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Research Article

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Evaluation of Colour in a Newly Developed Food Product: Fresh Cheese with Red Fruits

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Abstract As a response to the increasing demand of the consumers for new, tasty and health improving foods, the objectives of this work were to develop a new type of cheese incorporating red fruits with potential health benefits and to analyse the product in terms of colour, due to the importance for consumer acceptability.

The types of cheese produced included fresh raspberry, fresh blueberry, frozen blueberry and a mixture of fresh raspberry and blueberry. Also a control cheese was produced, without addition of fruits. The colour measurements were done with a colorimeter in the CIE Lab colour space.

The results showed that the introduction of the fruits originated important colour changes, namely a reduction in lightness and an increase in redness while at the same time decreasing yellowness. The results further showed that those changes were mainly perceptible in the sides of the cheese and not in the top and bottom faces. The values of total colour difference were mostly situated in the range corresponding to recognizable differences, with exception of two samples for which the differences were clear, when compared with the control sample.

Keywords new product development, red berries, colour difference, functional food.

1. Introduction

The origin of cheese is not well known, but it is believed to have probably originated in the Middle East, already 10 thousand years ago. Since ancient times, cheese has been an important component of the human diet in many parts of the world. Cheese is a food product rich in proteins, fats, minerals and vitamins. Since then, many technological changes and methods have been developed and applied to cheeses, allowing the emergence of a vast and diverse range of cheeses, giving way to peculiar and meaningful expression of cultural diversity and diet throughout the world[1].

Cheese colour is, among other properties, very variable along the ripening process [2] and depends on several different factors, including the type of milk, the processing operations and maturation conditions [3].

The consumer's preference for raw milk cheese is continuously increasing because of its more intense and varied flavour when compared with cheese made with pasteurized milk. The development of aroma in raw milk cheeses is mainly governed by its naturally occurring microbial flora, which also contributes to the inhibition of food borne pathogenic bacterial growth. Lactic bacteria, the dominant indigenous microorganisms of raw milk cheese, produce substances that inhibit pathogenic organisms, such as bacteria, organic acids, hydrogen peroxide, and it is possible to manufacture cheese with microbiologically desirable qualities. However, hygiene in milk and cheese production environments and the post-production phase need to be constantly monitored according to microbiological parameters [4].

There have been done many studies where were investigated foods and food ingredients for their effects on various populations. The demand for natural compounds as a form of conventional therapy has been increasing and in this sense it is important that the consumer has information based on scientific knowledge [5].Several studies have shown that diets rich in plant foods, such as fruits and vegetables, protect humans against chronic

noncommunicable diseases such as cancer and cardiovascular disease. Due to increased consumer concern about their health and diet there has been an evolution in dietary guidelines. These have a special focus on the adequate intake of essential nutrients in order to prevent nutritional deficiencies and reduce chronic diseases such as cardiovascular diseases and obesity. On the other hand, fruits and vegetables are naturally rich in bioactive compounds with antioxidant activity and can participate in disease prevention [6].

Some specific benefits of red fruits are: a) Raspberry has detoxifying action, helps to lose weight, combats fluid retention, stimulates blood circulation, increases body defences, protects eyesight; b) Blueberry helps curb memory decline, reduces the risk of cardiovascular problems, combats aging, reduces bad cholesterol; c) Blackberry reduces the risk of osteoporosis, combats aging, increases energy levels, prevents joint diseases, improves intestinal transit, prevents diabetes, and strengthens the immune system [7]. The importance of natural compounds with antioxidant capacity has been widely recognized in recent years. It has been confirmed that foods with certain biologically active substances can have positive health outcomes and more and more consumers are aware of this and of the importance of a balanced diet, preferring thus consuming natural products that act positively on well-being, instead of simply eating food [8].

The objectives of this work were focused on the development of innovative products based on cheese, but to which red fruits are added, in order to obtain cheeses pleasing to the consumer, and on the other hand with added health benefits due to the potential antioxidant capacity of red fruits. The specific objectives of this work were then: to develop the product at the experimental level, making several trials with fruits (blueberry and raspberry) and to analyse the product with regard to colour attributes, for being important organoleptic characteristics that determine product acceptability by consumers.

2. Experimental Procedure

2.1. Cheese preparation

For the preparation of the fresh cheeses the usual processing steps were followed, and they were prepared in a cheese factory following the same workflow.

Each of the prototypes of cheese with berries took on average 10 to 12 L of milk (cow's milk), 5 g of salt and 10 g of fruit (fruits of different types). The fruits were added whole, milled or on a semi-shredded state (Figure 1).

