

## Salted crackers added with surimi fish and powdered tomato: Acceptability in school feeding

Neliane Pereira do Nascimento<sup>1</sup>, Mariane Márcia Cunha de Oliveira<sup>2</sup>, Candido Pereira do Nascimento<sup>3</sup>,  
José Maria Correia da Costa<sup>1</sup>, Rafael Audino Zambelli<sup>1</sup>, Elisabeth Mary Cunha da Silva<sup>1</sup>

<sup>1</sup> Universidade Federal do Ceará, Centro de Ciências Agrárias, Departamento de Tecnologia de Alimentos, Fortaleza, CE, Brasil. E-mail: nelianepereira@hotmail.com (ORCID: 0000-0001-6898-0066); correiacostaufc@gmail.com (ORCID: 0000-0002-6266-6778); zambelli@ufc.br (ORCID: 0000-0003-2996-2900); elisabeth.cunha@gmail.com (ORCID: 0000-0002-3267-4267)

<sup>2</sup> Universidade Federal do Ceará, Departamento de Química, Fortaleza, CE, Brasil. E-mail: marianemarciaco@gmail.com (ORCID: 0000-0002-1524-9031)

<sup>3</sup> Instituto Federal do Ceará, Reitoria, Campus Limoeiro do Norte, Limoeiro do Norte, CE, Brasil. E-mail: nascimento.cpe@gmail.com (ORCID: 0000-0003-0565-556X)

**ABSTRACT:** This study aimed to develop a salted cracker added with surimi fish and powdered tomato and to verify their acceptability in school feeding. Using the Rotational Central Composite Design (RCCD), 11 formulations of crackers were tested, with different percentages of surimi from dehydrated Nile Tilapia (*Oreochromis niloticus*) and powdered tomato, which were physically characterized. The two formulations with the best results in the physical analyzes, along with a control formulation were evaluated for centesimal composition, microbiological analysis, sensorial analysis and amino acid profile. The results were submitted to normality and variance analysis, Tukey test, multiple regression and response surface. The selected formulations, formulation 1 (10% surimi + 15% powdered tomato) and formulation 2 (13% surimi + 13% powdered tomato) displayed protein enrichment, when compared to the control formulation, with an increase in the amino acids profile. All formulations obtained < 3 MPN/g of coliforms at 45 °C and could be submitted to sensorial analysis, which obtained results varying between indifferent and liked, showing that both formulations are feasible for production. However, formulation 2, because it contains the highest protein and lipid content, is the one that best suits to the employment in school feeding.

**Key words:** cereals; lycopene; tilapia

## Biscoito salgado adicionado de surimi e tomate em pó: Aceitabilidade na alimentação escolar

**RESUMO:** O objetivo deste trabalho foi desenvolver um biscoito salgado adicionado de surimi de peixe e tomate em pó e verificar a sua aceitabilidade na alimentação escolar. Por meio do Delineamento Composto Central Rotacional (DCCR) foram testadas 11 formulações de biscoitos, com diferentes percentuais de surimi de Tilápia do Nilo (*Oreochromis niloticus*) desidratado e de tomate em pó, que foram caracterizadas fisicamente. As duas formulações com melhores resultados nas análises físicas, juntamente com uma formulação controle foram avaliadas quanto à composição centesimal, análise microbiológica, análise sensorial e perfil de aminoácidos. Os resultados foram submetidos à análise de normalidade dos dados, análise de variância, teste de Tukey, regressão múltipla e superfície de resposta. As formulações selecionadas, formulação 1 (10% de surimi + 15% de tomate em pó) e formulação 2 (13% de surimi + 13% de tomate em pó) apresentaram enriquecimento proteico, quando comparadas à formulação controle, com incremento no perfil de aminoácidos. Todas as formulações obtiveram contagem < 3 NMP/g de coliformes a 45 °C podendo ser submetidas a análise sensorial as quais obtiveram resultados variando entre indiferente e gostei, mostrando que ambas as formulações são viáveis para produção. No entanto, a formulação 2, por conter o maior teor proteico e lipídico, é a que mais se adequa ao emprego na alimentação escolar.

**Palavras-chave:** cereais; licopeno; tilápia

## Introduction

According to the Food Guide for the Brazilian Population, nutritionally speaking, fish consumption is advantageous as it is considered as a source from calcium, iron, vitamins and all essential amino acids, which are necessary for the required protein synthesis in the growth and maintenance of the human body and are rich in essential fatty acids, beneficial to health (Brazil, 2008).

