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Addition of different tuna meal levels to pizza dough

Inclusão de diferentes níveis de farinha de atum em massas de pizza

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Abstract

The aim of this study was to develop pizza dough with different levels of tuna meal (*Tunnus* spp.). In order to produce tuna meal, tuna torsos without fins were used, cooked for 1 hour, pressed, milled and dehydrated for 24 hours at 60 °C. Pizza dough was produced without (0%) or with the addition of 5, 10, 15 and 20% of tuna meal, calculated based on the quantity of wheat flour. The tuna meal and different pizza pastries were analyzed for moisture content, crude protein, total lipids, ash, carbohydrates, caloric value and fatty acid profiles. Microbiological and sensory analyses were also carried out on the pizza pastries. The increasing addition of tuna meal resulted in gains in the crude protein (10.89 to 18.94%), total lipid (4.63 to 5.89%) and ash (2.54 to 3.54%) contents of the pizza pastries, not influencing the moisture content or caloric value. The inclusion of tuna meal linearly increased the quantity of n-3 series fatty acids in the pizza pastry, from 1.56 to 5.93 g/kg with the addition of 20% tuna meal. The ratio between the polyunsaturated and saturated fatty acids in the tuna meal and pizza pastries varied from 1.21 to 1.85. The microbiological analyses showed that the pizza pastries were produced under proper hygiene conditions. It was also observed that the addition of 5 to 20% of tuna meal to the pizza pastry did not significantly ($p>0.05$) alter the parameters of aroma, flavor, overall impression and purchase intention. It was therefore concluded that the addition of 5 to 20% tuna meal is effective in improving the nutritional value and fatty acid profile of pizza pastry.

Keywords: *Non-standardized tuna; Dough; Ômega-3; Fishery technology.*

Resumo

O objetivo deste trabalho foi desenvolver massas de pizza com diferentes níveis de inclusão de farinha de atum (*Tunnus* spp.). Para a produção da farinha de atum, foram utilizados troncos de atum sem nadadeiras, cozidos por uma hora, prensados, moídos e desidratados por 24 horas a 60 °C. Foram elaboradas massas de pizza sem inclusão (0%) ou com inclusão de 5, 10, 15 e 20% de farinha de atum, sendo estas inclusões calculadas com base na quantidade de farinha de trigo. A farinha de atum e as diferentes massas foram analisadas quanto aos teores de umidade, proteína bruta, lipídeos totais, cinzas e carboidratos, além do valor calórico e do perfil de ácidos graxos. Análises microbiológica e sensorial foram realizadas nas massas de pizza. A crescente inclusão de farinha de atum resultou em aumento do teor de proteína bruta (10,89 a 18,94%), de lipídeos totais (4,63 a 5,89%) e de cinzas (2,54 a 3,54%) nas massas, sem influenciar no teor de umidade e no valor calórico. A inclusão de farinha de atum aumentou linearmente a quantidade de ácidos graxos da série n-3 nas massas, com aumento de 1,56 para 5,93 g/kg, em 20% de inclusão de farinha de atum. A relação entre ácidos graxos poli-insaturados e saturados da farinha de atum e das massas variou entre 1,21 e 1,85. A análise microbiológica demonstrou que as massas foram produzidas em condições adequadas de higiene. Observou-se que a inclusão de 5 a 20% de farinha de atum na massa de pizza não interferiu significativamente ($p>0,05$) nos parâmetros de aroma, sabor, impressão global e intenção de compra. Concluiu-se que a inclusão de 5 até 20% de farinha de atum é eficaz para melhorar o valor nutritivo e o perfil de ácidos graxos de massa de pizza.

Palavras-chave: *Atum despadronizado; Massa alimentícia; Ômega-3; Tecnologia do pescado.*

1 Introduction

In Brazil, the beef and poultry industries have developed different products from industrial byproducts, but the Brazilian fish industries have not accompanied these innovations since they do not recognize this resource as a feedstock for other products (MALUF et al., 2010) despite being considered as having high nutritional quality. However, the application of such byproducts is very advantageous since it contributes to reducing the amount of unused waste materials and production costs, as well as decreasing environmental pollution generated by inappropriate waste management.