Figure 1: Cheese with whole raspberries and blueberries

The types of cheese produced in duplicates were: a) including fresh raspberry; b) including fresh blueberry; c) including frozen blueberry and, finally, d) including a mixture of fresh raspberry and blueberry. A control cheese was produced without addition of fruits.

The cheeses were fresh, hence they did not go through any maturation process, and therefore they were transported to the laboratory for analysis right after production. The transportation step was done under refrigeration at controlled temperature.

2.2. Evaluation of colour

The colour was evaluated using a hand tristimulus colorimeter (Chroma Meter - CR-400, Konica Minolta) which was calibrated with a white standard tile (Figure 2).

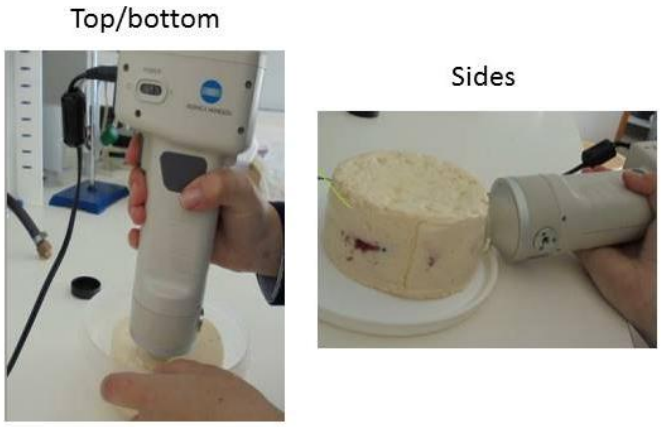

Figure 2: Performing the colour measurements in the cheese samples

The CIE standard illuminant D65 was used to assess the CIE Lab colour space coordinates, L*a*b* values (Figure 3(a)). This system is suggested by Mendoza et al. [9] as the most suitable colour space for quantification in foods with curved surfaces. The coordinates measured were the lightness L*, which varies from 0 to 100 (corresponding respectively to black and white), and the coordinates of opposed colour: a* and b*, which vary from –60 to +60, where the a* assumes negative values for green and positive values for red, while b* assumes negative values for blue and positive for yellow [10–12]. In each cheese 10 measurements were made in the bottom and in the top faces, plus 10 in the sides, to calculate the mean value and standard deviation.

The Cartesian coordinates can be used to calculate the polar or cylindrical coordinates (Figure 3(b)): L*HºC, with Hº representing the hue angle and C the chroma, as defined by equations (1) and (2):

$$\begin{cases} Hº = arctg\,(b^*/a^*),\ for\ a^*>0\ ;\ b^*>0 \\ Hº = 180º + arctg\,(b^*/a^*),\ for\ a^*<0\ ;\ b^*>0 \\ C = \sqrt{a^{*2} + b^{*2}} \\ Hº = 270º + arctg\,(b^*/a^*),\ for\ a^*<0\ ;\ b^*<0 \end{cases} \quad (1)\ (2)$$

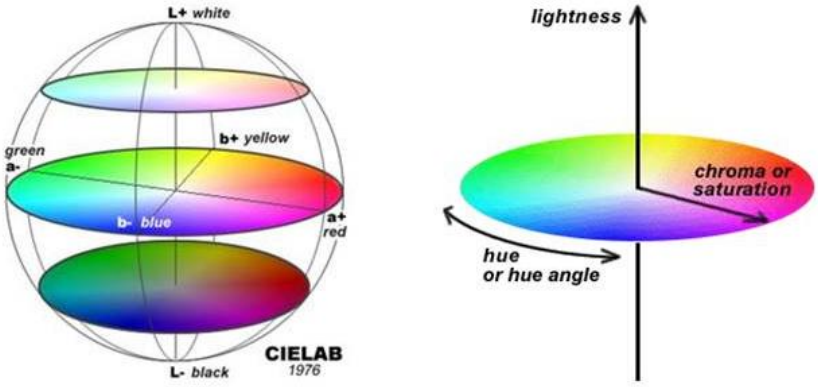

Figure 3: (a) CIELAB colour space in Cartesian coordinates, (b) Cylindrical colour coordinates

The total colour difference (TCD), was the parameter considered for the overall colour difference evaluation, between a sample and the control (designated with an index 0) on equation (3):

$$TCD = \sqrt{(L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2} \quad (3)$$

The control sample was used as the reference and a larger TCD denotes greater colour change from the reference material.A typical scale for evaluation of the colour difference is as follows: TCD in the range [0.0 – 2.0] corresponds to unrecognizable differences, in the range]2.0 – 3.5] corresponds to differences possible to recognize by an experienced observer and over 3.5 corresponds to clear differences of colour [13].

