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Elaboration of garlic and salt spice with reduced sodium intake

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ABSTRACT

Garlic and salt spice is widely used in Brazilian cookery, but it has a high sodium content; as high sodium intake has been strongly correlated to the incidence of chronic diseases. This study aimed to develop a garlic and salt spice with reduced sodium intake. Sensory evaluation was conducted by applying the spices to cooked rice. First, the optimal concentration of spice added during rice preparation was determined. Subsequently, seasonings (3:1) were prepared containing 0%, 50% and 25% less NaCl using a mixture of salts consisting of KCl and monosodium glutamate; a seasoning with a 0% NaCl reduction was established as a control. Three formulations of rice with different spices were assessed according to sensory testing acceptance, time-intensity and temporal domain of sensations. The proportions of salts used in the garlic and salt spice did not generate a strange or bad taste in the products; instead, the mixtures were less salty. However, the seasonings with lower sodium levels (F2 and F3) were better accepted in comparison to the traditional seasoning (F1). Therefore, a mixture of NaCl, KCl and monosodium glutamate is a viable alternative to develop a garlic and salt spice with reduced sodium intake.

Key words: KCl, monosodium glutamate, TDS, TI.

INTRODUCTION

Salt is an additive with a long history and is primarily used in cooking and the food industry. This compound imparts a salty taste and is a characteristic spice in food. In addition to its sensory characteristics, salt also reduces microbial activity by decreasing the active water content in food, preventing deterioration and making certain foods safe for consumption (Cruz et al. 2011). However, excessive NaCl consumption has been associated with an increased risk of hypertension, cardiovascular disease, osteoporosis and kidney stones (Sihufe et al. 2003, Heaney 2006). Thus, besides encouraging people to read food labels and choose low sodium products (Petersen et al. 2013), the development of new products with reduced sodium content is also very important.

According to a Brazilian newspaper, Folha de São Paulo, the ABIA (Brazilian Association of Food Industries), which was approved by the Ministry of Health in 2013, concluded that most of the sodium consumed by Brazilians came from both processed foods and the cooking salt and seasonings added at home. In addition, a survey administered by the Ministry of Health (2011) found that Brazilians consume 12g sodium chloride / day (4800 mg

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Na / day) on average; however, the healthy limit established by the World Health Organization (WHO) is 5g of sodium chloride per day, corresponding to approximately 2000 mg of sodium per day. Therefore, the Ministry of Health and the Brazilian food industry agreed to reduce the sodium content of various food categories by 2016 (WASH 2012).

Because several products need to adhere to the lowered sodium regulations, including garlic seasoning salt, reducing the sodium content is extremely important since these products are used in most culinary preparations. One word, reducing the sodium content in food products is challenging because decreasing the NaCl content is associated with a decrease in acceptance of the modified product (Toldrá 2006).

Several NaCl substitutes have been studied; potassium chloride stands out due to having physical properties similar to those of NaCl. However, completely replacing NaCl with KCl is not recommended because a bitter taste is imparted to the products, rendering them inacceptable (Nascimento et al. 2007). Therefore, combining salts during the preparation of products with reduced sodium and sensory acceptance is an interesting solution.

Another interesting alternative used to reduce the sodium content in foods is incorporating flavor enhancers, such as monosodium glutamate (Brandsma 2006). Mojet et al. (2004) showed that enhancing the umami taste increases the perception of the saltiness of food; therefore, foods containing a high content of umami substances may allow for a lower NaCl content without decreasing consumer acceptance.

Replacement salts containing potassium, magnesium, and calcium have been investigated in several products (Katsiari et al. 2001, Johnson et al. 2009, Ayyash and Shah 2011, Souza et al. 2012, Canto et al. 2014). Grummer et al. (2012) showed that potassium chloride could be used successfully to achieve large reductions in sodium when replacing a portion of the NaCl in Cheddar cheese. It is possible to produce this low sodium Cheddar cheese in a way that results in high consumer acceptance and low bitterness (Grummer et al. 2013). Kamleh et al. (2012) and Karimi et al. (2012) also demonstrated that Halloumi cheese and feta cheese could be successfully manufactured using NaCl/KCl. Kamleh et al. (2012) suggested that using ingredients that would help mask this bitterness, would improve the acceptability of Halloumi. Campagnol et al. (2012) showed that it is possible to produce fermented sausages with 50% replecement with KCl and with addition of lysine with sensorial quality and Dos Santos et al. (2013) showed that the reformulated sausages containing monosodium glutamate combined with lysine, taurine, disodium inosinate and disodium guanylate masked the undesirable sensory attributes associated with the replacement of 50% and 75% NaCl with KCl, enabling the production of fermented cooked sausages with good sensory acceptance and approximately 68% sodium reduction.

