ice cream. In the acceptance test, samples developed with RCW obtained averages 7.06 (out of max. 9.00) for general taste and most consumers said they would buy the products. The importance of consuming low-fat products and preserving the environment is not a recent concern, and the use of RCW in ice cream proved to be a suitable alternative with a positive contribution to the economy, industry, consumers, and the environment.

Key words: low fat, ricotta cheese whey, environment, use, ice cream.

RESUMO
O objetivo deste estudo foi avaliar a viabilidade da aplicação de Ricotta Cheese Whey (RCW) em sorvetes, avaliando o impacto dessa adição sobre diferentes fatores de qualidade. Foram desenvolvidas cinco amostras de sorvete de chocolate com diferença entre as formulações apenas quanto à proporção de RCW (25, 50, 75 e 100% (p / p)) na mistura de sorvete. A amostra desenvolvida apenas com leite integral (WM) também foi analisada. Os sorvetes foram submetidos a diversas composições centesimal, propriedades físico-químicas, qualidade microbiológica e análises sensoriais. Os resultados mostraram que o aumento no nível de RCW ocasionou diminuição no teor de nutrientes e que sua aplicação em sorvetes reduziu significativamente o teor de gordura. Uma pequena alteração na textura e cor instrumental do sorvete, que indicou mais dureza e maior intensidade de cor, não afetou negativamente os testes sensoriais. Além disso, os sorvetes experimentais mostraram maior resistência ao derretimento (sem sinais de dessorção) ao incorporar RCW no sorvete. No teste de aceitação, as amostras desenvolvidas com RCW obtiveram médias de 7,06 (de no máximo 9,00) para o sabor geral e a maioria dos consumidores disse que compraria os produtos. A importância do consumo de produtos com baixo teor de gordura e preservação do meio ambiente não é uma preocupação recente, e o uso do RCW em sorvetes mostrou-se uma alternativa adequada com contribuição positiva para economia, indústria, consumidores e meio ambiente.

Palavras-chave: baixo teor de gordura, soro de queijo ricota, meio ambiente, uso, sorvete.

1 INTRODUCTION

Dairy production generates large quantities of effluent with high organic load, and can create serious environmental problems if not used or treated correctly (Gonzalez Siso,1996; Rivas *et al*., 2010; Janczukowicz *et al*., 2008). Considering the nutritional and technological potential, the use of dairy by-products can have a positive impact not only on consumer health, but also on the economy of many companies, reducing raw material costs and thus, reducing the production costs of several other processed food products, such as ice creams (Sansonetti *et al*., 2009; Singh and Singh, 2012; Božanić *et al*., 2014).

The uses of cheese whey in the food industry include meat and meat products, reduced-fat products, yoghurts and ice creams, cheeses, bakery products, confectionery and pastry products, infant formulas, and whey drinks (Królczyk *et al*., 2016). It is known that Ricotta Cheese Whey (RCW), "scotta", has a high content of lactose, acidity and pleasant taste, and appears as the main by-product of ricotta cheese manufacturing process (Sansonetti *et al*., 2009). Nevertheless, it is considered highly pollutant, characterized by BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) values of 50 $g.L^{-1}$ and 80 $g.L^{-1}$, respectively. Since RCW is a dairy by-product, it is required to have an appropriate and expensive treatment that most dairy industries are not willing to pay (Marwaha and Kennedy, 1988; Sansonetti *et al*., 2009). Therefore, its use is economically interesting because it has a lower cost than the treatment itself.

Ice cream is a frozen dessert consumed worldwide by groups of all ages and cheese whey is the most widely used dairy by-product in its production in any form (i.e. whey powder, and whey protein hydrolyzed, concentrated, isolated, etc.) (Parsons *et al*., 1985; Haque and Ji, 2003; Rodríguez and M´Boumba, 2011). However, other interesting dairy by-products are not well exploited, for example RCW (Young, 2007; Jasińska *et al*., 2012, Balthazar *et al*., 2017).

Taking into consideration that any modifications in the composition of ice creams can result in changes in their main characteristics (colour, appearance, flavour, texture, melting, etc), which are key factors to their success, the present study intends to investigate the feasibility of the use of ricotta cheese whey in ice creams, observing the behaviour of its application in various quality parameters for this type of product.