However, the consumption of fish by schoolers reflects the low habit of fish consumption by the Brazilian population, where the insertion of fish and fishery products into school feed is low due to justifications such as: low acceptance, lack of habit, high cost, containing non-edible parts that may pose a health risk, among others. Reflecting on an average *per capita* consumption of 41.4 g/student/meal, which results in an annual per capita consumption of 2.0 kg (FNDE, 2013), if the fish is included in a weekly meal, a value considered low according to the World Health Organization (WHO), which recommends consumption of 12 kg *per capita*<sup>-1</sup> year<sup>-1</sup> (FNDE, 2013).

Different from the reality of fish consumption are the cereals and their derivatives that are the food basis of Brazilians since the 1970s to the present day, and have increased their consumption, with the consumption of biscuits drawing attention within this group (Brazil, 2008). The latest Family Budget Survey released (POF 2008/2009) reveals an annual *per capita* consumption in Brazil of biscuits and the like of 4,795 kg, with the Northeast region being the one with the highest consumption of biscuits in the country, having a *per capita* consumption of 5,619 kg (IBGE, 2010).

The Food Guide for the Brazilian population also recommends that the consumption of fruits, vegetables and greens, since they are sources from vitamins, minerals and bioactive compounds (Brazil, 2008). However, researches such as the Family Budget (2008-2009) and the National Survey of School Health (IBGE, 2012) reveal that Brazilians and consequently schoolers have a low consumption of these foods (IBGE, 2010).

As an alternative to the low fish consumption is the elaboration of new products by the food industry, using a wide accepted and consumed food, such as the biscuit, to serve as basis to be enriched with animal protein, like the surimi from fisheries, generating a practical food for consumption and with an added protein/nutritional value (Rebouças et al., 2012). In addition to the protein sources, fruits, vegetables and greens can also be added to cereals and other foods, in order to nutritionally enrich them with micronutrients and bioactive compounds, such as the lycopene (Bick et al., 2014).

In view of the exposed above, this study aimed to develop salted crackers added with surimi fish and powdered tomato and to verify their acceptability in the school feeding.

## Materials and Methods

### Raw material

The mechanically separated meat (MSM) from tilapia, necessary for the surimi elaboration, came from the National

Department of Works Against Drought (DNOCS) and the powdered tomato from a company located in São Paulo-SP. The other ingredients that were part of the biscuit formulation (wheat flour, margarine, baking soda, sodium bicarbonate, soy lecithin and salt) were purchased in the local markets from Fortaleza, Ceará.

### Reagents and equipment

The Meat and Fish Laboratory, the Grain Technology Laboratory, the Quality Control Laboratory and the Food Microbiology Laboratory, from the Federal University of Ceará, made the reagents and equipment necessary in order to carry out the research available. The space for conducting the sensorial analysis of the product was provided by Integral Elementary Schools located in the city of Quixeramobim-CE.

### Description of the experiment

The surimi was elaborated from mechanically separated meat (MSM) from tilapia that underwent dehydration to be used along with the powdered tomato in the development and enrichment of salted crackers that were evaluated for the acceptance in the school feeding. Surimi usage aimed at the protein increase, while the use of powdered tomato, which is a functional ingredient, made it possible to add bioactive compounds and micronutrients to the formulations.

Through the Rotational Central Composite Design (RCCD), applying a factorial design of 2<sup>2</sup>, 9 formulations and 2 replicates of the central point were elaborated with addition of different proportions from dehydrated surimi (7.92 to 22.07%) and powdered tomato (8.96 to 16.03%), having being required the patent (BR 10 2017 012775-3) for the formulations. The two formulations with best technological performance were selected and submitted to the centesimal composition analysis, microbiological analysis, sensorial analysis and amino acid profile, which were compared to a control formulation (without addition of surimi and powdered tomato).

### Physical characterization

The crackers formulations were evaluated for the following physical characteristics: weighing before and after cooking, thickness, diameter, specific volume by the 72-10 method of the AACC (2000), density by the inverse relation between the dislocated volume of millet seeds and the weight of the AACC (2000) baked sample, and the expansion index by methodology of Silva et al. (2003). We selected the two formulations with the best technological performance taking into account the physical characteristics.