Tuna (*Tunnus* spp.) possesses great quantities of polyunsaturated fatty acids of the omega-3 (n-3) series (FRADET et al., 2009), mainly due to its diet which is composed of saltwater phytoplankton and zooplankton, which are rich in n-3 fatty acids (LORDAN et al., 2011). The majority of the tuna consumed in Brazil is imported, coming from marine extractive fishery, even though Brazilian production reached 725 t in 2010 (BRASIL, 2012).

Several nutritional and health benefits have been attributed to n-3 fatty acids, especially to eicosapentaenoic acid (EPA or 20:5n-3) and docosahexaenoic (DHA or 22:6n-3). These benefits include the prevention and treatment of cardiovascular diseases, reduction of hypertension, the prevention of a variety of psychiatric and neurological disorders in neurodegenerative conditions, and the prevention of many types of cancer (DYALL; MICHAEL-TITUS, 2008; VAN DEN ELSEN et al., 2012; MERENDINO et al., 2013). Furthermore, fish products contain low levels of cholesterol (mainly low-density lipoprotein LDL), are rich in minerals, mainly calcium and phosphorus, and contain some vitamins, such as A, D and the B complex, (VILA NOVA et al., 2005). They are also good protein sources, having high biological value and good digestibility. Generally they are rich in methionine and cysteine, which are limiting amino acids in many foods (JABEEN; CHAUDHRY, 2011). The high nutritional value of fishery and its by-products encourages the development of new products for human nutrition (FELTES et al., 2010), if they are recovered under appropriate conditions to be incorporated into food products.

The World Health Organization (WHO) recommends the consumption of 12 kg of fish per person/year, but in Brazil the consumption is around 9.75 kg of fish per person/year (BRASIL, 2012). This value is low since consumer eating habits lack products derived from fish, due to the low availability of good quality fish on the market, the consumer socioeconomic factor and an insufficient offer of convenient fish products (e.g. easy to cook or ready to eat) (TRONDSEN et al., 2003).

Pizza is one of the most famous foods worldwide. The consumer demand for pizza, a product that is traditionally consumed in European countries, has also expanded in American countries, such as in the USA and Brazil (SAHOTA, 2006). Pizza came to Brazil through its Italian immigrants at the end of the 20th century, and today is considered to be one of the most popular foods in the country.

Brazilian purchasing power is growing and the pursuit for tasty, nutritional and convenient products has led to a differentiation in the pizza market, with diversified flavors, different ingredients added to the dough, a variety of fillings and different preparation techniques. Nowadays, pizzas made with whole grain dough, rich in fibres, gluten free, low in calories, thin base, square shaped, round shaped, frozen, fresh, and ready to eat, amongst others, are available on the market. However, the market lacks pizza dough enriched with proteins or omega-3, thus the objective of this study was to develop pizza dough with the addition of different levels of tuna meal, aiming to improve the nutritional value of pizza crusts.

2 Material and methods

The tuna meal was produced in the Laboratory of Fishery Technology at the Iguatemi Experimental Farm of the State University of Maringá (UEM) in November 2012. To produce the meal, 8.1 kg of tuna torsos (without fins, but with bones, skin and muscles, considered off-standard for industrial classification), obtained from the fishery processing company Gomes da Costa located in Itajaí – SC, Brazil, were used.

The tuna torsos were washed in chlorinated water, weighed, and then placed separately in industrial pressure cookers (20 L capacity) containing enough water to cover the tuna torsos. In sequence, 0.5% of BHT antioxidant and 0.5% of peroxitane were added, and the material was cooked on an industrial stove for sixty minutes. The water was then discarded and the tuna torsos pressed in a hydraulic press (15 t capacity) with 10 t of pressure. The resulting cake was milled in an electric meat grinder, and the resulting mass submitted to dehydration in a forced air oven for 24 h at 60 °C. After dehydration, the mass was milled in a knife mill, resulting in the fish meal used in the evaluations. The fish meal was conditioned in plastic bags and stored in a freezer (-15 °C) until used to produce the dough.