2 Materials and Methods

2.1 INGREDIENTS

The ricotta cheese whey (RCW) was obtained from ricotta production of an agro-industry located at the Federal Institute of Alagoas (Satuba/AL/Brazil). The samples were sent frozen in thermal boxes for up to 12 hours to the Food Technology Laboratory (FTL) of the School of Pharmacy at the Federal University of Bahia (Salvador/BA/Brazil). Regarding the other ingredients used in ice cream production (Table I), the acquisition took place in a local market in Salvador/BA/Brazil.

Table I
Formulations and their respective chocolate ice cream codes.

INGREDIENTS (%)	***RCW*** 0%	***RCW*** 25%	***RCW*** 50%	***RCW*** 75%	***RCW*** 100%
	0RCW	25RCW	50RCW	25RCW	100RCW
Whole milk (Italac®)	58.14	43.61	29.07	14.53	---
Ricotta cheese whey (RCW)	---	14.53	29.07	43.61	58.14
Sucrose (DA BARRA®)	17.44	17.44	17.44	17.44	17.44
Cream (Nestlé®) (17% fat content)	11.63	11.63	11.63	11.63	11.63
Stabiliser/Thickener (Selecta®)	0.58	0.58	0.58	0.58	0.58
Emulsifier (Selecta®)	0.58	0.58	0.58	0.58	0.58
100% alkalised cocoa powder (Nestlé®)	11.63	11.63	11.63	11.63	11.63

2.2 FORMULATION, PROCESSING AND STORAGE OF ICE CREAMS

Chocolate ice creams were prepared at the FTL of the School of Pharmacy at the Federal University of Bahia (Salvador/BA/Brazil). Table I summarises the five formulations developed in this study differing only by the absence and different proportions of RCW. The ice cream mix preparation process was carried out as follows: homogenisation of the mixtures – mix (single stage at controlled temperature of 25 ± 2 °C and ambient pressure), pasteurisation (80 °C for 30 seconds), maturation (4 °C for 12 hours), and chilling/freezing (single stage at -10 ºC and ambient pressure) in suitable equipment (Cuisinart® ICE-100, USA) for 30-40 minutes, until reaching consistency. The distribution was made in 250 mL polypropylene containers (PRAFESTA®) and stored at -18 °C until analysis. Three batches of formulations were prepared on different days and the ice cream samples were collected for triplicate analysis.

2.3 PHYSICOCHEMICAL ANALYSES

The fat content of ice cream was determined by the Bligh and Dyer method (Bligh and Dyer, 1959), while moisture, ash, and proteins by the Association of Official Analytical Chemists method (AOAC, 1995). Carbohydrates (Nifext fraction) were obtained by the difference between the mentioned elements, and the energy content of these nutrients was calculated from the Atwater coefficient of proteins ($4kcal.g^{-1}$), fat ($9kcal.g^{-1}$), and carbohydrates ($4kcal.g^{-1}$) (FAO, 2003).

2.4 ACIDITY AND PH

The acidity was expressed as % lactic acid measured by titration (0.1N NaOH) (AOAC, 1995). Using a previously calibrated digital pH-meter (model DM-23 Digimed; Digicrom Analítica Ltda. - Brazil), the pH was measured directly at controlled temperature of 25 ± 2 °C.

2.5 MELTING RESISTENCE

The melting behaviour of ice creams was determined according to the method described by Prindiville *et al.* (2000) with some modifications. Approximately 40g/50mL of the ice cream samples were carefully removed from the freezer (-18 °C) and quickly placed on a wire mesh ($1cm^2$ in each bore) at a set-controlled temperature (25 ± 1 °C). A graduated cylinder with a funnel was placed under the mesh to collect the melted ice cream and the dropping weight was measured every 5 minutes for 60 minutes. The melting rates were determined based on the linear regression coefficient of the recorded weights of each ice cream sample versus time.

2.6 DESORPTION RESISTANCE

After melting, the ice cream samples were checked to assess the appearance of desorption. In case the melted ice cream exhibited whey, such melted portion was transferred to the separation funnel and the whey fractions of the samples were weighed.