3. Results and Discussion

The graph in Figure 4 shows the values of lightness for all samples evaluated. The control sample, corresponding to fresh cheese without addition of fruits, presented a value of L* equal to 92.60±0.65, which is close to that reported by Yasin and Shalaby[14] for cream cottage cheese (also unripe): L* = 88.40. In this way both chesses were very clear, with values very close to 100, which represents white.

It is clear from the graph in Figure 4 that the addition of fruits did not influence the lightness of the surfaces (top or bottom) but turned in general the colour of the sides less clear, i.e., with lower L*.

According to Matos [15], the values of L* for blueberries are around 30 to 37 and, according to Pacheco[16], the values for the raspberries are between 28 and 36. Therefore, these fruits are dark and when they are added to cheese they induce a decrease in luminosity. Also the value of the standard deviation is considerably higher, due to the measurements being made in areas of white cheese or sometimes in areas of dark fruits (see figure 1).

Regarding the variations between the evaluated samples, the cheese made with frozen blueberries presented the lowest value of L*.

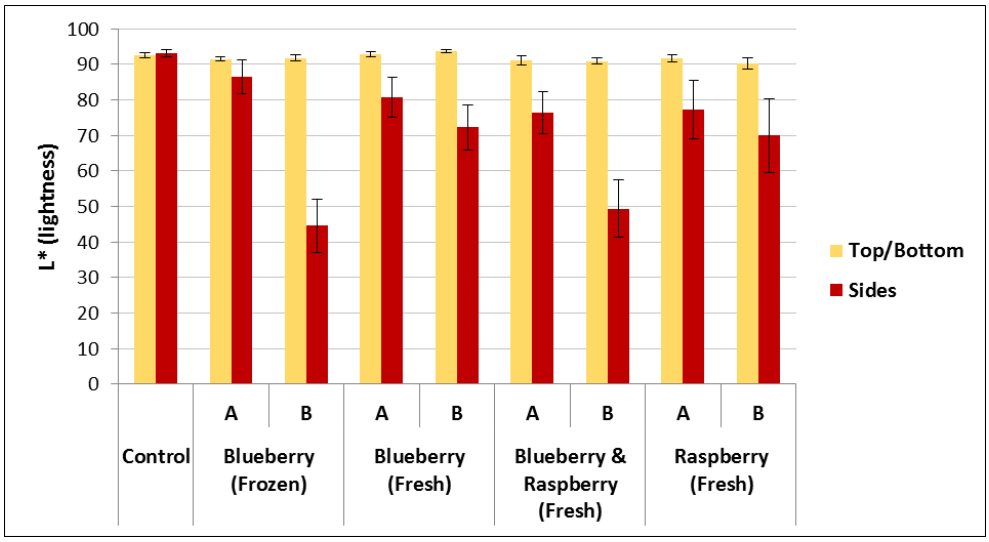

Figure 4: Colour coordinate L evaluated in different cheese samples*

Figure 5 presents the values of the colour coordinate a* for the cheese samples analysed. The control sample, which was the plain cheese, presented a value of a* of -1.51±0.08, which is quite different from that reported by Yasin and Shalaby [14] for cream cottage cheese, being in that case a* = -9.17. Nevertheless, both values are negative, indicating the presence of a greenish coloration instead of reddish. Hence the control in this work revealed to be much less pending to green as compared to the cottage cheese, but that is probably due to the differences in the kind of cheese itself, the type of milk used and the processing operations. Although the milk used in both cases was cow's milk, it may vary according to the breed, age or diet of the animals.

As shown in Figure 5, it can be seen that the parameter a* of the samples has in general negative values, which means that the green colour predominates in the majority of the samples, when the measurements are made in the top or bottom. However, in the sides the scenario is slightly different and in some cases the predominant colour is red, owing to the presence of the fruits spread on the sides. The samples made with fresh blueberry & raspberry mixture and with fresh raspberry are those that showed the highest values of a*, 10.01±2.89 and 9.05±2.51, respectively. This is clearly the result of the influence of the "red" fruits added. According to Matos [15] the values of a* for blueberry are around -0.02 to 0.62, and according to Pacheco [16] the values of the

same coordinate for raspberry range between 22 and 28. This shows that raspberry is very red indeed, given the high values of a*.