The formulations for the preparation of the pizza dough with the inclusion of 0, 5, 10, 15 and 20% of tuna meal, are shown in Table 1, the increases in tuna meal being compensated by decreases in wheat flour. The quantities of tuna meal used in the different pizza doughs were calculated based on the quantity of wheat flour used in the control.

In order to prepare the different doughs, the ingredients were manually mixed in a recipient for about 5 min, at room temperature until complete homogenization.

The dough then rolled out to a thickness of 7 mm using a roll, and baked for 20 min at 210 °C, in a gas oven. The pizza crusts were cooled for further use.

The chemical composition (moisture, total lipids, crude protein and ash) of the meal and of the different pizza crusts was determined in triplicate, according to AOAC methodology (LATIMER, 2012), and the carbohydrate content determined by difference. The total caloric value was obtained by multiplying the average values for proteins, lipids and carbohydrates by the factors of 4, 9 and 4 respectively and adding up the results (SOUCI et al., 2000).

The fatty acid profiles of the tuna meal and different pizza crusts were determined according to AOAC methodology (LATIMER, 2012) in the CBO Laboratorial Analysis (Campinas, SP).

In order to verify the processing and handling hygiene conditions of the pizza crusts, microbiological analyses were carried out for coliforms at 35 and 45 °C, coagulase positive Staphylococcus and *Salmonella* spp. (BRASIL, 2003).

A sensory analysis was carried out at a local farm fair in the city of Maringá – PR, with 100 randomly chosen untrained tasters. Pizza crust samples with the addition of different levels of tuna meal were offered to judges under natural light. The five samples were placed in disposable plastic dishes and randomly identified. The tasters were oriented on how to carry out the analysis.

In order to evaluate the sensory attributes of pizza crusts (colour, aroma, softness, flavour and overall impression), a 9-point hedonic scale was used, set between a minimum and maximum score: 1 (disliked extremely) and 9 (liked extremely) (DUTCOSKY, 2007). The samples were also submitted to a purchasing intention test, using a 5-point hedonic scale with extremes of 1 (certainly would not buy) and 5 (certainly would buy). A cup of water was offered in order remove the aftertaste.

The statistical analysis was carried out with the aid of the statistical program SAS 9.0 (Statistical Analysis System; SAS Inc., Cary, North Caroline, USA). The chemical composition and sensory analysis data for the different treatments was submitted to the PROC GLM procedure and in the event of significant difference ($p<0.05$), a linear regression analysis was carried out for the chemical composition and Tukey's test for the sensory analysis.

Descriptive analysis of the data was used to evaluate the fatty acid profiles and microbiological analyses.

3 Results and discussion

The nutritional value, appearance and flavour has an important role in pizza crusts. The dough is commonly prepared from wheat flour, presenting around 65% of starch, less than 2% of lipids, less than 0.5% of ash and around 12% of crude protein (VASIL; ANDERSON, 1997; CARTER; HAULER, 2000). The chemical composition of the tuna meal presented a much higher value for crude protein compared to the previously cited wheat dough, as well as higher values for total lipid and ash and a lower value for carbohydrate (Table 2).

The moisture content observed in the tuna meal was lower than the values reported in studies with shrimp cephalothorax meal (5.77%) (FERNANDES et al., 2013) and tilapia head meal (6.00%) (STEVANATO et al., 2007). The crude protein values found for tuna meal were superior to those found in shrimp cephalothorax meal (50.05%) and tilapia head meal (38.44%) in studies by Fernandes et al. (2013) and Stevanato et al. (2007), respectively. However, the same authors found higher ash values of 19.40% for shrimp cephalothorax meal and 20.97% for tilapia head meal. The high values for protein and low values for ash observed in this study can be explained by the greater use of the musculature and consequently, reduced proportion of bones in the elaboration of the tuna meal.

No differences were observed ($p<0.05$) for the moisture contents and caloric values of the pizza crusts with different levels of tuna meal. The crude protein, total lipid and ash contents increased linearly according to the increase in tuna meal addition. To the contrary, the

Table 1. Ingredients (g/kg) of the pizza dough with different levels of tuna meal.