### Centesimal composition

Humidity analysis was performed using AACC method 44-31 (2000), protein by the AACC method 46-13a (2000), lipids by the AACC method 30-26 (2000), ashes by the AACC method 08-12 from AACC (2000), carbohydrates by difference, not considering fiber, for it is already part of the carbohydrate content.

### Microbiological analyzes

The microbiological quality was attested by the analysis of coliform counts at 45 °C (APHA, 2001), carried out at the Food Microbiology Laboratory from the Federal University of Ceará.

### Sensory analysis

The sensorial evaluation from the selected formulations of cracker was held with 120 students of both sexes, enrolled in from the 6th to the 9th grade of Integral Elementary Schools in the city of Quixeramobim-CE. The formulations acceptability was evaluated using a structured hedonic scale of 5 points ranging from 1 – hated to 5 – loved, following a pattern suggested by the Manual for Application of Acceptability Tests in the Brazilian National School Feeding Program – PNAE, for children enrolled from the 6th year of elementary school. The attributes of appearance, color, aroma, flavor, crunchiness and global impression were evaluated (CECANE, 2017).

### Amino acids profile

The analysis of the amino acid or total amino acid profile was performed employing the Z100 high performance liquid chromatography (HPLC) method and the SAMITEC Institute (Analytical, Microbiological and Technological Solutions Ltd) performed the analysis. By means of the used methodologies (MacDonald et al., 1985; White et al., 1986; Elkim & Waszynczuk, 1987; Hagen et al., 1989), the composing protein from the food were hydrolyzed with 6 N hydrochloric acid for 24 hours. The released amino acids on the acid hydrolysis were reacted with phenyl isothiocyanate (PITC), separated by HPLC in reverse phase and detected by U.V. at 254 nm. The quantification was done by internal multilevel calibration, with the aid of  $\alpha$ -aminobutyric acid (AABA) with internal standard.

### Ethical aspects

The study was approved by the Research Ethics Committee of the Federal University of Ceará – UFC, under the legal opinion of number 1,540,475 and respecting Resolution no. 466/2012 concerning research involving human beings. The parents or guardians and the participants of the research were clarified of the objectives proposed by this investigation through the presentation of the Informed Consent Form (ICF)

and the Term of Assent, and they were asked to express the agreement of their participation in the research with the signature of the terms. The confidentiality of the information provided was guaranteed, as well as anonymity preservation of the participants.

### Statistical analysis

The results were submitted to the assessment of data normality, Analysis of Variance (ANOVA), Tukey test for means comparison at a significance level of 5%, regression analysis and response surface, with the data being expressed as mean and standard deviation. We used the Statistica 9.0 and Microsoft Excel 2013 softwares.

In the evaluation from the variables effects on the physical parameters of the crackers, the second-order regression model was used, by means of the equation 1.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_{11} X_1^2 + \beta_{22} X_2^2 + \beta_{12} X_1 X_2 \quad (1)$$

in which: Y = Dependent variable;  $X_1$  = surimi;  $X_2$  = powdered tomato;  $\beta_0$  = constant of the intercept;  $\beta_1$  and  $\beta_2$  = coefficients of linear effects;  $\beta_{11}$  and  $\beta_{22}$  = coefficients of quadratic effects;  $\beta_{12}$  = coefficient of effect and interaction among variables.

## Results and Discussion

### Physical characterization

A total of 9 formulations, 2 center point replicates and 1 control formulation of salted crackers added with surimi and powdered tomato were elaborated, according to the experimental design matrix, where the independent variables were addition of surimi and powdered tomato and the dependents were: specific volume, density and expansion index.

Table 1 displays the results obtained for the dependent variables and the Tukey test at 5% of significance.

Regarding the specific volume, the highest result was from assay 9 ( $1.83 \pm 0.07 \text{ mL g}^{-1}$ ) while the lowest was observed in formulation 6 ( $1.27 \pm 0.09 \text{ mL g}^{-1}$ ), in which the highest surimi percentage (22.07%) was added, which shows that the higher the amount of surimi added, the lower was the cracker

