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Consumer acceptance of carotenoid enriched cakes using fruit pulp microencapsulated as ingredient

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Abstract
The study developed three cakes formulations containing 2, 4 and 6% of mixed pulps of mango and passion fruit microencapsulated with inulin, and were evaluated their sensory characteristics, color and content of carotenoids. The cakes mixes available on the market do not have in their composition fruit pulp inherent of the flavor and make use of flavorings, colorings and hydrogenated vegetable fat. The cakes developed were approved by the panelists and the cake with 6% microsphere obtained the best evaluation and a more intense color and showed a possible way to contribute to the consumption of carotenoid and inulin.

Keywords: spray drying, bakery products, inulin, tropical fruits

1. Introduction
The cake has always been on the table of the Brazilian families and with the population changing current lifestyle the consumption of bakery products has been increasing [1, 2]. The cake mix is an easy and fast alternative to prepare a cake making the cakes mixes come gained ground in homes. Mango and passion fruit are fruit with great emphasis production in Brazilian fruit farming [3]. Both are fruits rich in bioactive compounds, in particular carotenoid, that has important functions in the body as provitamin A and acts as an antioxidant [4]. The microencapsulation technique has been used as food preservation, is well established due to the wide availability of equipment on the market, low operating costs, high production rates, reproducibility, wide variety of encapsulation materials, encapsulation efficiency of 10-90%, powders with low activity water, ease of transportation and storage and easy handling [5, 7]. The use of encapsulating agents with functional potentials tends to add benefits to the products Fruits and fruit extracts has been microencapsulated and successfully being applied in various products such as cakes, ice cream and pasta [8, 9].
The focus of this work was to formulate and evaluate a cake mix using different levels of mango and passion fruit microencapsulate in order to obtain the best cake mix formula. On the other hand, the study shall show the profile of the cake mix formulations on the market. This information could be important to characterize the presence of additives in this product. The goals of the research were to evaluate the carotenoid content of the enriched cakes, the acceptability of the cake, in order to find its commercial value.

2. Material and Methods
2.1 Material
It was used frozen mango and passion fruit pulp, acquired in Rio de Janeiro, Brazil. According to a previous study, mango and passion fruit pulp was defrost and prepared the formulation with 70% mango and 30% passion fruit and were subsequently added to the formulation 10% encapsulating agent in the ratio 2:1 inulin, OrafitiBeneo ST Raftline (Tienen, Belgium), and maltodextrin, Mor-Rex 1910 Corn Products (Mogui-Guaçu, Brazil). The mixed pulp microencapsulated was obtained in spray-dryer Niro Atomizer (Copenhagen – Denmark) with nozzle 1.0 mm in diameter, mass flow used power was 14L / min and air inlet and outlet temperatures were 160 °C and 90 °C, respectively at Embrapa Food Technology, Rio de Janeiro, Brazil. The wheat flour and other ingredients used in the formulation of the cakes were obtained from the local market.

2.2 Methods
2.2.1 Profile composition of commercial cake mix
The types of cake mixtures in the main markets of the city of Macaé were researched. Only mixtures of cakes with fruit or vegetable flavors were selected to perform the composition profile of the cake mix formulations. Were noted brands, flavor and composition of the products according to the label, taking into account the presence of fruit pulp or vegetable powder, presence or absence of hydrogenated vegetable fat, the presence of food additives: flavorings, colorants, emulsifiers, thickeners and stabilizers.

2.2.2 Cake development enriched with mango and passion fruit microspheres
Three cake formulations containing respectively 2%, 4% and 6% of pulp mixed microencapsulated were developed and were designated as the control, C2, C4 and C6. All cakes contained 31.91% of wheat flour, 15.95% sugar, 18.6% of eggs, 10.63% margarine free from trans-fat acids, 21.27% milk and 1.59% of yeast in powder. The ingredients

were mixed in a mixer on medium speed for 4 minutes. The cakes were baked in a preheated conventional convection oven at 180 °C for 45 minutes.