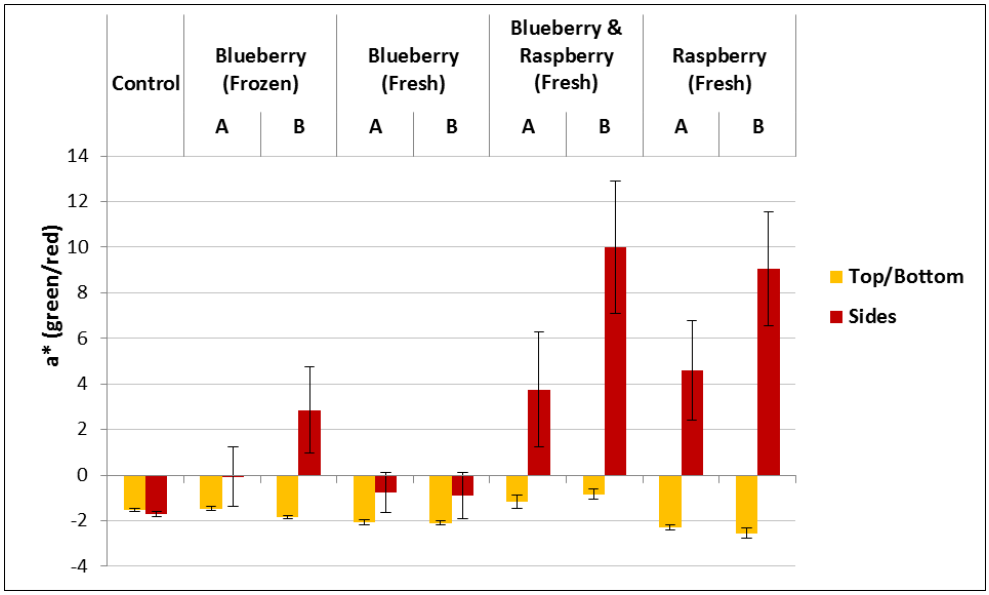

Figure 5: Colour coordinate a evaluated in different cheese samples*

The graph shown in Figure 6relates to the values of the coordinate b*, which is always positive, so corresponding to the predominance of a yellow coloration instead of blue (which would be for negative values of b*). The simple fresh cheese (control sample) presented a value of b* equal to 16.39±0.23, which is again relatively close to that reported by Yasin and Shalaby[14] for cream cottage cheese (b* = 14.73). These values indicate that the dominance of the yellow coloration was similar in both types of fresh cheese.

As to the different types of cheese, the results in Figure 6 show that the values of the b* coordinate of the samples are in all cases positive, that is, there is predominance of the yellow coloration in detriment of the blue. However, the intensity of the yellow colour is higher in the top and bottom faces of the cheeses and not so much in the sides, where some spots of dark fruits appear.According to Matos[15] the values of b* for blueberry are around -5.02 to -7.77 (corresponding to predominance of blue), while according to Pacheco[16] b* for raspberries varies between 10 and 18 (corresponding to predominance of yellow over blue).

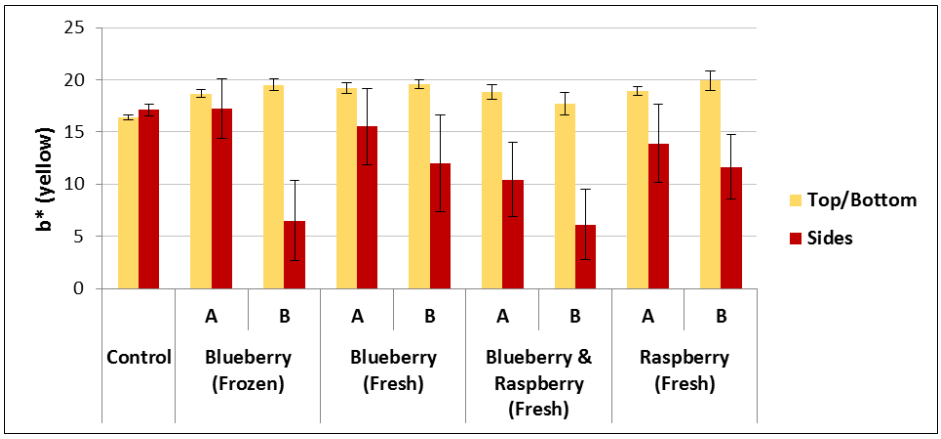

Figure 6: Colour coordinate b evaluated in different cheese samples*

Figure 7 shows the values of chroma for all the samples evaluated. Higher values of chroma indicate higher purity of colour, while lowest values (close to zero) correspond to more faint colours. The results obtained indicate that again the purity of the colours was greater for the top and bottom faces when compared to the sides, being in accordance with the results obtained for previous parameters.