**Table 1.** Physical parameters from the salted crackers added with surumi and powdered tomato.

Performed assay	Surimi (%)	Powdered tomato (%)	Specific volume ( $\text{mL g}^{-1}$ )	Density ( $\text{g mL}^{-1}$ )	Expansion index
1	10	10	$1.71 \pm 0.17 \text{ ab}$	$0.58 \pm 0.06 \text{ b}$	$0.30 \pm 0.01 \text{ a}$
2	10	15	$1.56 \pm 0.06 \text{ abc}$	$0.64 \pm 0.02 \text{ b}$	$0.30 \pm 0.01 \text{ a}$
3	20	10	$1.67 \pm 0.04 \text{ ab}$	$0.59 \pm 0.01 \text{ b}$	$0.28 \pm 0.01 \text{ b}$
4	20	15	$1.52 \pm 0.11 \text{ abc}$	$0.65 \pm 0.04 \text{ ab}$	$0.29 \pm 0.01 \text{ ab}$
5	7.92	12.5	$1.64 \pm 0.07 \text{ ab}$	$0.61 \pm 0.02 \text{ b}$	$0.30 \pm 0.01 \text{ a}$
6	22.07	12.5	$1.27 \pm 0.09 \text{ c}$	$0.79 \pm 0.06 \text{ a}$	$0.30 \pm 0.01 \text{ a}$
7	15	8.96	$1.48 \pm 0.17 \text{ bc}$	$0.66 \pm 0.05 \text{ ab}$	$0.30 \pm 0.01 \text{ a}$
8	15	16.03	$1.77 \pm 0.12 \text{ ab}$	$0.60 \pm 0.08 \text{ b}$	$0.31 \pm 0.01 \text{ a}$
9	15	12.5	$1.83 \pm 0.07 \text{ a}$	$0.54 \pm 0.02 \text{ b}$	$0.30 \pm 0.01 \text{ a}$
10	15	12.5	$1.71 \pm 0.15 \text{ ab}$	$0.59 \pm 0.05 \text{ b}$	$0.30 \pm 0.01 \text{ a}$
11	15	12.5	$1.81 \pm 0.13 \text{ ab}$	$0.55 \pm 0.03 \text{ b}$	$0.30 \pm 0.01 \text{ a}$

\* Results expressed as mean  $\pm$  standard deviation. \*\* Means followed by the same letters in the same column do not present significant difference from each other by the Tukey test at 5% of significance.

specific volume, possibly because it interferes in the gluten network formation, which is not advantageous in bakery products. A slightly higher result was found in a cookie-type biscuit with substitution of 10% from wheat flour for defatted sesame flour, in which a specific volume of  $1.37 \pm 0.03 \text{ mL g}^{-1}$  was observed (Clerice et al. 2013).

About the density, assay 6 ( $0.79 \pm 0.06 \text{ g mL}^{-1}$ ) was the one that had the highest result, whereas the lowest value was obtained in assay 9 ( $0.54 \pm 0.02 \text{ g mL}^{-1}$ ), thus, lower levels of surimi addition are related to lower values of density. Because the surimi is a non-gluten-forming raw material, it has the characteristic of reducing the volume and increasing the density of the crackers. As for the expansion index, there was a variation between 0.28 and 0.30, with statistical difference being found only in two assays, 2 and 3, which shows that this parameter was practically unaffected by the different percentages of the ingredients addition.

The model that describes the behavior of the specific volume regarding the surimi and powdered tomato was represented by a second degree polynomial (Specific Volume =  $1.78 - 0.14(\text{Surimi}) - 0.16(\text{Surimi})^2 + 0.08(\text{Tomato}) - 0.08(\text{Tomato})^2$ ), in which the coefficient of determination found was  $R^2 = 0.7258$ , being it significant and the model valid.

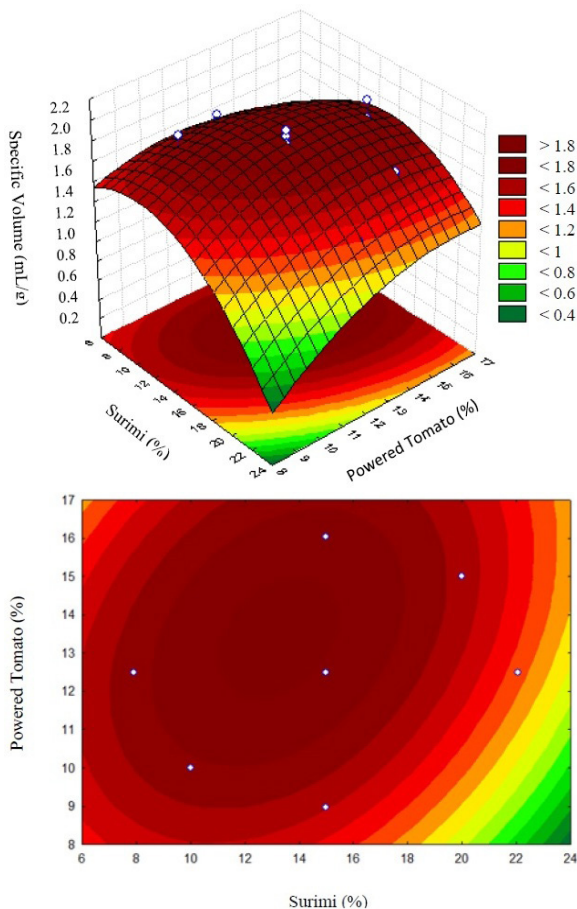
When analyzing the response surface (Figure 1), only two points were close to the region of greater specific