2.2.3 Total carotenoid

The method of extraction of carotenoids was performed according Rodriguez-Amaya, (2001). The absorbance was read at 453 nm in a Spectrophotometer Shimadzu Model UV-1800 (Kyoto, Japan). To calculate the carotenoid content was used the following equation:

$$Total\ carotenoids\ content\ (\mu g/g) = \frac{A.volume\,(mL).10^4}{A_{1cm}^{1\%}\ .\ weight\ sample\,(g)}$$

2.2.4 The colorimetric analysis

The colorimetric analysis of the cakes was performed in a Color Quest XE, Minolta (Northants, UK), scale CIE L*, a*, b* and CIELCh, with openness of 0,375mm in diameter, with illuminant D65/15, recommended by the CIE (International Commission on Illumination), to represent the average light of the day.

The total difference of color was calculated by the following equation:

$$\Delta E* = [\,(Li* - Lf*)^2 + (ai* - af*)^2 + (bi* - bf*)^2]^{\frac{1}{2}}$$

Where I is the initial value and f is the final value.

2.2.5 Sensory analysis of the cake samples

This study was approved by the Ethics Committee, CAAE 45788715.4.0000.5257, and only participated in the experiments panelists who signed the Informed Consent Form (ICF). We carried out the acceptance test in the Sensory Analysis Laboratory of Pólo Ajuda at the Federal University of Rio de Janeiro - UFRJ, in individual cabins with 35 panelists, consisting of university students in undergraduate and graduate programs, professors, staff and visitors, potential consumers of the product. Some demographic and sociological characteristics of consumers are shown in Table 1and 2 they were given a brief overview of how the sensory test would be conducted and they filled in a brief questionnaire about their knowledge and consumer habits with respect to cakes and mixes cakes.

Table 1: Demographic and social characteristics of respondents

S. No.	Characteristics of Responders		Number of consumers	Percentage
1.	Gender	Female	21	60
		Male	14	40
2.	Age (years)	18-30	22	63
		31-45	8	23
		>45	4	11
3.	Marital status	Single	23	35
		Married	7	20
		Others	5	14
4.	Education	Complite and uncomplite primary education	4	5,7
		High school graduates and undergraduates	6	17,1
		College graduates and undergraduates	20	57,1
		Pos graduatian	7	20,0

Table 2: Cake consumption habits

S. No.	Characteristics of Responders		Number of consumers	Percentage (%)
1.	Consumption of cakes	Yes	30	86,7
		No	5	14,3
2.	Frequency of consumption	1/week	5	16,6
		2/week	3	10,0
		1/month	2	6,6
		2/month	11	36,6
		Sporadically	9	30,0
3.	Consumption of mix cakes	Yes	13	37,1
		No	22	62,9
4.	Frequency of consumption of mix cakes	1/week	3	27,7
		2/week	1	9,9
		1/month	1	9,9
		2/month	2	18,2
		Sporadically	6	54,5
5.	Would consume enriched cake	Yes	21	60,0
		No	12	34,3
		Maybe	2	5,7
6.	Reason for the consumption of enriched cake Healthy		23	41,1
		No aromas and artificial colors	17	30,4
		Differentiated product	16	28,6

2.2.6 Affective test hedonic scale

Analyse have the objective to determine the maximum accepted mango/passion fruit microencapsulated (2, 4 or 6%) in cakes. Samples of the three formulations cake were checked according to the intention of buy the products and assessed the attributes of flavor, color, aroma, texture attributes and global impression by hedonic scale of nine points, ranging from 1 to 9 points: 1 - dislike very much and

9 - liked very much. The cake samples were cut into squares of 3 cm x 3 cm, were coded with three digits numbers and served in monadic sequence according to a randomized complete block design and balanced [10].

To perform the tests, panelists received along with the samples printed tests and disposable cup with water filtered at room temperature, for ingestion between tasting cake and palate cleansing in order to ensure adequate perception of sensory aspects.

2.2.7 Acceptability Index

For Acceptability Index calculation of the product it was adopted the expression:

$$AI\ (\%) = \frac{Ax100}{B}$$

Where, A = average grade obtained for the product and B = maximum score given to the product. The AI with good effect has been considered ≥ 70%.

2.2.8 Statistic

All analyzes were performed in triplicate, with the results being expressed as the mean of three determinations and standard deviation. The results were analyzed statistically by the Tukey test at 5% significance ($p < 0.05$) using XLSTAT pro 7.5 software.