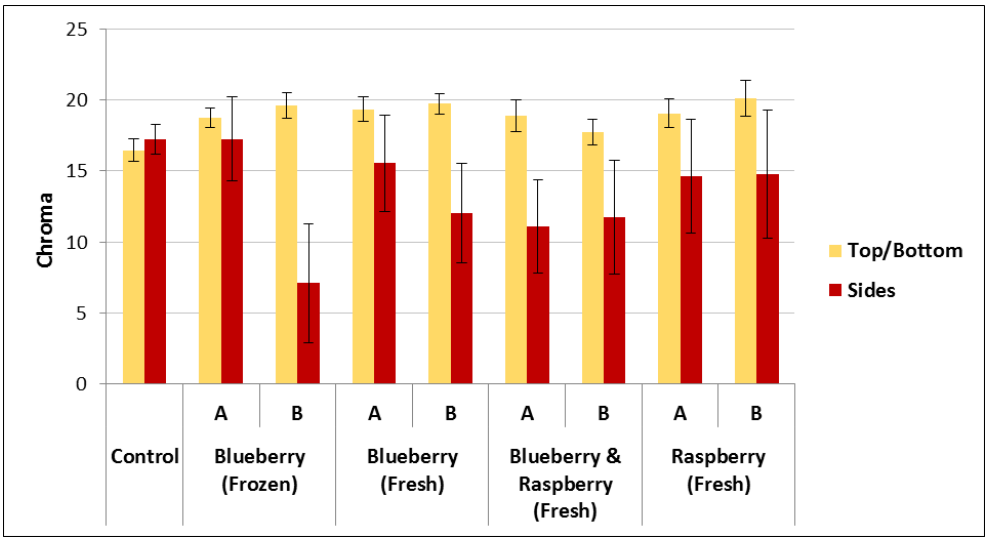

Figure 7: Colour coordinate chroma evaluated in different cheese samples

The hue angle varies between 0º and 360º, and denotes variable colours as indicated in Figure 3(b). For values of hue near 0ºC or 360ºC the tone is red, while for hue angles around 180º the tone is green (Figure 9). The results obtained for hue are in accordance with those seen for a*, i.e., the samples being in the red and green zones, depending on the fruits and version of the cheese.

Figure 10 shows the values of total colour difference obtained considering the whole cheeses, i.e., average values of the measurements on top, bottom and sides. The results indicate that different cheeses made with the same fruit combinations (versions A and B) present important differences in colour, so there is no homogeneity in the cheese making. Nevertheless, this is normal, given that the objective of the formulation of this product was not to produce a homogeneous aspect but to show spots of fruits spread over the white mass of cheese.

In relation to the range of the values of TCD, not in any case the values were under 2.0, thus indicating that there were no samples that contained fruits with a similar colour to the control sample. In most samples, the values of TCD indicate that there were differences possible to recognize by an experienced observer (values of TCD from 0.2 to 3.5). However, in two cases, the values of TCD were over 3.5, and in those cases the differences were clearly visible (cheese A made with frozen blueberry and cheese B made with fresh raspberry).