volume, corresponding to assay 8 and the central points. The optimum for the independent variables, for the specific volume, was 13.23% surimi and 13.40% powdered tomato. Such percentages could be considered advantageous when evaluating the specific volume of the cracker.

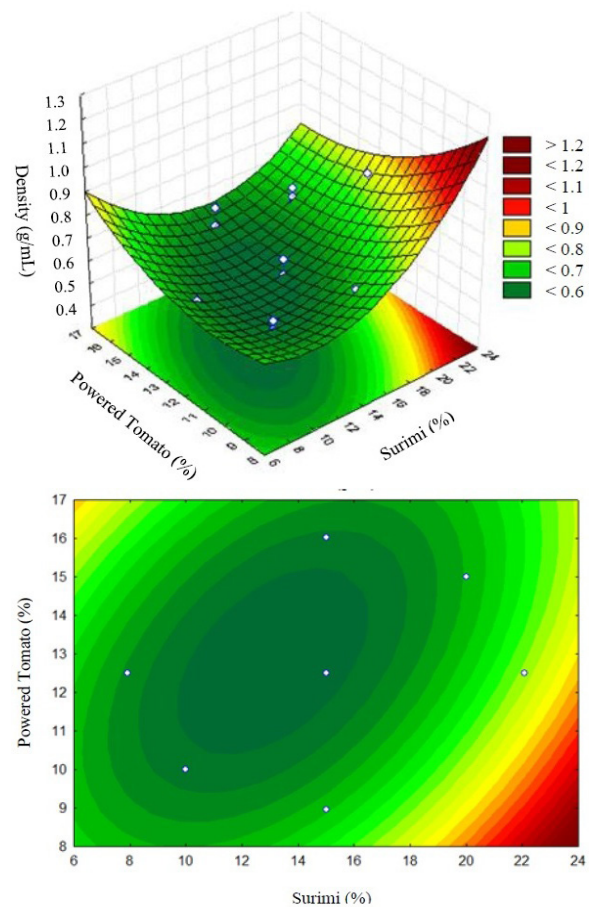
The addition of dry, non-gluten-forming ingredients is associated with the weakening of the gluten network and viscoelastic alterations that compromise the retention of gases from the fermentation, resulting in a lower specific volume (Borges et al., 2013). In the formulations in question, it is observed that surimi and powdered tomato are examples of non-forming gluten network ingredients, which may have negatively interfered with the specific volume of the crackers.

The density behavior is described by a surimi and powdered tomato model and is represented by a second degree polynomial (Density =  $0.56 + 0.05(\text{Surimi}) + 0.06(\text{Surimi})^2 - 0.02(\text{Tomato}) + 0.03(\text{Tomato})^2 - 0.04(\text{Surimi} * \text{Tomato})$ ), with the coefficient of determination from  $R^2 = 0.7069$ , having significance and being valid the model.

The response surface (Figure 2) shows that the higher the percentage of surimi addition is, the higher the density in the crackers will be, however, higher percentages of powdered tomato addition did not have a significant influence on the values of the cracker density. Among the 11 assays, only the



**Figure 1.** Response surface for the specific volume from assays of the salted crackers added with surimi and powdered tomato.



**Figure 2.** Response surface for the specific volume from assays of the salted crackers added with surimi and powdered tomato.



central points were located in the desired region of lower density. The optimal percentages of surimi and powdered tomato addition for a better density were respectively 13.10% and 12.80%. The optimal percentages could be considered advantageous when evaluating the density of the cracker.

Anjos et al. (2014) reported that the density is linked to the pattern of formed alveoli during the masses kneading, with the used ingredients being able to influence this technological characteristic. As for the expansion index,  $R^2$  was of 0.3920; therefore, the response surface does not present sufficient statistical reliability to express the effect of surimi and powdered tomato on the expansion index of crackers. Thus, the non-statistical reliability of the evaluation from the index of expansion by the response surface prevents the use of this parameter as one of the selection requirements from the formulations with the best technological performance.