2.7 OVERRUN

Ice cream overrun was determined by the method described by Alamprese *et al*. (2002) with some modifications, following the equation:

$$\text{Overrun (\%)} = 100 \times (\text{ice cream volume} - \text{mix volume}) \times (\text{mix volume})^{-1}.$$

2.8 INSTRUMENTAL COLOUR

The instrumental colour measurement of the samples was determined by Minolta colourimeter (Chroma Meter, CR-400 - Japan), properly calibrated, measuring L* (brightness), a* (transition from green -a* to red +a*), and b* (transition from blue -b* to yellow +b*). The light source for the colourimeter was the standard daytime light (C) and the standard observer was 2°.

2.9 TEXTURE PROFILE ANALYSIS (TPA)

TPA (hardness) was measured using a TA.XT Express texture analyser (Stable Micro System, UK) and Software Exponent to determine hardness (maximum force during penetration (N)). The penetration of each ice cream sample (in 250 mL polypropylene containers (PRAFESTA®)), which was immediately removed from the freezer (kept for 24 hours at -18 °C) and placed in the centre of the equipment metal base, followed the similar method of El-Nagar *et al*. (2002): penetration distance = 25mm, force = 0.1N, and probe velocity pre-penetration, during, and post penetration = 1mm/s. The analysis was carried out at controlled temperature (18 ± 2 °C) and penetrations were made by a P/6 stainless steel cylindrical probe attached to a 10kg load cell.

2.10 MICROBIOLOGICAL QUALITY

The methodology described by Silva *et al.* (2007) was used to evaluate the microbiological quality of ice creams that had the norms established by Resolution 12/2001 of the National Health Surveillance Agency (Brasil, 2001) as parameters.

2.11 CONSUMER TESTS

To comply with the principles of ethics in research with human beings, the project was approved by the Research Ethics Committee of the University Hospital Clementino Fraga Filho (CAAE 77418117.7.0000.5257). A free, prior, and informed consent form was used for the agreement of participation and application of the questionnaire.

The degree of product acceptance was assessed using a form with a nine point hedonic scale (1 = extremely disliked to 9 = extremely liked), with the participation of 50 untrained testers who evaluated the following attributes: appearance, aroma, flavour, texture, and overall liking. The testers also indicated their purchase intention using a five point hedonic scale (1 = certainly would not buy to 5 = certainly would buy).

2.12 STATISTICAL TREATMENT

Statistica 7.0 software (StatSoft - USA) was used for statistical analysis in conjunction with the one-way analysis of variance (One-way Anova) and Tuckey HSD test, with a significance level of 0.05 to define the difference between the means.

3 RESULTS AND DISCUSSION

3.1 PHYSICOCHEMICAL CHARACTERISTICS

The proximate composition of whole milk, RCW, ice cream formulations are presented in Table II. RCW presented higher moisture value than whole milk, different from the other nutrients (ash, lipids, proteins, carbohydrates) and energy value, which were all lower. There is little information on the composition of RCW, but the results of the present study were very close to those reported by other authors who also characterized this dairy by-product (Sansonetti *et al.*, 2009).

Table II
Chemical composition, caloric value, pH, and acidity of RCW, milk, and ice cream formulations.

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein(s) (%)	Carbohydrates (%)	Energy (Kcal/100g)	pH	Acidity (% Lactic acid)
RCW[X]	94.47±0.31^{a}	0.48±0.03^{b}	0.02±0.00^{b}	0.51±0.04^{b}	4.51±0.17^{b}	20.26±1.36^{b}	4.41±0.07^{b}	0.52±0.01^{a}
WM[Y]	84.80±0.55^{b}	0.95±0.04^{a}	3.15±0.21^{a}	3.28±0.00^{a}	7.83±0.32^{a}	72.79±1.44^{a}	6.62±0.06^{a}	0.19±0.01^{b}
Ice Cream Formulations								
0RCW	63.03±0.44^{e}	1.40±0.01^{a}	4.48±0.27^{a}	3.71±0.08^{a}	27.38±0.30^{a}	164.68±2.64^{a}	6.40±0.06^{a}	0.41±0.05^{e}
25RCW	64.37±0.27^{d}	1.35±0.02^{b}	3.45±0.07^{b}	3.62±0.00^{b}	27.21±0.05^{a}	154.41±1.34^{b}	6.03±0.01^{b}	0.58±0.02^{d}
50RCW	65.67±0.15^{c}	1.32±0.00^{c}	2.79±0.16^{c}	3.25±0.16^{c}	26.97±0.11^{b}	145.99±0.80^{c}	5.76±0.01^{c}	0.65±0.04^{c}
75RCW	66.90±0.76^{b}	1.30±0.02^{c}	2.55±0.01^{d}	2.75±0.00^{d}	26.50±0.28^{c}	139.91±3.25^{d}	5.51±0.01^{d}	0.78±0.02^{b}
100RCW	68.46±0.31^{a}	1.22±0.05^{d}	2.51±0.02^{e}	2.63±0.13^{e}	25.18±0.23^{d}	133.83±1.28^{e}	5.21±0.11^{e}	0.95±0.04^{a}