Ingredients (g/kg)	Levels of tuna meal in the pizza dough[1] 0%	5%	10%	15%	20%
Wheat flour	495.28	470.52	445.75	420.99	396.23
Tuna meal	0.00	24.76	49.53	74.29	99.06
Butter	23.58	23.58	23.58	23.58	23.58
Soybean oil	24.76	24.76	24.76	24.76	24.76
Biological yeast	58.96	58.96	58.96	58.96	58.96
Sugar	15.33	15.33	15.33	15.33	15.33
Salt	16.51	16.51	16.51	16.51	16.51
Milk	294.81	294.81	294.81	294.81	294.81
Egg	70.75	70.75	70.75	70.75	70.75
Total	1000	1000	1000	1000	1000

[1]Levels of the tuna meal added according to the wheat flour used in the control dough.

Table 2. Chemical composition of the tuna meal.

Parameters (%)	Tuna meal
Moisture	4.57±0.03
Crude Protein	79.47±0.33
Total lipids	5.34±0.23
Ash	5.03±0.16
Carbohydrates	5.54±0.56
Caloric value (kcal/100 g)	388.17±1.29

Data presented as the mean ± standard deviation.

carbohydrate content decreased linearly with the increase in tuna meal addition (Table 3).

According to Stevanato et al. (2007) and Franco et al. (2013), the addition of tilapia head meals to soups given as school lunch or the addition of tilapia carcass meals to cookies and biscuits, leads to an increase in the quantity of crude protein, lipids and ash in these products, supporting the results of the present study.

Twenty four types of fatty acids were identified in the tuna meal and pizza crusts with different levels of tuna meal. Of the major fatty acids, docosahexaenoic acid (22:6n-3) was found in the greatest proportion in tuna meal, followed by palmitic acid (16:00) and oleic acid (18:1n-9 c) (Table 4).

The different pizza crusts presented greater proportions of palmitic acid (16:00), with values varying from 12.02 to 15.36 g/kg, oleic acid (18:1n-9 c), from 13.31 to 15.19 g/kg, and linoleic acid (18:2n-6), from 17.81 to 23.26 g/kg (Table 4). This was probably due to the fact that the tuna meal contained 18.86 g/kg of palmitic acid (16:00) and 11.28 g/kg of oleic acid (18:1n-9 c). Furthermore, the soybean oil used in the pizza formulation, like other vegetable oils (sunflower, safflower, maize and cotton), presents high contents of the n-6 series fatty acids, mainly linoleic acid (18:2n-6) (NOVELLO et al., 2010).

Higher proportions of the n-3 fatty acids were identified in pizza crusts with higher levels of tuna meal, due to a gradual increase in the proportions of linolenic acid (18:3n-3), eicosapentaenoic acid (EPA or 20:5n-3) and docosahexaenoic acid (DHA or 22:6n-3) as the level of tuna meal increased. The same pattern was observed for the sum of the polyunsaturated fatty acids (PUFA) and for the PUFA/SFA (Saturated Fatty Acids) ratio. The n-6/n-3 ratio gradually decreased with the increment in tuna meal in the pizza crust (Table 4).

The fatty acids DHA and EPA were found in tuna meal in concentrations of 30.91 and 5.96 g/kg, respectively. Moreira et al. (2003) found much lower concentrations of DHA in the heads of “matrinxã” (*Brycon cephalus*), 4.10 g/kg, “piraputanga” (*B. microlepis*), 5.50 g/kg, and “piracanjuba” (*B. orbignyanus*), 5.00 g/kg. The same was observed for the EPA concentrations in “matrinxã” (0.70 g/kg), “piraputanga” (1.60 g/kg) and “piracanjuba” (2.20 g/kg). Saltwater fish present higher concentrations of PUFA, such as EPA and DHA, than freshwater fish, probably due to the cold waters where these fish are found, since PUFA are important to maintain membrane flexibility (SARGENT et al., 1995). In addition saltwater fish feed on algae, which contain great quantities of the n-3 series fatty acids (MARTINO, 2003).