Furthermore, Drake et al. (2011) studied the sodium-reduction in cheese sauce, cottage cheese, and milk-based soup and they found that the complexity of the food matrix, influenced salty taste perception in addition to the percentage sodium reduction that was noticeable to consumers. Thus, further research for each product is necessary to further clarify salty taste perception.

Replacing NaCl with other salts leads to several possibilities regarding the reduction of saltiness and leads to the introduction of a metallic, bitter or astringent taste. Therefore, it is necessary that, in addition to acceptance sensory tests, tests such as analyses of the temporal dominance of sensations (TDS) and time-intensity (TI) must be performed to characterize the sensory profile of the product during its intake.

The objective of this study was to prepare a seasoning and garlic salt with a low sodium content using various mixtures of salts, including NaCl, KCl and monosodium glutamate. Additionally, sensory tests and evaluations of temporal acceptance (TI and TDS) were performed.

MATERIALS AND METHODS

The study (CAAE: 18827013.8.0000.5148) was reviewed and approved by the Ethics Committee of the Federal University of Lavras (Protocol 363 827).

Preparation of the Product

Garlic and salt spice

The materials used during food preparation in this study included the following: garlic, potassium chloride (99% Vetec®, Rio de Janeiro – RJ, Brazil), monosodium glutamate (99% Aji-no-moto ®, São Paulo – SP, Brazil) and sodium chloride (99% Vetec®, Rio de Janeiro – RJ, Brazil). Each spice mixture was prepared in a 3:1 ratio (salt:garlic). The garlic was crushed and mixed with salt in a Walita brand multiprocessor.

Rice

Every formulation was prepared with rice and garlic seasoning salt in cooker using three parts water to one part rice.

Sensorial Analysis

Just-about-right-scale

To perform the sensory tests and optimize the spice content in the rice, the concentrations were determined during pre-testing: the rice formulations were prepared using 1%, 4%, 7% and 10% of garlic and salt spice composed of three parts salt to one part garlic.

The optimal spice concentration was determined using sensory tests with an ideal scale (Just-about-right-scale), using a scale of five points. During the analysis, 60 panelists evaluated the samples and recorded their responses on a specific scale based on how perfect these samples were regarding the salty taste using the method reported by Vickers (1998). The method proposes that the panelists have to evaluate the samples according to an unstructured line scale anchored with “not nearly salty enough” at the left, “just right” at the center, and “much too salty” at the right was used to optimize saltiness in the garlic and salt spice.

The responses were converted into numerical values and analyzed via regression analysis in a SISVAR program (Ferreira 2002).

Through the results of the jus-about-righ-scale, three garlic and salt spice formulations were prepared from the results of the pre-tests: formulation 1 - 0% NaCl reduction; formulation 2 - 25% NaCl reduction and formulation 3 - 50% NaCl reduction (Table I).

TABLE I
Ingredients used to produce the garlic seasoning and salt (3:1) per 100g.

Rice	Spice	NaCl	KCl	Glu	Garlic
F1	Spice1	2,4375g	-	-	0,8125g
F2	Spice2	1,8281g	0,5246g	0,3266g	0,8931g
F3	Spice3	1,2188g	0,3497g	1,3064g	0,9583g

Time-Intensity

For the sensory panel analysis of time-intensity, 28 participants (fourteen men and fourteen women aged 24-56 with experience in sensory evaluation who consumed garlic and salt spice at least once a week and who had interest and time availability were selected for the sensory panel analysis of time-intensity through the use of questionnaires. For acquisition of data and subsequent analysis, the SensoMaker program was used (Nunes and Pinheiro 2012). Through a graphical interface in the form of a 10-point scale, with 0 meaning no perception and 10 signifying an extreme perception of salty taste, each panelist indicated the intensity of the attribute of each sample. The samples were presented in a monadic way, using a balanced complete block design (Wakeling and MacFie 1989) by mouse stimulus. During the analysis, warning messages were presented before each step with instructions regarding the action to be performed (Cardello et al. 2003). First, the panelist clicked on the “start” button and took the full amount of the sample during two seconds, then, for an additional 20 seconds, indicated the intensity of the particular sensory attribute (salty flavor) on the scale. Finishing the analysis a message indicated the end of the test and the panelist proceeded to another sample.