*Data are presented as mean± SD and analysed with one-way analysis of variance. Different letters in the same column indicate a statistical difference ($p < 0.05$) among different samples using the Tukey test.
[X] Ricotta Cheese Whey.
[Y] Whole Milk.

Following the behaviour mentioned before, and based on the difference from the 0RCW sample values, it is observed that the addition of RCW can significantly influence the nutritional composition of the ice cream, increasing moisture (between 2.13 and 8.61%) and reducing ash (between 3.57 and 12.86%), lipids (between 22.99 and 43.97%), proteins (between 1.08 and 29.11%), carbohydrates (between 0.77 and 8.03%), and energy value (between 6.24 and 18.73 %) (Table II). The chocolate ice creams showed % Total Solids (%TS) from 31.54% (100RCW) to 36.97% (0RCW), difference of about 5%TS, and % Solids-Non-Fat (%SNF) from 29.03% (100RCW) to 32.49% (100RCW), difference of about 3%SNF. However, the most apparent change was the composition of lipids, allowing to classify the developed samples from 50RCW as "light" by the standards established by the International Dairy Food Association (IDFA), since it presented a reduction of more than 25% fat in comparison with the ice cream prepared utilising solely milk. This particular situation is interesting in providing health benefits related to the intake of low-fat foods. The success of lipid fraction reduction was also observed in the study by Rodrigues *et al.* (2006), where by-products of dairy products were added to ice cream.

Moisture in the present study ranged from 63.03% to 68.46%, which coincides with most of the results found by different authors who analysed milk-based ice cream: Bery *et al.* (2014) with 54%; Boff (2013) with 63 to 70%, and Rodrigues *et al*. (2006) with 55 to 59%. The average values of ash content in chocolate ice cream found in the present study are in line with those in the literature for that same flavour, as Bery *et al.* (2014) with 1.17%, Rodrigues *et al.* (2006) with 1.27%, and Boff (2013) with 1.24%.

In Brazil, ice cream should contain minimum of 2.5% protein (Brasil, 1999) and a difference (84.45%) between the values of proteins in the ice cream prepared using RCW and whole milk was observed (Table II), which is due to the fact that this dairy by-product is obtained from a technological process (cheese production with a high concentration of proteins), naturally reflecting a lower protein content, despite the difference between the means of % proteins obtained in the ice cream being much lower. Similar values for carbohydrates were found by Piati *et al.* (2015) (20.06%) and Boff (2013) (22.38%) in chocolate ice creams.

3.2 ACIDITY AND PH

According to the results presented in Table II, the lower pH value and higher acidity of the ice cream prepared using RCW compared to that prepared using whole milk explain the decreasing behaviour of the pH values and increase of acid values of the ice cream as RCW was added. It is interesting to note that the difference in pH values and acidity did not change much as RCW was added into the ice creams. The low pH of RCW is due to the processing of ricotta, obtained by acid and thermal action, which consequently generates several acidic compounds such as lactic acid, fatty acids, etc (Sansonetti *et al*., 2009).

RCW was more acidic (mean of pH: 4.41) than the mean presented by Bald *et al*. (2014) (5.44) and Lavari *et al.* (2014) (5.67) for the same raw material. This variation might be associated to the different types and proportions of cheese whey and acid used in the production of ricotta, which implies different pH (Sansonetti *et al*., 2009). According to the reports by Rodrigues *et al.* (2006) and the present study, the pH values of whole milk were close to neutrality, in agreement with the current legislation for milks (Brasil, 1997).