The n-3 fatty acids, especially DHA and EPA, are essential for normal growth and development, and may play an important role in the prevention and treatment of numerous diseases. The intake of n-3 fatty acids is low because of the low consumption of cold water fish, and the industrial production of animal feeds rich in grains containing n-6 fatty acids (KEARNEY, 2010).

Higher concentrations of DHA were found by Narayan et al. (2012) on working with tuna and seerfish (*Scomberomorous commerson*) heads, finding values of 267.00 and 132.00 g/kg, respectively. The same author found EPA concentrations that were also higher than the values observed in tuna meal, of 58.00 and 99.00 g/kg for tuna and seerfish heads, respectively. Head and viscera are expected to be rich in lipids and proteins and can be a good source of PUFA (SWAPNA et al., 2010). Thus, this probably explains the lower values for DHA and EPA observed in the present study, since the tuna meal used was produced without heads or viscera.

The PUFA/SFA ratios of the tuna meal and the pizza crusts presented values above 0.45 g/kg. Foods with PUFA/SFA ratios below 0.45 g/kg, are considered unhealthy, especially for people with cardiovascular problems (WILLIAMS, 2000; RAES et al., 2004).

Foods with a low n-6/n-3 ratio are not recommended for human nutrition, since n-6 and n-3 fatty acids are precursors of PUFA and substrates of the same enzyme, Δ-6 desaturase. This enzyme has a greater affinity for n-3 precursors, capable of leading to excess DHA formation in relation to arachidonic acid (ARA or 20:4n-6) (ZHENG et al.,

Table 3. Chemical composition of pizza crusts with different levels of tuna meal.

Parameters (%)	Levels of tuna meal in the pizza dough				
	0%	5%	10%	15%	20%
Moisture^{NS}	26.64±4.70	30.07±1.77	29.61±2.38	28.15±3.23	26.54±1.11
Crude Protein[1]	10.89±0.95	12.26±0.24	14.78±0.19	17.54±1.63	18.94±0.24
Total lipids[2]	4.63±0.33	4.75±0.35	5.05±0.25	5.89±0.33	6.10±0.41
Ash[3]	2.54±0.12	2.52±0.27	2.93±0.33	2.84±0.31	3.54±0.28
Carbohydrates[4]	55.30±3.54	50.40±1.92	50.40±1.93	45.58±2.99	44.87±0.84
Caloric value (kcal/100 g)^{NS}	306.40±20.90	293.40±7.62	295.10±7.61	305.50±15.73	310.20±3.89

Data presented as the mean ± standard deviation. ^{NS}Not significant. [1]Linear effect (Yi = 10.6 + 0.4279x), R^2 = 0.94. [2]Linear effect (Yi = 4.466 + 0.082x), R^2 = 0.77. [3]Linear effect (Yi = 2.408 + 0.046x), R^2 = 0.57. [4]Linear effect (Yi = 53.89 – 0.513x), R^2 = 0.70.

2009). Therefore, a greater proportion of n-6 in relation to n-3 fatty acids is recommended, in order to prevent a predominance of a certain type of fatty acid in detriment of others. Thus the n-6/n-3 ratio of foods has great relevance in human nutrition, with the most suitable values being between 4 and 5 g/kg (RAES et al., 2004). The pizza crusts with different additions of tuna meal, especially the two highest levels of 15 and 20%, presented good n-6/n-3 ratios of 4.72 and 4.00 g/kg, respectively.

Table 4. Fatty acid profiles of the tuna meal and pizza crusts with different levels of tuna meal.