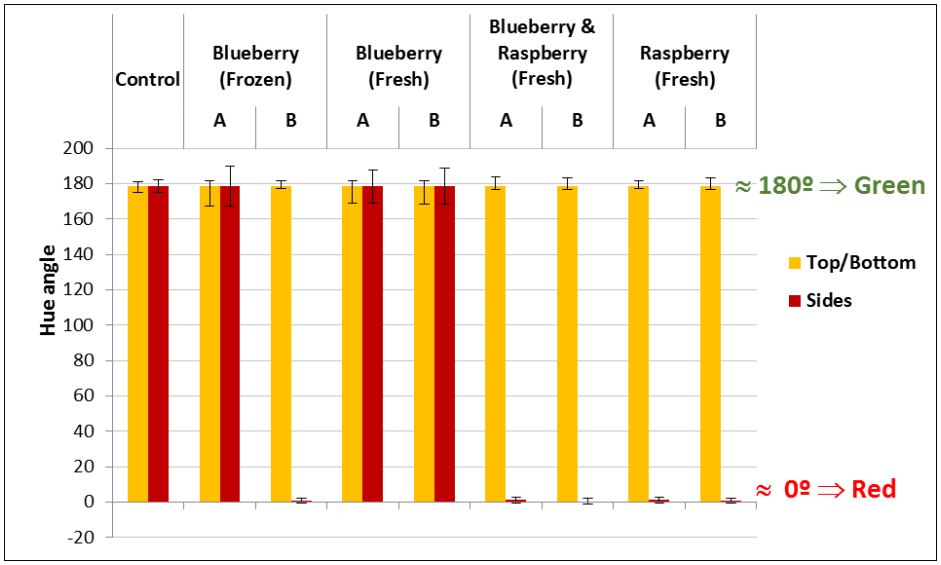

Figure 8: Colour coordinate hue angle evaluated in different cheese samples

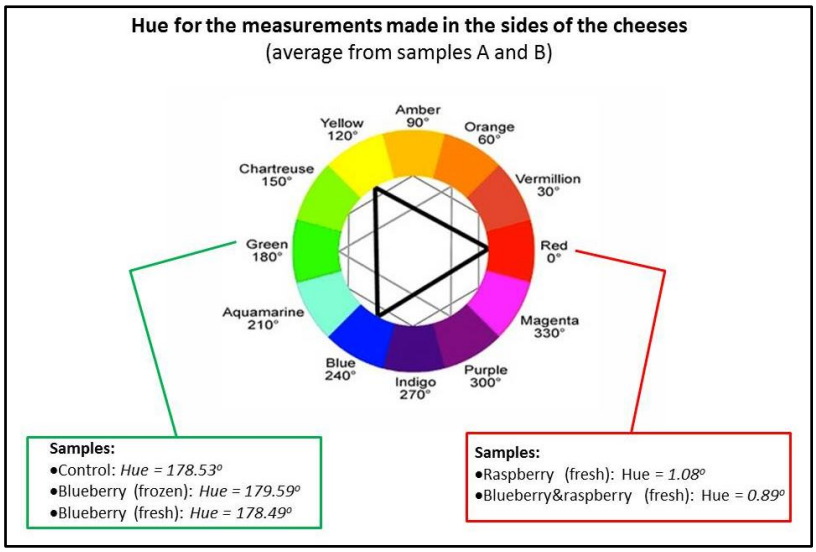

Figure 9: Hue angle special composition with evaluated samples

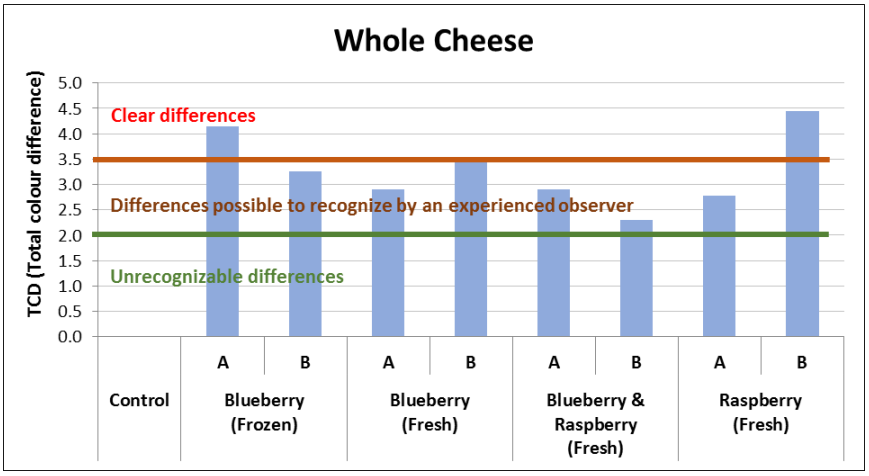

Figure 10: Total colour difference of cheese samples in relation to control

4. Conclusions

The results obtained with the present work allowed characterizing the colour parameters for cheeses produced with addition of red berries, namely blueberries and raspberries. The results showed that the introduction of the fruits in intermediate layers inside the white fresh cheese produced important colour changes, including a reduction in lightness and an increase in redness while at the same time decreasing yellowness. The results further showed that those changes induced by the presence of the fruits were visible mainly in the sides of the cheese and not in the top and bottom faces. The values of total colour difference were mostly situated in the range corresponding to recognizable differences, with exception of two samples for which the differences were clear, when compared with the control sample.

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