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Nutritional value of Brazilian mangrove mussel (*Mytella falcata*) burger supplemented with refined or herb salts

Giselda Macena LIRA[1*], Ana Maria Queijeiro LOPEZ[2], Gabriela Marques de Farias NANES[1], Caroliny Fenandes de Melo SANTOS[1], Gabriela Mendonça RAMOS[1], Fernanda Geny Calheiros Silva[1], Cíntia Karla Rodrigues do Monte Guedes[3], Ticiano Gomes do NASCIMENTO[4]

Abstract

The mangrove mussel *Mytella falcata* (d'Orbigny, 1846), synonym of *M. charruana* (d'Orbigny, 1842), has a good nutritional, functional and low cost value. The effect of refined or herb salts in the preparation of sururu burger was evaluated through the determination of proximate composition, cholesterol content, fatty acid profile and acceptability index. In herbs, phenols were evaluated. In both formulations, the protein content was above the minimum limit (15%) required by the Food Brazilian law, while the fat percentage was lower than the stablished (5%). Due to oxidation reactions, the total cholesterol content in the preparations supplemented with refined salt was significant lower ($p \leq 0.05$) than that in the burgers without salt supplementation or with the herb salt. The fatty acids were more preserved in the preparation with herb salt, once the herbs are rich in phenols with high antioxidant capacity. Oregano had a significant higher content of total phenols ($p \leq 0.05$), compared to rosemary and parsley. In relation to the flavor, as the Brazilian public is more adapted to more salty formulations, the acceptability index of the formulation with refined salt was significantly higher ($p \leq 0.05$).

Keywords: fish-burger; spices; natural antioxidant; fatty acids; acceptability.

Practical Application: The mangrove mussel called "sururu", with the addition of herbal salt, can be used in burger preparations, being an alternative to increase the consumption of fish and enjoy its health benefits. The herbs preserved the lipid profile of the food due to its antioxidant capacity, preventing losses in nutritional quality. This formulation can help to reduce salt intake..

1 Introduction

The mangrove mussel *Mytella falcata* (d'Orbigny, 1846), synonym of *M. charruana* (d'Orbigny, 1842), known at the Northeast coast of Brazil as sururu, is a mollusk of the gastronomic tradition of the State of Alagoas (Silva & Pereira-Barros, 1987) and, also, very enjoyed by tourists. It is a food of great social value, due to its low cost, and is often the only source of protein for some poorer villages (Pereira et al., 2003).

It has good nutritional quality, highlighting the high protein content of high biological value, being a source of polyunsaturated fatty acids of the omega-3 (ω-3) (Eicosapentaenoic - EPA and Docosahexaenoic - DHA) and the omega 6 (ω-6) series (Arachidonic acid); oleic monounsaturated fatty acid and stearic saturated fatty acid (Lira et al., 2004). The benefits attributed to fish consumption are mainly related to the presence of polyunsaturated fatty acids in their composition, especially from the omega- 3 series (Scherr et al., 2015; Merdzhanova et al., 2017).

The consumption of ω-3 fatty acid is associated with numerous health benefits. Several diseases can be prevented or minimized with their consumption, such as the improvement of the metabolic syndrome, the reduction of abdominal obesity, insulin resistance, dyslipidemia and hypertension, with less risk of cardiovascular disease, symptoms of depression and inflammatory diseases (Stefanello et al., 2019).

In addition, ω-3 supplementation can also cause an increase in HDL-cholesterol levels (Pessoa et al., 2018). Omega-3 deficiency is responsible for insulin resistance and metabolic syndrome, brain metabolic abnormalities, liver steatosis and non-alcoholic fatty liver disease (Merdzhanova et al., 2012). Extensive epidemiological studies show that fish consumption is inversely associated with the incidence of cardiovascular diseases (CVD), stroke (Merdzhanova et al., 2017).

The combination of these characteristics: nutritional, functional value and low cost of *in natura* sururu, justify the elaboration of formulations, which can generate a positive impact on health.

The burger has become a popular food due to its convenience of preparation, nutritional attributes, and the ability to satisfy hunger, aspects that fit the lifestyle of the population of large urban centers (Arisseto, 2003). According to Tokur et al. (2004), fish burgers (fish-burgers), have been increasing their popularity, being considered tasty and easily prepared foods. The flexibility in the options for preparing the burger makes it possible to include

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[1] *Faculdade de Nutrição, Universidade Federal de Alagoas – UFAL, Campus A.C. Simões, Maceió, AL, Brasil*
[2] *Instituto de Química e Biotecnologia, Universidade Federal de Alagoas – UFAL, Campus A.C. Simões, Maceió, AL, Brasil*
[3] *Departamento de Nutrição, Centro de Ciências da Saúde, Universidade Federal da Paraíba – UFPB, João Pessoa, PB, Brasil*
[4] *Instituto de Ciências Farmacêuticas, Universidade Federal de Alagoas – UFAL, Campus A.C. Simões, Maceió, AL, Brasil*
*Corresponding author: gmlira2@gmail.com

the *in natura* sururu in this preparation and may represent an alternative to increase regular access to quality food, contributing to the promotion of consumer health.