After the physical characterization and response surface analysis of the 11 assays from salted crackers added with surimi and powdered tomato were selected two assays with better technological performance regarding specific volume and density, in order to carry out the centesimal composition, microbiological analysis, sensorial analysis and amino acid profile, along with the control formulation. For the next steps, the selected assays were named control formulation, formulation 1, with addition of 10% surimi and 15% powdered tomato and formulation 2, with addition of 13% surimi and 13% powdered tomato, with the latter formulation coming from the optimum points identified in the response surface and the formulation 1 with the percentages that most approached the results from the optimal points.

### Centesimal composition

Table 2 displays the results of the centesimal composition (humidity, carbohydrates, proteins, lipids and ashes) from the control crackers formulations and from formulations 1 and 2, selected through the physical assessments.

Regarding the humidity percentage, formulation 2 differed from the others, having the lowest result. The humidity contents from all formulations were considered low and within the limit stipulated in legislation, which is 14.0% (Brazil, 1978), which is advantageous for maintaining the sensory and microbiological quality during the storage. The lowest humidity content, 3.12% and 0.48%, were found in crackers added with fish and prepared in microwave and by frying, respectively (Neiva et al., 2011).

It is possible to verify a significant difference ( $p < 0.05$ ) in the carbohydrate content between the control formulation and the other formulations (Table 2), with the control formulation having a higher carbohydrate content, which would be expected, considering that the surimi addition increased the protein percentage from formulations 1 and 2, reducing the percentage of carbohydrate.

Regarding the protein content, the three samples had a significant difference ( $p < 0.05$ ) between them, and the control sample, in which there was no surimi addition, had, as expected, the lowest protein value and formulation 2, in which the highest percentage of surimi was added, presented the highest protein content, making the surimi added crackers good protein sources. In wheat-based crackers, added with sturgeon fillet powder, protein contents ranging from 13.23 to 17.12% were observed (Abraha et al., 2018).

The surimi addition to the formulations promoted an increase in the protein percentage of the crackers, which can be considered advantageous, bearing in mind that this study sought to develop a cracker that is a good source from proteins to be offered in school feeding. For Vitolo (2014), the proteins supply to children and teens is crucial in maintaining the growth of new tissues, a process that is accelerated in this cycle of life.

The lipid percentage presented a significant difference ( $p < 0.05$ ) between the formulations. In formulation 2, a higher lipid content was observed in relation to the others, possibly due to the addition of a higher surimi percentage. In fish-based crackers, prepared in the microwave and by frying, different percentages of lipids were observed, due to the different preparation methods, with the non-fried crackers having a percentage of lipids of 0.42% and the fried crackers having 26.11% lipids (Neiva et al., 2011). In this study, no interference from the cooking in the final lipid content occurred, as observed in the cited study, considering that the crackers were baked in the oven and not fried.

Since the crackers formulations have been subjected to storage, it is necessary to understand the possible interferences in product quality that are linked to their lipid content. According to Koblitz (2017), the presence of lipids in the food matrix may favor degradation reactions through the action of lipases, which promote hydrolytic rancidity, as well as due to the presence of oxygen, through oxidative rancidity.

The control formulation showed a significant difference when compared to formulations 1 and 2, with the control

**Table 2.** Centesimal composition of the control formulation and of the selected formulations of salted crackers added with surimi and powdered tomato.

Variables (%)	Formulations		
	No surimi addition	10% surimi + 15% powdered tomato	13% surimi + 13% powdered tomato
Humidity	5.73 ± 0.05 a	5.68 ± 0.10 a	5.08 ± 0.23 b
Carbohydrates	71.10 ± 0.44 a	64.71 ± 0.25 b	63.88 ± 0.35 b
Proteins	12.28 ± 0.41 c	17.99 ± 0.21 b	19.28 ± 0.58 a
Lipids	8.27 ± 0.13 b	8.41 ± 0.07 ab	8.55 ± 0.07 a
Ashes	2.62 ± 0.02 b	3.21 ± 0.03 a	3.22 ± 0.04 a

\* Results expressed as mean ± standard deviation. \*\* Means followed by the same letters in the same column do not present significant difference from each other by the Tukey test at 5% of significance.