The pH values of ice creams are generally around 6.3, but pH and acidity are parameters that can be influenced by the composition of the mixture, such as the addition of ingredients (fruits, cocoa, etc.) into the formulation and the use of milk from different origins (Arbuckle *et al*., 1986; Correia *et al*., 2008). Additionally, alkalised or non-alkalised cocoa powder can also affect the pH of ice cream system. In this study, the pH values and acidity for ice creams were similar to the ones mentioned above and to other studies with chocolate ice cream (Rodrigues *et al*., 2006; Bery *et al*., 2014).

3.3 MELTING RESISTANCE

A good ice cream is expected to present a moderate melting resistance so that during ice cream consumption the solid frozen state is maintained for a reasonable period (Bodyfelt *et al*., 1988; Waltra and Jonkman, 1998; Marshall, 2003).

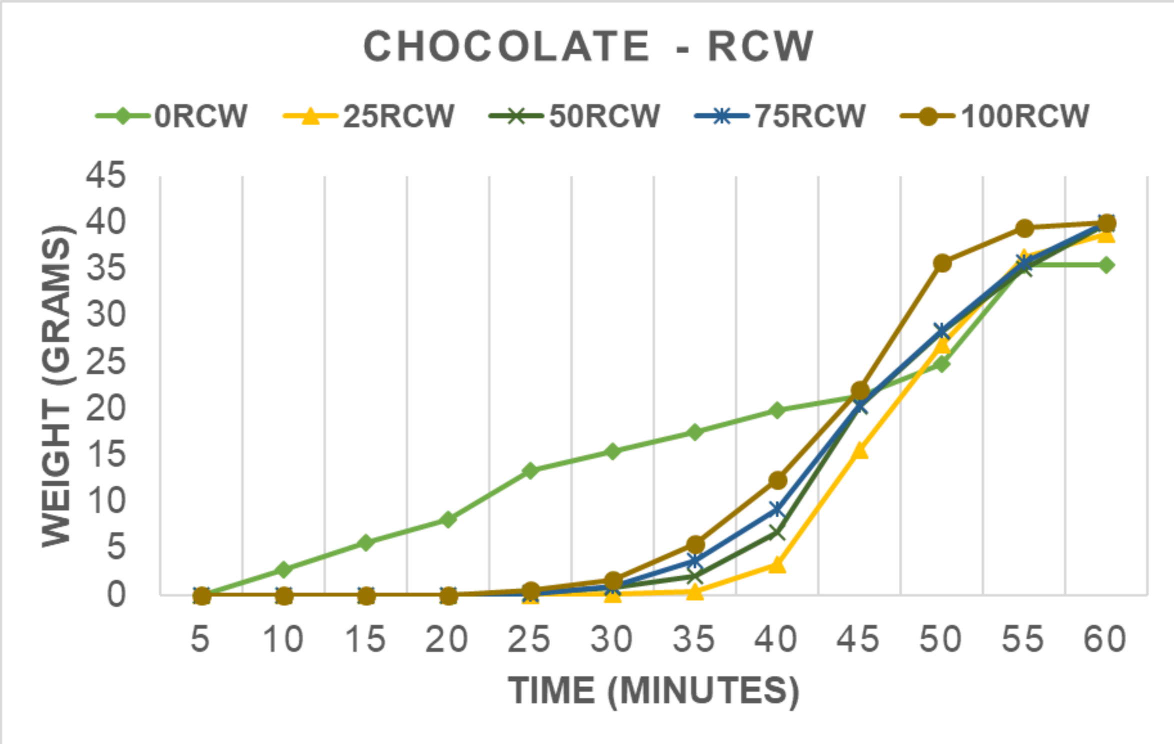
According to Table III and Figure I, the ice cream developed with whole milk showed higher melting rate (i.e. lower melting resistance) when compared to the samples developed with RCW, which in turn, showed no significant differences between them. The first signs of melting could be seen for the ice cream developed with milk (in 5 minutes), which was different from the ones with RCW (25 minutes). This behaviour was also observed by Li *et al.* (2015) when evaluating the effect of the addition of collagen on the rheological properties in chocolate ice cream, finding that the time required for the beginning of the melting was also high (23.33 and 35.67 minutes) with low melting rates.