3. Results and Discussion

3.1 Profile composition of cake mix

There were found five different brands of cakes mixes. The flavors found for commercialization of fruit cakes mixes were: pineapple, lemon, coconut, orange, banana and passion fruit. To vegetable cake mixes was found the taste of carrots. Not all brands had the same flavors. The great variety of flavors available on the market for consumption may be an important factor for the promotion and increased consumption of cake mixes by Brazilian consumers. Between 1995 and 2005 was observed that there was an increase in the consumption of cakes among girls 8 to 12 years of the city of Rio de Janeiro [1] Were observed in fruits cakes mixes that 64% contained in their formulation some kind of food additive, beyond the flavoring, and among those food additives observed 35% were thickeners, 23% emulsifiers and 29% stabilizers. It was also observed that 100% of cakes mixes had in their composition hydrogenated vegetable fat. The labels of the cakes mixes found in the market does not exist specification if the flavorings used were natural or synthetic, although it is known that the exaggerated consumption of food additives can cause hyperactivity in children [11]. Regarding the vegetable cakes mixes was observed the presence of carrot powder in all of products found, but was also observed presence of flavoring in all them. Important fact seen in this kind product was the presence of colorings, which was not observed in the fruits cake mixes. Among the colorings observed 50% of the products used natural coloring annatto and 50% used synthetic coloring identical to natural β-carotene. It was also observed that 100% of vegetable cake mixes had in their compositions food additives and among the food additives used 50% were emulsifiers and 50% were thickeners. The hydrogenated vegetable fat was also observed in 100% of the products. In Brazil, it is mandatory to declare the content of Trans fatty acids per portion on the labels of all food products (ANVISA, 2005), so it was possible to observe in the nutritional information of cakes labels the presence of 0, 4 to 1g of trans fat per serving of cake mixes. The use of Trans fatty acid in commercial bakery products have been seen in many studies. Fifteen samples of the most common industrial bakery products sold in Spain were analyzed for their fatty acid composition showed percentage of trans fatty acids, which were found in all samples, showed a mean value of 5.7% [12]. In another study were observed the fatty acid compositions of 39 brands of cookies and bakery products were the average content of trans-fatty acids was 5.20% [13]. The consumption of trans fatty acids may influence cholesterol levels in the body by increasing LDL-cholesterol as well as lowering HDL-cholesterol level. The elevation of LDL-cholesterol contributes to the increased risk of cardiovascular disease [14]. Due to the Brazilian does not have the habit of reading food labels or do not understand them [15] it is possible that many are making ingredients intake that did not know to be consuming thus contributing to increase the acceptable daily intake of various ingredients. In a study with children it was observed that most of the study population was exceeding the acceptable daily intake for certain colorings in your day to day and several studies have associated with childhood obesity with hydrogenated vegetable fat consumption [16, 17].

3.2 Acceptance Testing

Acceptance testing revealed that in all evaluated parameters (overall appearance, color, taste, aroma and texture) there was no significant difference between samples in the formulations C2, C4 and C6, however for the acceptance index was difference between the formulations as shown in Table 3.

Table 3: Acceptability index of attributes color appearance, flavor, texture and aroma.

Attributes	Acceptability index (%)		
	2%	4%	6%
Appearance	67	66	74
Color	74	69	70
Flavor	73	68	71
Texture	65	59	69
Aroma	74	68	73

The average of the grades obtained by the evaluators showed that the product was well accepted. The cake C6 achieved the best results, having their appearance as the most highly rated parameter followed by aroma, flavor, color and texture. In acceptability index obtained values ≥ 70% for the appearance, color, flavor and aroma parameters, could be considered a product of good acceptance. The aroma, color and flavor parameter were the most scored by the evaluators in the three formulations.

A good evaluation on aroma parameter may be assigned to microencapsulation technique that tends to preserve the aroma of the fruits in the product.

In previus study it was observed that the external surfaces had continuous walls without fissures or cracks. It is known that the presence of fissures and cracks can influence the gas permeability and the loss of volatile compounds responsible for the aroma of the product. This result shows the potential of the product as alternative of artificial flavoring, widely used in the food industry.

The color of the product was attractive because the

concentration of carotenoid in microencapsulated pulp thus acting as a natural coloring on the cake. Carotenoids are a family of compounds widely used for coloring food in place of synthetic coloring, and are excellent substitutes additionally is an antioxidant compound [18].