Fatty acid (g/kg)	Tuna meal	Levels of tuna meal in the pizza dough				
		0%	5%	10%	15%	20%
12:00	0.08	0.65	0.24	0.23	0.22	0.44
14:00	3.13	3.11	2.07	1.72	2.15	2.20
15:00	0.66	0.33	0.29	0.24	0.34	0.26
16:00	18.86	15.29	13.76	12.02	15.36	12.93
17:00	0.78	0.23	0.22	0.21	0.28	0.23
18:00	6.52	5.14	4.86	4.42	5.70	4.81
20:00	0.19	0.13	0.11	0.12	0.16	0.15
21:00	n	n	0.02	0.02	0.02	0.03
22:00	0.16	0.13	0.11	0.10	0.12	0.16
23:00	0.06	0.05	0.03	0.04	0.03	0.04
24.00	0.39	0.12	0.10	0.12	0.15	0.14
14:1n-5	0.41	n	0.08	0.09	0.07	0.14
16: 1n-7	3.32	0.95	0.76	0.68	0.8	0.88
18:1n-9 c	11.28	15.19	14.7	13.31	14.54	14.79
20:1n-9	1.25	0.10	0.12	0.13	0.17	0.21
22:1n-9	0.11	0.01	0.01	0.01	0.02	0.02
18:2n-6	1.41	17.81	19.45	19.22	19.89	23.26
18:3n-3	0.61	1.45	1.56	1.55	1.69	2.18
20:2n-6	0.14	0.03	0.05	0.05	0.05	0.04
20:3n-6	0.08	0.04	0.05	0.06	0.05	n
20:4n-6	2.08	0.16	0.26	0.28	0.34	0.42
20:5n-3	5,36	0.03	0.15	0.17	0,31	0.50
22:6n-3	30.91	0.08	0.71	1.53	2.31	3.25
18:1n-9 t	n	n	0.11	0.09	0.11	0.09
[1]SFA	30.82	26.33	21.81	19.24	24.53	21.39
[2]MUFA	16.89	16.25	15.67	14.22	15.6	16.04
[3]PUFA	40.76	19.6	22.34	22.95	24.75	29.74
[4]PUFA/SFA	1.32	1.21	1.43	1.61	1.59	1.85
n-6	3.78	18.04	19.81	19.61	20.33	23.72
n-3	36.98	1.56	2.42	3.25	4.31	5.93
[5]n-6/n-3	0.10	11.56	8.19	6.03	4.72	4.00

[1]Saturated fatty acids. [2]Monounsaturated fatty acids. [3]Polyunsaturated fatty acids. [4]Ratio of polyunsaturated and saturated fatty acids. [5]Ratios of n-6 and n-3 fatty acids. n = Not identified.

The microbiological analyses showed some critical points in the dough preparation procedure, in which microbiological contamination could occur, such as from the raw material itself, cooking, storage, kneading and stretching (BRASIL, 2003). Of the most common contaminants, *Salmonella*, *Coliforms* and *Staphylococcus* are highlighted, and the higher the numbers of these bacteria, the more inadequate are the hygiene conditions during production, causing a shorter shelf life of the product and greater consumer health risks.

According to RDC Brazilian resolution nº 12 of January 2nd 2001 concerning bread, pizzas and other partially prepared doughs, seasoned or not, maximum values of $5x10^2$ MPN/g were established for Coliforms at 45 °C, $5x10^3$ CFU/g for coagulase positive Staphylococcus and the absence of *Salmonella* (BRASIL, 2001). The microbiological analyses of all the pizza crusts produced, showed a quantity of microorganisms below the suggested limits of the Brazilian Legislation (Table 5), indicating that the products were produced in accordance with adequate hygiene conditions and consequently suitable for consumption.

The sensory attributes demonstrated that, with respect to colour, the lowest scores were for pizza crusts with 15 to 20% of tuna meal, with scores between 5.68 and 5.08, respectively (neither liked/ nor disliked). Regarding softness, the score was 6.21 (liked slightly) for the addition of 5% tuna meal. This score did not differ significantly from the score of 5.92 attributed to the control, or the score of 5.46 attributed to the addition of 15% of tuna meal (Table 6).

The remaining parameters of the sensory attributes, aroma, flavour and overall impression, showed the same score pattern, with the control crust obtained the highest scores and those with different levels of inclusion not differing significantly one from the other. All the crusts with the addition of meal were awarded scores near to 5 (neither disliked/ nor liked) for aroma, flavour and overall impression. This means that the judges were indifferent in relation to the addition of tuna meal. The same pattern

Table 5. Microbiological analyses of the pizza crusts with different levels of tuna meal.