However, care must be taken with the choice of ingredients and the form of preparation, so that its beneficial properties are preserved after being subjected to cooking. Because, due to the high content of unsaturated fatty acids, fish meat is the most susceptible to lipid oxidation, resulting in loss of quality (Sancho et al., 2011).

The use of natural antioxidants is relevant due to the inhibitory effect on the progress of lipid oxidation (Kulawik et al., 2013; Del Ré & Jorge, 2012) preventing the deterioration of the functional and sensory attributes of food products. Vegetables are natural sources of antioxidant compounds (flavonoids, phenolic acids, lignans, terpenes, tocopherols and others). These bioactive plant compounds can also protect the human organism, reducing the risk of developing cancer, cardiovascular and neurodegenerative diseases, as these disorders are related to increased oxidative damage (Cory et al., 2018)

Herbal salt is a mixture of refined salt with dehydrated herbs, used in total or partial replacement of table salt (Ghawi et al., 2014; Brasil, 2014a). Being made with spices such as oregano (*Origanum vulgaris* L.), rosemary (*Rosmarinus officinalis* L.), basil (*Ocimum basilicum* L.) and/or parsley (*Petroselium sativum* L.) in the proportion of 25% each (Brasil, 2014a). These herbs can contribute to the fight against lipid oxidation in foods, as natural antioxidants (Lira et al., 2020) for their ability to sequester or prevent the formation of free radicals (Kulawik et al., 2013).

Thus, the aim of this study was to evaluate the effect of the use of herbal salt on the chemical characteristics and sensory acceptability of the sururu burger (*M. falcata*).

2 Materials and methods

2.1 Sururu burger components

About 6 kg of fresh sururu (*Mytella falcata*) were acquired already without shell. To remove the mussels from the shells, the shellfish gatherers place them in a cauldron with water at 100 °C for 30 minutes. After opening the shells, the water is discarded, and the mussels are washed and sold.

The samples were collected in September 2019, at Lagoa Mundaú, located in the state of Alagoas, Brazil, between the geographical coordinates of -9.36 latitude and -35.48 longitude, being packed in plastic bags. These were deposited in a polystyrene box with ice and immediately transported to the Bromatology Laboratory of the Faculty of Nutrition at UFAL.

The condiments garlic (*Allium sativum* L.), onion (*Allium cepa* L.), coriander (*Coriandrum sativum* L.) were purchased fresh, at a local supermarket and turmeric (*Cúrcuma longa* L.) was purchased dry, in powder form, at a health food store. The herbs used (oregano, rosemary, and parsley) were purchased dried at a natural products store in Maceió, Alagoas, Brazil. Herbal salt was prepared according to the recommendation of the Good Practice Guide of the Brazilian Health Surveillance Agency (Brasil, 2014a), which consisted of a mixture of parsley, oregano, rosemary and refined salt, in the proportion of 25%, each.

2.2 Sururu burger preparation

After carrying out some preliminary experimental tests, a batch of fresh sururu (1000 g) was washed three times under running water, to remove possible impurities and then it was boiled (in 2000 mL of water) for 10 minutes. After that, the cooked sururu was fragmented with the aid of a domestic knife.

The condiment mix (garlic, onion and coriander, cut into small pieces) and the turmeric and small amount of refined salt (0.21 g) were sautéed in olive oil for 2 minutes/81.5 °C over medium heat. The sururu was added to this stir-fry, mixed and left to stand for 10 minutes. Then, wheat and oat flour (as described in Table 1) were added to improve the texture of the burger, as well as the water, and mixed once more.

A similar procedure was carried out with the supplementation of refined common salt or with the herb salts. The amount of salt used was based on the WHO recommendation, up to 5 grams/day or 2 g sodium/day (World Health Organization, 2013; Mill et al., 2019), as well as on the recommendation of the Food Guide for the Brazilian population (Brasil, 2014b): 0.5 g of salt or 200 mg of sodium per preparation. Therefore, 0.84 g of refined salt or 0.84 g of herbal salt were then added to 100 g of the basic formulation (Table 1).

The mass formulated for the sururu burger was placed in a circular aluminum mold ($\theta \cong 9$ cm) and then the obtained slices (about 60 g) were baked (81.5 °C) for 2 minutes on each side, without adding oil, in a frying pan.