The flavor result shows that the microencapsulation process did not change the pleasant flavor of the fruit. The development of enriched cake with microencapsulated phenolic extract of blueberry got low rating in taste parameter [9]. This shows that microencapsulation of in nature pulp tends to be more advantageous than the extracts of bioactive compounds of fruit when applied in food, as these extracts eventually lose the flavor of the fruit leaving the product unflavored.

The texture parameter was the one that had the lowest scores in the evaluation and got acceptability index below 70% in all formulations. In a study with enriched cake with blueberry microspheres noted that the texture parameter was also the one that had the lowest score [9].

The lowest score in the texture parameter can be associated with encapsulating agents used in the microencapsulation which may have an influence on the cake dough texture. The inulin is widely used in the food industry as a fat replacer, particularly as regards the technological property of fat in food texture [19, 21], its presence as the carrying agent in microspheres may have influenced the texture of the cake. Studies using inulin as ingredient in bakery products show that the inulin has influence in texture parameters. In the development of bread with inulin as fat replacer the texture parameter had lower scores in accordance with the increase of the amount of used inulin [21], in develpoment of pogaça bread drastic decrease in soſtness values were observed in the replacement of fat by increasing the amount of inulin [19].

In several countries such as France, Holland, Japan, South Korea, Singapore, Brazil, Chile and Colombia inulin is considered a functional food being allowed a health claim for products containing inulin in its composition.

The recommended intake values range from countries from 1.25 to 20 g/day [22]. The cakes enriched with 2%, 4% and 6% microspheres showed in its composition respectively 1, 20, 2,41 and 3,63g inulin/100g cake, consumption may contribute strongly to recommended daily intake of inulin.

It is important to emphasize that the inulin consumption has been associated with health benefits such as reduction in the prevalence and duration of infectious and diarrhea agents, reducing the inflammation associated with antibiotics and the symptoms associated with inflammatory bowel disease, protective effects against colon cancer, increased bioavailability and absorption of minerals, decrease risk factors for cardiovascular diseases, satiety and weight loss [22].

The cake C6 had the highest buying intention (71, 43%) when compared with C4 and C2 (48, 57%, 58,82%) being in accordance with the acceptance rate.

In developing bakery products, it is noteworthy that over 50% purchase intent values are considered positive purchase intent. A cake development study with different concentrations of watermelon bast flour had purchase intent ranged from 62% and 64% [23] in study with panettone development enriched with pupunha flour was found 31% of evaluators would probably buy the product and 69% said they definitely would buy the experimental panettone [24].

3.3 Colorimetric analysis

Regarding the color of the cake was possible to observe that as much higher the percentage of microencapsulates pulp used, less was the L value and higher the value of a *, indicating a product with a more reddish tone. The b* values indicate the cake had the yellow color, the result of C and H show that the cakes were in the range of orange shades (Table 4). The total color difference (ΔE*) showed values of ΔE* <3 indicating there were visual color difference between cake C2, C4 and C6 and control, as can be seen in Figure 1.

The color parameter sensorily evaluated had good score showing the possibility to replace the use of artificial colorings in bakery products by the microspheres produced in this study.

It is known the enrichment of bakery products with β-caroten lead to be instable [25], however the present study show is possible the use of pulp fruit microspheres rich in β-caroten as coloring.

The microencapsulate technique lead to protect the β-caroten from the oxidative agents and keep the stability of the color.

Table 4: Colorimetric evaluation of enriched cakes with mixed pulp of mango and passion fruit microencapsulated

Formulation	L*	a*	b*	C	H
2%	65,81±0,40^{b}	7,49±0,10^{c}	33,03±0,27^{b}	33,87±0,27^{c}	77,22±0,16^{b}
4%	61,66±1,27^{c}	9,24±0,18^{b}	34,48±0,24^{b}	35,70±0,23^{b}	75,01±0,30^{c}
6%	56,88±2,73^{d}	10,48±0,33^{a}	34,17±1,47^{b}	35,75±1,39^{b}	72,93±0,93^{d}
Control	70,54±0,55^{a}	4,12±0,07^{c}	27,30±0,33^{a}	27,61±0,34^{a}	81,43±0,11^{a}

Results in column followed by the same letter do not differ among themselves at 5% probability by Tukey test.