Table III
Colour parameters of RCW, milk, ice cream formulations, and melting rate, colour parameters, and texture of ice cream formulations.

Sample	**L*** ^{X}	**a*** ^{X}	**b*** ^{X}	**Melting rate**^{X} **(g/min)**	**Hardness**^{X} **(N)**	**Overrun**^{X} **(%)**
RCW^{y}	31.29 ± 0.90^{b}	-11.55 ± 0.25^{b}	2.15 ± 0.58^{b}	-	-	-
WM^{z}	86.34 ± 0.42^{a}	-7.25 ± 0.17^{a}	21.67 ± 0.18^{a}	-	-	-
Ice Cream Formulations						
0RCW	40.69 ± 0.75^{a}	10.57 ± 0.08^{a}	6.18 ± 0.18^{a}	0.73 ± 0.03^{a}	33.99 ± 1.07^{e}	64.56 ± 8.41^{a}
25RCW	39.88 ± 0.05^{b}	10.01 ± 0.12^{b}	5.99 ± 0.00^{b}	0.67 ± 0.01^{b}	35.21 ± 0.13^{d}	60.15 ± 9.87^{ab}
50RCW	39.72 ± 0.07^{c}	9.80 ± 0.08^{c}	4.88 ± 0.12^{c}	0.67 ± 0.02^{b}	36.18 ± 0.21^{c}	53.06 ± 6.34^{ab}
75RCW	38.64 ± 0.46^{d}	9.41 ± 0.15^{d}	4.46 ± 0.02^{d}	0.67 ± 0.01^{b}	37.18 ± 0.17^{b}	49.22 ± 5.46^{b}
100RCW	37.63 ± 0.22^{e}	8.33 ± 0.15^{e}	3.38 ± 0.30^{e}	0.67 ± 0.01^{b}	38.43 ± 0.92^{a}	44.96 ± 6.77^{b}

* Data are presented as mean± SD and analysed with one-way analysis of variance. Different letters in the same column indicate a statistical difference ($p < 0.05$) among different samples using the Tukey test.
^{X} Tests carried out at a set-controlled temperature (25 ± 1 °C).
^{Y} Ricotta Cheese Whey.
^{Z} Whole Milk.

Figure I. Melting curves of ice cream samples.



According to this study and Akalin *et al.* (2008), possibly due to the effect of dissolved solids on freezing point depression, samples that were high in solids and fat melted faster than those that were low in solids and fat. Additionally, the results of Udabage *et al.* (2005) suggest alteration of the emulsion characteristics of ice cream mixes with the increased whey protein denaturation, which consequently altered the ice cream properties, resulting in ice creams with better melting resistance. In this study, similarly, the presence of RCW in ice cream (higher denatured protein content compared to milk) increased melting resistance.

3.4 DESORPTION RESISTANCE

None of the samples presented serum formation and, thus they could not be quantified whatsoever. Taking into consideration that a good ice cream should not show phase separation during and after melting, all samples met this quality attribute. According to Tharp *et al.* (1998) and Bodyfelt *et al.* (1988), among the factors that strongly influence phase separation after melting is protein concentration. This is exemplified by the fact that ice creams containing high protein concentration in water are generally less stable in this aspect than others with lower concentration. Therefore, this finding may explain the absence of phase separation in the ice creams of the present study due to low protein concentration.

3.5 OVERRUN

There were no significant differences among overrun values of ice creams except that found between 0RCW sample with 75RCW and 100RCW sample, i.e., high levels of RCW reduced the yield of ice cream (Table III).

There are no studies in the literature that have applied overrun analysis in ice cream manufactured with partial or total replacement of milk by RCW; however, Yilsay *et al.* (2006) reported that substitution of a whey protein fat replacer for milk fat decreased the overrun.

3.6 INSTRUMENTAL COLOUR

As seen in Table III, the whole cow milk was lighter (higher L* value) than RCW due to the absence of carotenoids in its composition (Nozière *et al*., 2006). Additionally, the higher concentration of RCW in the ice creams made the samples subtly darker.