2.3 Chemical analysis

Determination of total phenolic compounds in herbs used to sururu burger production

The oregano, rosemary and salsa samples were macerated according to Elfalleh et al. (2012), and homogenized at 80% methanol, at a ratio of 1:10 (m:v). The total phenolic contents were detected according to the method of Singleton et al. (1999) modified by Meda et al. (2005). The absorbance of the reaction mixtures was measured at 750 nm and the results were expressed as gallic acid equivalent (mg gallic acid/100 g sample extract).

Analysis of the in natura samples and burgers of sururu

Samples of the *in natura* sururu and sururu burgers (without salt supplementation and supplemented with refined or herb salts), were homogenized in a blender. Then, appropriate aliquots were weighed, in triplicate, to carry out the analyzes. Being packed in polyethylene films and covered with aluminum foils, identified, and stored in a freezer at -17 °C (± 1 °C), until the moment of the analyzes (period not exceeding 10 days).

The following determinations were made in triplicate in all the treatments:

Proximate composition

The moisture, protein, ash contents were determined using the methodologies of the Manual of the Association of Official

Table 1. Sururu burger formulation without salt supplementation or with the addition of refined or herb salts.

Ingredients	Burger Formulations (g or mL)		
	Without salt supplementation	Supplemented with herb salt	Supplemented with refined salt
Coocked Sururu	100	100	100
Garlic	3.2	3.2	3.2
Onion	14	14	14
Coriander	1	1	1
Turmeric	1.6	1.6	1.6
Olive oil (mL)	0.8	0.8	0.8
Wheat flour	0.8	0.8	0.8
Oatmeal flour	0.8	0.8	0.8
Water (mL*)	1.2	1.2	1.2
Oregano	----	0.21	----
Rosemary	----	0.21	----
Parsley	----	0.21	----
Refined salt	0.21	0.21	0.84

Analytical Chemists (1997). Total lipid was extracted by Folch et al. (1957) and the lipid content was gravimetrically determined. The caloric value was calculated from the caloric coefficients corresponding to the proteins and lipids (Livesey, 1990).

Cholesterol

The samples were homogenized and subjected to direct cold saponification, according to Mariutti et al. (2008). The extracts obtained were dissolved in the mobile phase, filtered through a 0.45 µm Millipore membrane and injected into a high-performance liquid chromatograph, using the chromatographic conditions established by Saldanha et al. (2006).

A liquid chromatograph (Shimadzu) was used, with UV-visible detectors (SPD-10 AVvp) and refractive index (RID-10 A) connected in series. The analytical column used was Nova Pack HP (300 mm × 3.9 mm × 4 µm, Waters), with a 20 µL loop manual injector, and kept under controlled temperature (32 °C). The mobile phase consisted of n-hexane: isopropanol (97:03) at a flow rate of 1 mL/min (1), the analysis time being 50 minutes and the chromatographic grade solvents were filtered and degassed.

Fatty acid profile

Aliquots of lipid extracts, obtained according to Folch et al. (1957), were converted to methyl esters (Hartman & Lago, 1973) and injected into a SP-2560 fused silica chromatographic column (biscynopropyl polysiloxane, with 100m in length and 0.25 mm in diameter), of a gas chromatograph (GC) (Shimadzu® 2010-plus/software SP-2560 GC solution). The column temperature programming was isothermal at 140 °C for 5 min and then heating at 4 °C/min to 240 °C, remaining at this for 20 min. The vaporizer temperature was 250 °C and the detector temperature was 260 °C, using Helium (1 mL/min) as gas carrier. The sample split ratio was 1/50. The retention time of methyl esters of the samples was compared with the retention time of standard fatty acid methyl esters. The quantification of the fatty acids was done by normalizing the area, expressing the result in mg/100 g.

2.4 Sensory analysis

Population and ethical aspects

Sensory analysis was carried out with fifty-eight young people, between 18 and 26 years old, being excluded those with allergy or intolerance to any component used in the preparation of the samples. The profile of the judges was established through a questionnaire specially developed for the research. The study was approved by the Research Ethics Committee of the Federal University of Alagoas (protocol: 91133118.0.0000.5013).

Preparation and presentation of samples

The processing of burgers supplemented with refined or herb salts, was carried out under good manufacturing practices, as described above, and later stored until use in an oven at 70 °C. Portions of about 30 g of the samples were presented simultaneously to the judges, in individual booths with white light, according to Instituto Adolfo Lutz (2008) and Ferreira (2000). For obvious reasons, unsalted samples were excluded from the sensory analysis.