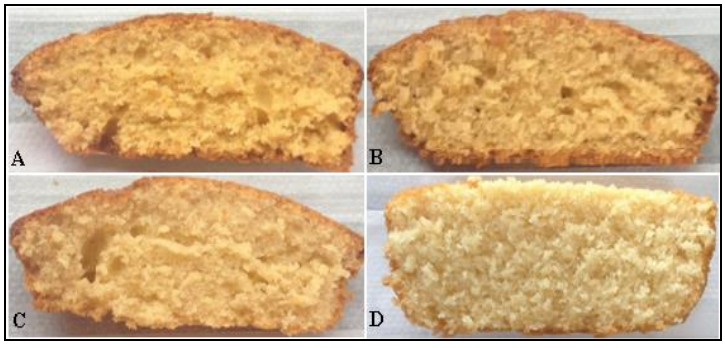

Fig 1: Visual observation of cake enriched with 6% 4% and 2% mixed pulp of mango and passion fruit microspheres and control

3.4 Carotenoids content

The cake C6 showed a higher content of total carotenoids (1013, 30µg/100g ± 42,12[a]) followed by the samples C4 (479, 43µg/100g ± 22,53[b]), C2 (242, 76 ± 8,63[c]) and control (198, 61µg/100g ± 7,33[c]). The content of carotene in the enriched cake were still higher than those reported for some other foods known as carotenoids sources, such as tomato juice, 200µg/100g [26].

The food microencapsulation technique tends to be efficient as the stability of the interest product encapsulated due to the use of encapsulating agent that acts as a protective barrier. In a study with cake mix incorporated with encapsulated oil gac powder was observed stability over 3 months shelf life of the coloration and carotenoid content that was assigned to the encapsulation [27].

The amount of vitamin A needed from the diet depends on the age, sex and genetic and lifestyle. Vitamin A recommended daily allowances for children 1-3 years, 4-6 years, 7-10 years and adults are 400, 450, 500 and 600 ug equivalent/day retinol, respectively [28]. The carotenoid conversion in the body is estimated at 6µg of β-carotene: 1µg retinol equivalent [29]. Thus, it can be concluded that 100 g of cake C6 may reach 42.7, 38.0, 34.2 and 28.5% of the daily requirement of vitamin A for children 1-3 years, 4-6 years, 7-10 years and adults respectively.

The average per capita intake of carotenoids in Brazil is below the values considered safe. The intake of carotenoids among women is higher than men and residents of urban ingest higher amounts of carotenoids and pro-vitamin [30].

By the fact that cakes are eaten in smaller meals, such as breakfast and snacks, you can suggest eating up to two servings per day, taking into account the needs of other nutrients and total caloric intake. The bioavailability of vitamin A can be affected by gender, level of physical activity, interaction with other nutrients and anti-nutritional factors, therefore the type of conversion to be used in the calculations of portioning and labeling must take into account such factors [31].

4. Conclusion

We can conclude that 100% of fruit and vegetable cakes mixes found in the market use flavoring in their compositions. None of fruit cake mixes was observed the presence of powdered fruit pulp, was only observed in the presence of powdered vegetable in cake mixes for the carrot flavor, but the same contained coloring in their compositions. The presence of hydrogenated fat and trans fat was observed both in fruit cakes as vegetable. Because the homemade cakes have in their composition pulp fruits and vegetables and this type of culinary preparation being replaced by cake mixes due to population habit change, this change of habit makes the consumers ending up consuming Products without any nutrients from fruits and vegetables and with high flavoring content, artificial colors, and hydrogenated vegetable fats.

The cakes enriched with 2%, 4% and 6% of microencapsulated mango/passionfruit pulp had good sensory acceptance with no significant difference between them. The acceptability index indicated that the enriched cake with 6% microencapsulated pulp had over 70% acceptance for all parameters, except texture and a more pronounced coloration due to their higher carotenoid content. The cake is presented as a source of inulin. The microspheres produced were shown excellent source of carotenoids through its use in bakery products. The mixed pulp of mango and passion fruit microencapsulated has potential as enriching ingredient and substitute artificial flavors and colorings can be explored by the food industry.

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