formulation having the lowest ashes content. The formulations 1 and 2 did not present significant differences ( $p \geq 0.05$ ) from each other regarding ash content, considering that ashes are composed from important minerals to the organism function, both crackers are shown as good sources from minerals for the students, the target audience. Lower ashes contents were observed in crackers prepared with varying percentages of quinoa flour, ranging from 1.15% to 2.19% (Bick et al., 2014). In fish-based crackers, the results from the ashes analyzes were similar to those obtained in this research, with 3.58% in microwave cracker and 2.64% in fried cracker (Neiva et al., 2011). When comparing with the literature, it was possible to notice that the fish addition to the cracker formulations may have had a positive influence on the ashes content.

### Microbiological analysis

In the coliform count at 45 °C in the three crackers formulations that were submitted to the sensorial analysis, we found coliform values at 45 °C < 3 MPN g<sup>-1</sup>. The current legislation establishes as maximum tolerance in indicative samples the coliforms amount of 10 MPN g<sup>-1</sup> at 45 °C. Thus, considering the established limits, all formulations are in accordance with board resolution (Resolução da Diretoria Colegiada - RDC) no. 12, which guarantees the sanitary quality of the processed crackers in the analyzed parameter (Brazil, 2001).

### Sensorial analysis

The sensorial analysis of the three formulations, control and addition of surimi and powdered tomato, was carried out in two full-time elementary schools in the municipality of Quixeramobim-CE, counting on a total of 120 non-trained and randomly selected tasters. Participants were characterized as to gender, age group and schooling, and such information is shown in Table 3.

Table 3 shows that female participation was slightly higher, with 50.83% (n = 61); that the age range of the tasters ranged from 11 to 17 years old, with a predominance of 12 and 13

years old participants, which represents a total of 65.83% (n = 79). Among the tasters; students enrolled in from the 6th to 9th grades of elementary school participated in the research, with a higher participation of the students who were attending the 7th year, while the 8th year had the lowest number of participants, mainly due to the recruitment form of the tasters, in the which all the students were invited to participate and then decided whether or not they wanted to take on the test.

The taste, color, aroma, crispness, flavor and global impression of the crackers were evaluated by the acceptability test (Table 4), and the tasters assigned scores ranging from 1 (detested) to 5 (loved).

The inclusion of surimi and powdered tomato influenced the evaluated sensorial parameters, leaving the control formulation classified between "liked" and "loved" for appearance, color and global impression, while its flavor was evaluated between "indifferent" and "liked". Aroma and crispness were not influenced by the inclusion of surimi and powdered tomato.

When comparing with other results found in studies with fish addition in crackers, it can be stated that the acceptance of the surimi added crackers were within an average positive acceptance and that possibly small adjustments in the formulations could generate better results for shared meals.

In the research carried out with salty crackers added with fish protein concentrate, average scores for appearance, aroma, flavor, texture and global impression were observed, with an similar evaluation to that observed in the added crackers with surimi and powdered tomato, bearing in mind that the cited research used a hedonic scale of 9 points and obtained average scores between "do not liked it, nor disliked it" and "liked it slightly" (Rebouças et al., 2012).

Positive results from sensorial acceptance were also observed in microwave and fried fish crackers, where, within a hedonic scale of 9 points, attributes color, crispness, taste and general acceptance, obtained average scores above 7 in their majority (Neiva et al., 2011).

**Table 3.** Characterization of the tasters.

	Gender		Age (years old)						Grade/Year			
	F	M	11	12	13	14	15	17	6th	7th	8th	9th
No.	61	59	9	47	32	17	14	1	20	65	12	23
%	50.83	49.17	7.5	39.16	26.67	14.17	11.67	0.83	16.67	54.16	10	19.17

**Table 4.** Acceptability of the control formulation and of the selected formulations from salted crackers added with surimi and powdered tomato in schoolers from Quixeramobim/CE.

Sensorial parameters	Formulations		
	No surimi addition	10% surimi + 15% powdered tomato	13% surimi + 13% powdered tomato
Appearance	4.09 ± 0.91 a	3.53 ± 0.97 b	3.42 ± 1.08 b
Color	4.04 ± 0.92 a	3.42 ± 0.98 b	3.36 ± 1.06 b
Aroma	3.77 ± 1.11 a	3.54 ± 1.20 a	3.42 ± 1.22 a
Crunchiness	4.26 ± 1.02 a	3.93 ± 1.17 ab	3.84 ± 1.23 b
Taste	3.91 ± 1.19 a	3.34 ± 1.39 b	3.34 ± 1.42 b
Global Impression	4.11 ± 1.11 a	3.51 ± 1.31 b	3.58 ± 1.25 b

Source: elaborated by the author

\* Results expressed as mean ± standard deviation. \*\* Means followed by the same letters in the same column do not present significant difference from each other by the Tukey test t 5% of significance.