Acceptability test

It was carried out through a hedonic scale with 9 points (Stone et al., 2012), being evaluated the attributes appearance, odor, flavor, texture, and overall quality. The Acceptability Index (AI) was calculated using the expression:

AI (%) = A x 100/B, in which, A = average grade obtained for the product and B = maximum grade given to the product (Fernandes & Salas-Mellado, 2017). The product with good acceptance must present AI ≥ 70% (Gularte, 2009).

Statistical analysis

A completely randomized experimental design with three treatments (sururu burger without salt supplementation, sururu burger with herbal salt and sururu burger with refined salt) was used. Statistical analyzes were also performed for herbs (3 treatments) and sensory analysis (2 treatments).

The data were submitted to analysis of variance (ANOVA), with a significance level of 5%, with subsequent performance of the Tukey parametric test when necessary. The data were tabulated and analyzed using SPSS® Statistics software, version 17.

3 Results and discussion

3.1 Total phenolic compounds in the studied herbs

The antioxidants are added to the food in order to minimize or delay the oxidation process, and researches on natural sources of antioxidants, such as spices and aromatic plants are needed so that the synthetic additives can be replaced in the so-called "natural foods" (Sancho et al., 2011).

Table 2 shows the levels of total phenolic compounds in oregano, rosemary, and parsley. Oregano had a higher content of total phenolic compounds and a significant difference ($p < 0.05$), compared to rosemary and parsley. Similar results in the contents of oregano and rosemary were obtained by Lira et al. (2020).

The antioxidant activity of oregano and rosemary was detected in studies by Del-Ré & Jorge (2012), Lee et al. (2005) and Bhale et al. (2007).

Parsley is widely used as condiment; however, it is also used in therapeutic applications as a diuretic (Mendes et al., 2015). Primak et al. (2013), cites the presence of terpenoids such as apiol, myristicin, flavoid such as apigenin and coumarins, reporting that these phenolic compounds are generally responsible for the plant's antimicrobial and antioxidant characteristics.

Table 2. Total phenolic compounds (mg/g) of herbs.

Samples	Total Phenols
Oregano	156.32 (± 6.71) [a]
Rosemary	132.92 (± 4.31)[b]
Parsley	124.76 (± 7.64) [b]

Sample averages, in triplicate, with respective standard deviations. Averages followed by equal letters do not differ statistically at the level of 5% probability by Turkey test.

3.2 Proximate composition

The *in natura* sururu had high moisture content (76,51 g/100), and a high protein content (18,53 g/100), as it was detected by Lira et al. (2004) in the same species (17.26 g/100 g). As sururu is a food of low cost with proteins of high biological value, it represents an advantage for the consumers.

On the other hand, a low content of ash (1.55 g/100), lipids (3.99 g/100) and calories (107.68 kcal/100 g) was detected in such *in natura sururu*. According to the classification proposed by Ackman (1989), the *in natura* sururu can be considered a lean food because it presents less than 5 g of lipids/100 g of food.

Table 3 shows the results of the proximate composition analysis of the sururu burger formulations (without addition of salt or with supplementation of refined salt or herbal salt).

The formulation with herb salt had significantly lower moisture content ($p < 0.05$), compared to the burger without salt or with refined salt. Possibly, herbs had a higher dehydrating effect than refined salt. Consequently, there was a significant increase ($p < 0.05$) in the protein content of the herb salt burger, compared to the burgers without salts or with refined salt.

There was no significant difference ($p<0.05$) in the lipid content of the different burgers without salt or with the addition of herb salt. However, the burger with refined salt showed a statistically lower percentage of lipids ($p < 0,05$), compared to the two other formulations.

Although the ash content detected in the sururu burger supplemented with refined salt was higher than that found in the herbal salt formulation, this difference was not statistically significant. However, the ash concentration of the burger without salt supplementation was statistically lower than that of the other studied formulations.

The current legislation, regarding the burgers identity and quality establishes a maximum of 23% fat and a minimum of 15% protein (Brasil, 2000). The results obtained for these components in the formulations of this present study agree with the Brazilian legislation. In fact, the protein content is above the minimum required and the fat percentage is much lower than the established by law. In this way, the sururu burger meets consumer demand for a healthy and nutritious food, rich in protein and low in fat.

Table 3. Proximate composition (g/100 g) and caloric value (kcal/100 g) of sururu burgers without salt supplementation or with the addition of refined or herb salts.