Levels	Coliforms at 35ºC	Coliforms at 45ºC	*Salmonella* spp.	Coagulase positive Staphylococcus
0%	<0.3 MPN/g	<0.3 MPN/g	Absent	1 x 10 CFU/g
5%	<0.3 MPN/g	<0.3 MPN/g	Absent	1 x 10 CFU/g
10%	<0.3 MPN/g	<0.3 MPN/g	Absent	1 x 10 CFU/g
15%	<0.3 MPN/g	<0.3 MPN/g	Absent	1 x 10 CFU/g
20%	<0.3 MPN/g	<0.3 MPN/g	Absent	1 x 10 CFU/g

CFU/g – Colony forming units/gram; MPN/g – Most probable number/gram.

Table 6. Sensory attributes (colour, aroma, softness, flavour and overall impression) and purchasing intent for pizza crusts with different levels of tuna meal.

Parameters	Levels of tuna meal in the pizza dough				
	0%	5%	10%	15%	20%
Colour[1,3]	7.40±1.47a	6.84±1.71ab	6.19±1.60bc	5.68±1.82cd	5.08±2.21d
Aroma[1,3]	7.00±1.41a	5.79±2.01b	5.76±1.89b	5.67±1.95b	5.61±2.22b
Softness[1,3]	5.92±2.06ab	6.21±2.09a	5.00±2.15b	5.46±2.04ab	5.19±2.28b
Flavour[1,3]	6.92±1.64a	5.81±2.14b	5.67±1.87b	5.68±2.16b	5.37±2.29b
Overall impression[1,3]	6.84±1.64a	5.97±1.97b	5.64±1.71b	5.57±1.92b	5.20±2.32b
Purchasing intent[2,3]	3.67±1.67a	2.97±1.30b	2.84±1.12b	2.84±1.18b	2.77±1.47b

[1]Hedonic scale between 1 and 9. [2]Hedonic scale between 1 and 5. [3]Means in the same line followed by different letters differ from each other according to the Tukey test ($p<0.05$). Values expressed as the mean ± standard deviation.

was observed for purchasing intent, where the pizza crust with 0% of tuna meal addition was awarded a score of 3.67 (maybe would buy/ maybe would not). This score was significantly different from the scores attributed to crusts with different levels of addition. These pizza crusts were awarded scores of 2.97 for the 5% level, 2.84 for the 10 and 15% levels, and 2.77 for the highest level of 20%, not significantly differing from each other (Table 6).

Kadam and Prabhasankar (2012) used shrimp meal at three different levels, 10%, 20% and 30%, in a dough formulation, to develop a product with an enhanced nutritional profile, and showed that 20% of shrimp meal substitution had better sensory attributes and an improved nutritional value.

These results were different from those obtained by Chin et al. (2012), who aimed to produce a high-protein wet yellow noodle by incorporating surimi powder in the same concentration levels used in the present study. The sensory analysis demonstrated no significant differences in colour, hardness and elasticity, between the control noodles and those with the addition of 5% surimi powder, indicating 5% as the maximum amount accepted by the consumers. These results demonstrated that the incorporation of surimi powder had a much greater impact on the sensory attributes of noodles than the tuna meal used in the present study, contributing to a much fishier taste and aftertaste in the final product.

The enrichment of foods such as bread and other bakery products with fish oils is widely and extensively used around the world due to the increased EPA and DHA contents in the final product (KADAM; PRABHASANKAR, 2010). Currently, dough has become an excellent choice for the incorporation of functional ingredients, especially marine functional ingredients such as fish meals, due to their popularity with the consumers and easy handling, storage and preparation. However, there is still a lack of research regarding the application of such ingredients to dough and scientific validation of their technological and biological feasibility, in order to produce a product that reduces health problems by improving its composition profile (KADAM; PRABHASANKAR, 2010). Thus, more research is required to allow a better assessment of the possibilities of adding these ingredients to everyday food products to improve human health.

4 Conclusion

The addition of 5 to 20% of tuna meal to pizza dough is effective in improving the nutritional value and fatty acid profile of pizza crusts.

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