The coordinates a* (-a*/+a*) and b* (-b*/+b*) indicate the colour directions (Wetzel and Charalambous, 1998). As RCW was added, the values of a* increased and b* decreased. Therefore, the low values of a* and b* obtained from the chocolate ice cream samples of the present study showed the region where the brown tones are located. The visible lack of opacity in RCW justifies the increase of colour intensity in the ice cream samples with larger proportion of RCW in the formulation of ice cream mix.

The chocolate ice creams of the present study were lighter than those developed by Piati *et al.* (2015) with luminosity (L*) between 21.53 and 35.59, when analysing the behaviour of the addition of chia mucilage (*Salvia hispanica* L.) into chocolate ice cream. The results were also similar to those analysed by Crizel *et al.* (2013) in chocolate ice cream with added orange fiber (L* between 37.02 and 46.24) and Li *et al.* (2015) in chocolate ice cream with added collagen (L* between 41.64 and 43.03).

3.7 TEXTURE PROFILE ANALYSIS (TPA)

The "softest" ice cream was that with whole milk followed by the one with 25, 50, 75 and 100% incorporation of RCW (Table III). Thus, as RCW concentration in ice creams increased, the required force of deformation also increased, which means that the ice creams became "harder". The lowering in proteins content in such samples did not make the ice cream softer since the lowering in fat content was more expressive (Table II), making the ice cream harder. This same behaviour was observed by other authors, such as El-Nagar *et al.* (2002) in frozen yoghurt and Akalin and Erişir (2008) in low-fat ice creams. Moreover, studies conducted by Guinard *et al.* (1997), Alamprese *et al.* (2002), and Akalin *et al.* (2008) showed that the hardness of ice cream was inversely proportional to the fat content. Guinard *et al.* (1997) also pointed out that the reduction of fat content provides an increase in the formation of ice crystals, due to the reduced solids (%TS) and increased moisture, which can generate greater hardness in low-fat ice creams.

Aime *et al*. (2001) and Whelan *et al*. (2008) found higher values of firmness for ice cream with whole milk (86.30 N and 57.30 N, respectively), but Oliveira (2008) noted a value of 24.04N as instrumental firmness.

3.8 MICROBIOLOGICAL QUALITY

Table IV shows the results obtained from the evaluation of the microbiological profile of the ice creams, in which all the analysed samples were suitable for consumption, presenting values equal to or below the limit established by the current legislation. Additionally,

3.9 *SALMONELLA* SPP. WAS ABSENT IN 1G OF ICE CREAM SAMPLES

Table IV
Characterization of the ice cream samples for microbiological contamination (in Most Probable Number (MPN), Colony Forming Units (CFU)/g or presence).

Formulation	**Coagulase Positive *Staphylococci* (CFU*)**	**Thermotolerant Coliforms at 45 °C (MPN**)**
Brazilian legislation RDC 12/2001	500/g	50/g
	Amplitude	Amplitude
0RCW	11.00 – 18.00	3.00 – 6.10
25RCW	10.00 – 15.00	3.00 – 6.20
50RCW	11.00 – 17.00	3.00 – 3.60
75RCW	9.00 – 17.00	3.00 – 6.10
100RCW	10.00 – 19.00	3.00 – 7.20

* Colony Forming Units.
** Most Probable Number.

3.10 CONSUMER TESTS

Most ice creams (control sample included in this) were rated between "Slightly liked" and "Moderately liked" (Table V). The best means were samples 0, 25 and 50RCW, which were on par with the scores assigned to other ice cream samples. It was possible to observe that the appearance and the texture followed the order of the instrumental analysis for colour and texture respectively, i.e., brown coloured getting darker and harder observed by the judging panel. Despite the smallest difference in the means (75 and 100RCW), the samples received good scores by the consumers.