Sururu Samples*	Proximate Composition (g/100 g)*					
	Moisture	Proteins	Lipids	Ashes	Carbohydrates	Caloric value (kcal/100 g)
Burger without salt supplementation	73.83 (± 0.22) [a]	19.11 (± 0.29) [c]	4.43 (± 0.09) [a]	1.52 (± 0.11) [b]	1.11 (± 0.07) [b]	117.11 (± 1.08) [c]
Burger with herb salt supplementation	65.34 (± 0.27) [c]	26.74 (± 0.50) [a]	4.47 (± 0.10) [a]	1.85 (± 0.10) [a]	1.59 (± 0.06) [a]	153.56 (± 0.50) [a]
Burger with refined salt supplementation	69.21 (± 0.25) [b]	24.29 (± 0.49) [b]	3.97 (± 0.09) [b]	1.93 (± 0.11) [a]	0.61(± 0.02) [c]	135.31 (± 0.34) [b]

*Average ± standard deviation, in parentheses. Means followed by the same letter in the same columns do not differ statistically at 5% probability by the Turkey test.

3.3 Cholesterol content

The total cholesterol contents found in the samples of sururu *in natura* (171.17 ± 6.11 mg/100 g), roasted burgers without supplementation of salt (166.75 ± 6.04 mg/100 g) or with refined salt (150.23 ± 5.90 mg/100 g) or even with herbal salt (180.27 ± 6.07 mg/100 g), were well below the maximum limit of 300 mg/day of cholesterol for the prevention of chronic diseases, recommended by the World Health Organization (2003) and Faludi et al. (2017).

There was a significant decrease (p <0.05) in the cholesterol content of the samples with supplementation of refined salt compared to formulations without supplementation with this salt or with the addition of herbal salt. This diminution in the cholesterol content can be explained because the refined salt is a catalyst for oxidations, resulting in the conversion of part of the cholesterol content in cholesterol oxides (Saldanha & Bragagnolo, 2008). In addition, the salt-free sururu burger also had less cholesterol than the sururu *in natura,* due to the mollusk's pre-cooking and the small concentration of salt added, in addition to frying. The presence of herbal salt, however, with antioxidant action, protected the burger from these oxidizing agents (temperature and catalyst for oxidation reactions).

3.4 Fatty acid profile

The fatty acid profile identified in the burger without salt supplementation, burger with addition of herbal salt or addition of refined salt is shown in Table 4, with 22 fatty acids detected, of which 06 are saturated and 16 are unsaturated - 07 monounsaturated and 09 polyunsaturated.

Of the saturated fatty acids, the most prevalent were: Palmitic, followed by Heptadecanoic and Stearic. Although saturated fatty acids have an influence on the increase in plasma cholesterol and LDL-cholesterol concentration, stearic fatty acid does not elevate cholesterolemia since it has a neutral effect on cholesterol metabolism (Santos et al., 2013; Lottenberg, 2009).

Table 4. Fatty acid profile (mg/100 g) of the *in natura* sururu (not considered for statistical comparison purposes) and the sururu burgers without salt supplementation or with the supplementation of refined or herb salts.