**Table 5.** Total amino acids in the control and the added with surimi and powdered tomato salted crackers.

Amino acids	Formulations		
	No surimi addition	10% surimi + 15% powdered tomato	13% surimi + 13% powdered tomato
Aspartic acid (mg g <sup>-1</sup> )	2.8	11.1	13.1
Glutamic acid (mg g <sup>-1</sup> )	40.5	57	58.8
Serine (mg g <sup>-1</sup> )	4.4	6.7	7.8
Glycine (mg g <sup>-1</sup> )	3.1	6.4	7.9
Histidine* (mg g <sup>-1</sup> )	2.0	3.7	4.3
Arginine (mg g <sup>-1</sup> )	2.9	6.2	8.0
Threonine* (mg g <sup>-1</sup> )	2.3	5.3	6.5
Alanine (mg g <sup>-1</sup> )	2.7	6.8	8.1
Proline (mg g <sup>-1</sup> )	9.6	11.3	12.5
Tyrosine (mg g <sup>-1</sup> )	1.8	2.1	3.3
Valine* (mg g <sup>-1</sup> )	3.4	5.8	6.7
Methionine* (mg g <sup>-1</sup> )	1.6	2.8	3.9
Cystine (mg g <sup>-1</sup> )	1.7	1.7	2.1
Isoleucine* (mg g <sup>-1</sup> )	2.9	5.0	5.8
Leucine* (mg g <sup>-1</sup> )	5.9	9.8	11.0
Phenylalanine* (mg g <sup>-1</sup> )	4.2	5.6	6.3
Lysine* (mg g <sup>-1</sup> )	1.5	5.9	6.9

\* Essential amino acids.

### Amino acid profile (aminogram)

Considering that the surimi addition in the salted cracker formulation promoted a protein increase in the product and that the proteins are composed of amino acids, it is interesting to verify the quality of the amino acid profile present in the studied formulations. Table 5 shows the total amino acid profile quantified in the control formulation (with no addition of surimi and powdered tomato) and in the two formulations added with surimi and powdered tomato by means of HPLC.

In the aminogram, the presence of eight from the nine known essential amino acids were identified, being they: histidine, threonine, valine, methionine, isoleucine, leucine, phenylalanine and lysine. Moreover, there was an increase in the contents of said amino acids in the added formulations of dehydrated surimi, with formulation 2, which received 13% surimi addition, the one that presented higher levels of essential and non-essential amino acids. This result demonstrates that a nutritional increase occurred in the added formulations with surimi and powdered tomato.

We observed that with the addition of surimi and powdered tomato, there was an increase in the value from amino acids like histidine and threonine, which doubled in quantity. Among the essential amino acids, the greatest increases occurred in the lysine, threonine and methionine amino acids, while among the non-essential amino acids, the ones that had a significant increase in their amount were aspartic acid, alanine and arginine. The significant increase in the content from the lysine and threonine amino acids has its nutritional importance, bearing in mind that these are limiting amino acids in cereals (Neiva et al., 2011).

The fact that the crackers in question have a good source of essential amino acids becomes a nutritional advantage, since the said amino acids must be supplied through a balanced dietary intake, which meets the individual needs of each diner, providing the growth maintenance in children and teens, as well as homeostasis in adults (Tirapegui et al., 2016).

### Conclusion

It was possible to develop formulations of salted crackers added with surimi fish and powdered tomato, with an increase in nutritional value, especially in protein content and well accepted by schoolers.

Amino acid analysis showed increase in all amino acids in the surimi added formulations, especially for the lysine, threonine and methionine contents, which are essential amino acids.

Formulations 1 and 2, according to the sensorial analysis, are feasible to be produced. However, formulation 2 (13% surimi + 13% powdered tomato), due to it containing the highest protein and lipid content, is the one that is most suitable for employment in school feeding.

### Acknowledgements

To the Coordination for the Improvement of Higher Education Personnel - Brazil - CAPES (Financing Code 001), for granting the scholarship for the first author.

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