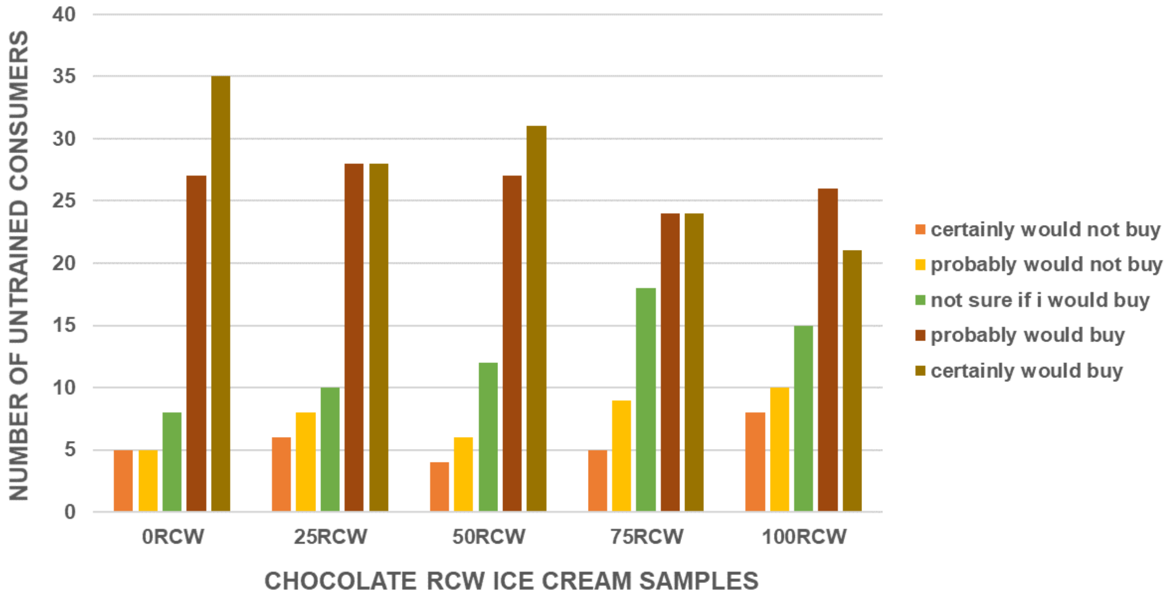
Table V
Sensorial quality of ice creams.

Formulation	Appearance^X	Aroma^X	Flavour^X	Texture^X	Overall liking^X
0RCW	7.41±1.50[a]	6.90±1.44[d]	7.05±1.58[b]	7.15±1.67[a]	7.15±1.49[b]
25RCW	7.26±1.31[c]	7.24±1.41[a]	7.22±1.56[a]	7.01±1.52[b]	7.22±1.39[a]
50RCW	7.37±1.23[b]	6.96±1.44[c]	7.22±1.60[a]	7.14±1.41[a]	7.21±1.18[a]
75RCW	7.10±1.45[d]	7.06±1.58[b]	6.80±1.58[c]	6.64±1.47[d]	6.94±1.38[c]
100RCW	6.87±1.52[e]	6.71±1.40[e]	6.59±1.56[d]	6.80±1.57[c]	6.76±1.36[d]

* Data are presented as mean± SD and analysed with one-way analysis of variance. Different letters in the same column indicate a statistical difference ($p < 0.05$) among different samples using the Tukey test.
^{X}Sensory score based on the 9-point hedonic scale.

Regarding the purchase intention (Figure II), the same behaviour was observed for all formulations: most consumers stated that they "probably would buy" or "certainly would buy" the experimental ice cream. Among the samples with ricotta cheese whey, 50RCW presented better result for purchase intention.

Figure II. Frequency distribution of scores corresponding to the scale used to assess the purchase intention of ice cream samples.



4 CONCLUSION

This study analysed the impact of the addition of RCW, in different proportions, on several quality attributes (proximal composition, yield, resistance to melting and desorption, and sensorial attributes) of ice creams. In physicochemical tests, the ice creams prepared with RCW presented a reduction of the fat and protein content leading to caloric reduction. The low pH values and high acidity characteristic of RCW did not negatively affect the developed samples.

Increase in the hardness, resistance to melting (no signs of desorption) and higher colour intensity were noted in ice cream prepared using incorporation of RCW, including, these differences were observed by the attributes of hardness and colour in sensory analysis. Furthermore, good evaluation of the sensory characteristics and intention of purchase was obtained in this study.

This research has resulted in a practical application in the dairy industry to value and add its by-product with the use of RCW in ice creams, proving to be a strong and interesting option to partially or totally substitute milk in its formulations, and, consequently, it constitutes an alternative of great environmental, technological and economic importance.

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