Fatty acid	*In natura** (&)	Without Salt *	Herb Salt *	Refined Salt *
Miristic (C14: 0)	92.09 (± 10.70)	93.43 (± 11.20)[a]	94.77 (± 11.69)[a]	69.95 (± 1.02) [b]
Pentadecyl (C15: 0)	18.44 (± 4.25)	21.84 (± 2.94) [b]	25.24 (± 1.62) [a]	13.08 (± 0.05) [c]
Pentadecenoic (C 15: 1)	22.75 (± 0.43)	22.09 (± 1.55) [a]	21.43 (± 2.67)[a]	17.25 (± 0.68) [b]
Palmitic (C16: 0)	776.46 (± 83.58)	868.82 (± 93.80) [ab]	961.18 (± 104.02) [a]	763.86 (± 24.42) [b]
Palmitoleic (C16: 1)	306.77 (± 30.30)	313.16 (± 21.34) [a]	319.55 (± 12.38) [a]	270.20 (± 2.59) [b]
Heptadecanoic (C17: 0)	305.00 (± 37.81)	310.83 (± 31.21) [a]	316.66 ± (24.60) [a]	260.01 (± 18.93) [b]
Cis-10Heptadecanoic (C 17: 1)	12.65 (± 0.12)	15.19 (± 0.55) [b]	17.73 (± 0.88) [a]	10.76 (± 0.00) [c]
Stearic (C18: 0)	166.56 (± 7.11)	190.87 (± 11.88) [b]	215.18 ± (16.64) [a]	193.60 (± 3.87) [b]
Oleic (C18: 1 ω-9)	125.28 (± 0.61)	586.04 (± 51.38) [c]	1046.79 (± 102.15) [a]	873.99 (± 30.83) [b]
Elaidic (C18: 1 ω-9t)	9.62 (± 0.14)	10.24 (± 6.30) [ab]	10.85 (± 1.74) [a]	7.97 (± 0.17) [b]
Linoleic (C18: 2 ω-6) *	48.33 (± 0.53)	130.87 (± 7.76) [c]	213.40 (± 14.98) [a]	171.93 (± 0.80) [b]
Linolenic (C18: 3 ω-3)	74.40 (± 2.44)	78.79 (± 5.53) [a]	83.17 (± 8.62) [a]	68.91 (± 2.62) [b]
Arachidic (C20: 0)	14.28 (± 2.22)	14.77 (± 3.54) [a]	15.26 (± 4.87) [a]	10.69 (± 0.22) [b]
Gadoleic (C20: 1 ω11)	46.12 (± 5.86)	44.72 (± 5.19) [a]	43.32 (± 4.51) [a]	41.73 (± 1.34) [a]
Eicosadienoic (C20: 2 ω-6)	39.61 (± 2.89)	41.38 (± 3.63) [a]	43.14 (± 4.38) [a]	40.81 (± 0.43) [a]
Dihomo-γ-linolenic (C 20: 3 ω-6)	9.41 (± 1.04)	9.82 (± 0.79) [a]	10.22 (± 0.54) [a]	9.20 (± 0.23) [a]
Arachidonic (C20: 4 ω-6)	88.94 (± 8.23)	88.15 (± 8.39) [a]	87.35 (± 8.54) [a]	66.36 (± 1.13) [b]
Eicosapentaenoic (EPA) (C20: 5 ω-3)	424.44 (± 34.26)	425.11 (± 39.05) [a]	425.77 (± 43.84) [a]	306.03 (± 9.59) [b]
Docosapentaenoic (DPA) (C22:5 ω-3)[#]	127.36 (± 6.97)	128.94 (± 7.44) [a]	130.52 (± 7.91) [a]	93.41(± 5.38) [b]
Docosapentaenoic (DPA) (C22:5 ω-6)[#]	53.50 (± 15.90)	45.41 (± 11.31) [a]	37.31 (± 6.71) [b]	32.85 (± 0.01) [b]
Docosahexaenoic (DHA) (C22:6 ω-3)	242.80 (± 31.93)	251.13 (± 30.81) [a]	259.45 (± 29.69) [a]	169.56 (± 15.41) [b]
Nervonic (C24: 1)	25.50 (± 2.31)	24.82 (± 3.94) [a]	24.13 (± 5.57) [a]	17.29 ± (0.82) [b]
Not identified	258.42 (± 46.34)	281.4 (± 30.18) [a]	304.46 (± 62.57) [a]	140.72 (± 5.91) [b]
ΣSaturated	1401.49 (± 41.6)	1529.4 (± 104.4) [b]	1657.29 (± 167.20) [a]	1379.51 (± 52.42) [c]
ΣUnsaturated	1852.27(± 256.8)	2420.1(± 269.61) [b]	2987.93 (± 282.42) [a]	2347.28 (± 84.46) [b]
ΣPolyunsaturated	1099.39(± 103.2)	1259.39(± 124.8) [a]	1419.38(± 146.39) [a]	1079.53(± 42.34) [b]
ΣMonounsaturated	516.34 (± 39.20)	993.48(± 82.02) [c]	1470.61 (± 124.84) [a]	1242.53 (± 41.28) [b]
PUFA/SFA	0.78	0.82	0.85	0.78
Σω-3	869.00 (± 75,60)	883,97 (± 82,84) [a]	898.91 (± 90.08) [a]	637.91 (± 33.00) [b]
Σω-6	239.79 (± 28.60)	315,63 (± 24.90) [b]	391.42 (± 35.15) [a]	321.15 (± 2.60) [b]
Ratio ω-6/ω-3	1:3.62 (± 0.10)	1:2.80 (± 0.10) [a]	1:2.30 (± 0.02) [b]	1:1.99 (± 0.08) [c]
EPA + DHA (mg/100 g)	667.25 (± 6 6.20)	676.24 (± 69.87) [a]	685.22 (± 73.53) [a]	475.59 (± 25.00) [b]

(&)Treatment not considered for statistical comparison purposes; *Averages (± standard deviation). Results in the same line with different superscripts, differ significantly at 5% level (p < 0.05) by the Tukey test; #DPA-22:5 (ω−3): *all-cis*-7,10,13,16,19-DPA and DPA-22:5 (ω−6): *all-cis*-4,7,10,13,16-DPA (osbond acid).

The most prevalent monounsaturated acids were: Palmitoleic and Oleic. As for polyunsaturated, Eicosapentaenoic (EPA), Docosahexaenoic (DHA), Docosapentaenoic (DPA) and Arachidonic acids were the most abundant.

These results are like ones of Lira et al. (2004). In the study carried out by Assis (2015), analyzing fatty acids of *M. charruana* mussel, the major predominance was for Palmitic, EPA and Palmitoleic, and the differences could be due to the different season and area of harvest.

Comparing the burger with the addition of herbal salt to that with the addition of refined salt, there were significantly higher levels ($p < 0.05$) of palmitic fatty acids (20.52%), heptadecanoic (17.88%) and stearic (10.02%); in the monounsaturated oleic (16.50%) and in the polyunsaturated: linoleic (19.43%), linolenic (17.14%), arachidonic (24.02%), eicosapentaenoic (EPA- ω-3) (28.12%) and docosahexaenoic (DHA - ω-3) (34.64%). As the beneficial effects on human health attributed to the consumption of fish, are mainly related to the presence of EPA and DHA (Merdzhanova et al., 2017), this loss caused in the sururu burger with the addition of salt is relevant.

An increase of 1.2 times more, of monounsaturated oleic fatty acid, was detected in the burger with the addition of herbal salt in relation to the burger with the addition of salt. Oleic is considered hypolipidemic because it reduces the plasma levels of LDL cholesterol and the LDL/HDL ratio (Dossiê Óleo, 2014). This fatty acid corresponds to the component present in the highest concentration in olive oil, used in the sautéing process, in both formulations.

Regarding the predominant fatty acid composition of olive oil, the Codex Alimentarius (Food and Agriculture Organization of the United Nations, 2001) defines as parameters: palmitic acid (7.5% to 20%), palmitoleic acid (0.3% to 3.5%), stearic acid (0.5% to 5.0%), oleic acid (55% to 83%), linoleic acid (3.5% to 21%), y-linolenic acid (<1.5%), lignoceric acid (<1.0%) and arachidic acid (<0.8%). Although olive oil was incorporated in both formulations, oleic fatty acid was more preserved in the burger with herbal salt.

The Brazilian Society of Cardiology (SBC), through the Brazilian Dyslipidemia and Atherosclerosis Prevention Directive (Faludi et al., 2017), recommends 0.5-1 g/day of omega 3 (EPA, DHA and linolenic acid) for individuals with normal levels of triacylglycerides (150-199 mg/dL). The burger with the addition of herbal salt and burger with the addition of salt presented 768.39 mg/100 g and 544.5 mg/100 g of EPA + DHA + linolenic acid, respectively, and are able to meet the daily needs for individuals with normal levels of triacylglycerides.

However, the results obtained point out that in the burger with the addition of herbal salt, the fatty acids were more preserved, and the lipid oxidation reactions were intensified in the burger with the addition of salt, since the salt accelerates the lipid oxidation because it is a pro-oxidant element of fat (Mársico et al., 2009; Belitz et al., 2012; Bertolin et al., 2011).

In making of the two formulations, coriander, garlic, and turmeric condiments were used. According to Melo et al. (2003), coriander may delay lipid oxidation due to its phenolic and carotenoid constituents. Sancho et al. (2011), found that coriander was efficient in preserving polyunsaturated fatty acids EPA and DHA, in fish meatballs cooked in boiling water (95 °C), for 30 min and stored at -18 °C, for 120 days. The ability of garlic as a natural antioxidant was reported in the studies by Mariutti et al. (2011) and Guizellini et al. (2020), which demonstrated a good performance in the useful life of fish burgers, and garlic can be substituted for synthetic antioxidants in this type of product.

Turmeric is a root known for its high antimicrobial and antioxidant potential, in addition to containing essential oils of excellent technical and organoleptic qualities (Majolo et al., 2014). The use of curcumin to reduce the production of malonaldehydes in meat products has been reported by Karami et al. (2011), who found the efficiency of this natural substance in controlling the oxidative processes of lipids in foods.

The presence of bioactive compounds with ample antioxidant capacity in coriander, garlic, and turmeric, may have contributed to minimize lipid oxidation, in both formulations. However, in the burger containing herbal salt, the oxidative process generated in the heat treatment was less intense and the fatty acids were more preserved, demonstrating that the phenolic compounds present in the herbs showed antioxidant capacity.

As for the PUFA/SFA ratio, the Department of National Health of England (Department of Health, 1994) describes that a rate below 0.45 constitutes an unhealthy diet, due to its potential to induce an increase in blood cholesterol (Venter, 2003). The values obtained in the two formulations: 0.85 mg/100 g (burger with herbal salt) and 0.78 mg/100 g (burger with refined salt), meet the established recommendation.

Merdzhanova et al. (2017) report that an unbalanced n-6 /n-3 ratio with a prevalence of n-6 PUFAs is highly prothrombotic and proinflammatory, and stimulates the development of atherosclerosis, obesity, and diabetes. Due to these facts, a balanced n-6/n-3 ratio 2: 1 is one of the most important dietary factors in the prevention of obesity, cardiovascular disease (CVD) and other chronic diseases. According to some nutritional recommendations, cited by Merdzhanova et al. (2017), the n-6/n-3 ratio in human diets should not exceed 5.0. The two formulations of the sururu burger present the ω-6/ω-3 ratio, which is considered adequate, and can be a beneficial food for the health of those who consume it.

3.5 Sensory analysis

Of the total of judges who participated in the sensory analysis, the majority were female (72.4%), while 27.7% were male. Of these, 91.5% said they like sururu; 69.4% had knowledge about herbal salt and 44% had consumed preparations that used it. Most of the judges (95%) claimed to consume sururu, occasionally (less than once a month).

The acceptability index (AI%) of the burger with herbal salt or refined salt, is shown in Figure 1. There was a statistically significant difference ($p < 0.05$) between the AI%, related to flavor and overall quality.

The greater preference for burger with salt, in relation to flavored, is possibly due to the eating habits of individuals, as the

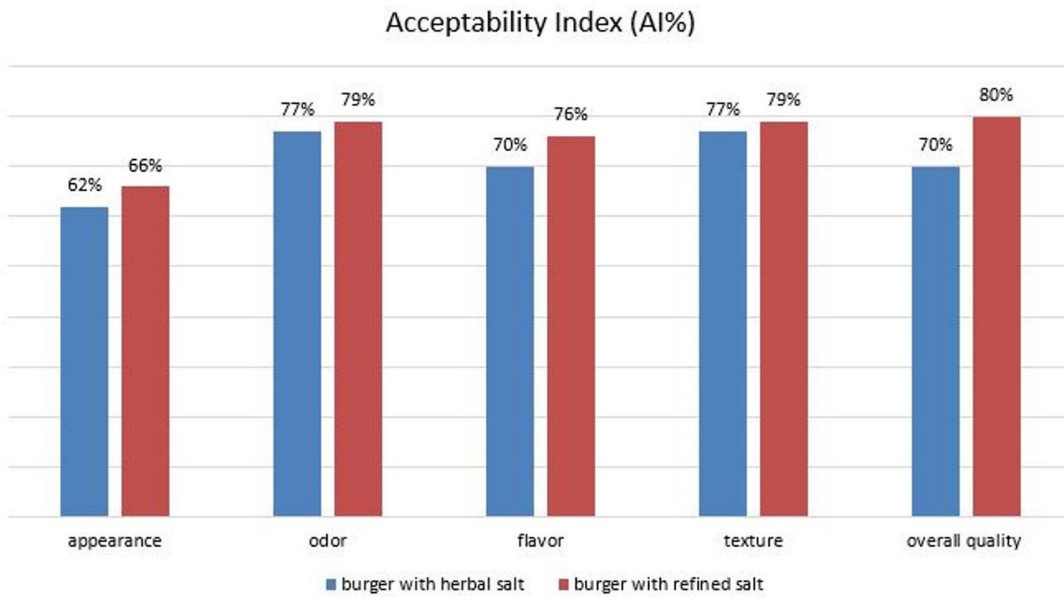

Figure 1. Acceptability index (%) for the sururu burger supplemented with herb or refined salts.

population is increasingly exposed to a large amount of sodium content in food due to the industrialization process (Kramer, 2017), which shapes the palate to a better acceptance of salty food.

However, it is necessary to educate the population to restrict daily sodium intake. In the Brazilian population, this consumption exceeds twice the maximum limit recommended by the World Health Organization, of up to 5 grams/day or 2 g of sodium/day (World Health Organization, 2013; Mill et al., 2019). Excessive consumption of this mineral contributes to the increase of chronic non-communicable diseases (NCDs) prevalence (Neves et al., 2017), among which systemic arterial hypertension stands out. This demonstrates the need to adopt healthier eating habits (Lourenço & Macedo, 2015; Instituto Brasileiro de Geografia e Estatística, 2014) and herbal salt can be an important ally in this situation, as a salt substitute.

4 Conclusion

The sururu burger with herbal salt showed good nutritional and functional value, with protein and lipid contents according to the legislation, being a source of proteins and low in fat. Also, it represents a source of fatty acids beneficial to health that, like cholesterol, were preserved from lipid oxidation reactions, indicating that herbs were able to act as natural antioxidants during heat treatment.

The formulation with herbal salt represents an alternative to increase the consumption of fish, as well as an incentive to the consumption of healthier foods, which can contribute in reducing salt consumption, generating perspectives for other studies with this food product.

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