The software SensoMaker analyzed the data collected during each sensory evaluation session and generated the parameters: Imax (maximum intensity recorded by the assessor); TImax (time in which the maximum intensity was recorded) (Palazzo and Bolini 2009). The data are presented in graphical form (through calculation parameters) using the Microsoft Excel 2012. In the graphs, the horizontal axis denoted time, while the vertical axis displayed the intensity values.

Temporal Dominance of Sensations (TDS)

We recruited 28 participants for the TDS analysis. To recruit the participants, questionnaires were administered to assess the consumption of garlic and salt spice (at least once a week) and experience with sensory analysis. The panelists were trained regarding the temporality of sensations (TDS) and were introduced to the SensoMaker data acquisition program (Nunes and Pinheiro 2012). The total duration of the experiment was 20 s, and the attributes selected for the panel were determined using the conventional method: salty, bitter, sweet, umami, sour, spicy, astringent and off-taste.

After the instructions, the panelists were asked to click on the "start" button and during two seconds to put the sample of rice (approximately 5g) in their mouths and immediately start the evaluation. During twenty seconds, using the mouse, the participants were requested to select the dominant taste over the time. They were told that the dominant taste is the taste that is perceived with the greatest clarity and intensity. For each of these eight descriptors a button on the computer screen was presented for evaluation.

The presentation was made in monadic order (Macfie et al. 1989) in disposable white plastic cups coded with three-digit numbers. The samples were served one by one, and the assessors were asked to rinse their mouth with water between each sample.

The methodology described by Pineau et al. (2009) was used in combination with the SensoMaker software to compute the TDS curves. The curves were ploted using a smooth equal 5% and they were used for visual interpretation. Briefly, two lines are drawn in the TDS graphical display: the "chance level" and the "significance level". The "chance level" is the dominance rate that an attribute can obtain by chance and the "significance level" is the minimum value this proportion should equal, in order to consider significant (Pineau et al. 2009). The "chance level" and "significance level" are calculated using the confidence interval of a binomial proportion based on a normal approximation according to Pineau et al. 2009 (1).

$$\text{(1)} \qquad Ps = P_0 + 1.645\sqrt{\frac{P_0(1-P_0)}{n}}$$

Ps is a significantly lower ratio value (a= 0.05) at any point in time for a TDS curve, and n is the number of subjects * replication.

Analogous to the parameters of the TI curves, three parameters of the TDS curves for the attribute salty were extracted, namely maximum dominance rate, duration of the salty dominance and area under the curve. Duration of the salty dominance and TDS area were calculated only above the chance level (p = 1/number of attributes; here: p = 12.5%) in order to exclude interference. Calculation of the dominance rates was conducted using SensoMaker software. For further analyses the data were exported to Microdoft Excel and the graphs were ploted. The evaluation process according to Pineau et al. (2009) suggests summarising the data for all evaluations.

To analyze the results of the curves significant sensations were considered, i.e. above the line "significant level". Curves were analyzed through the maximum rate of dominance, time of the maximum rate of dominance and area under the curve.

ACCEPTANCE TEST

The spices were analyzed using a sensory acceptance test with cooked rice incorporating the spice concentration found during the just-about-right-scale test, as previously reported by Fortes et al. (2012).

The samples were served in four sections, and the order of presentation was balanced according to the work of Wakeling and Mcfie (1995). The test was conducted in individual booths. The panelists received approximately 20g of each sample in plastic cups coded with three-digit numbers. The test was performed with proper lighting and without interferences, such as noise and odors (Bowles and Demiate 2006).

Sixty judges evaluated the samples compared to the acceptance salty flavor and overall impression using a nine-point hedonic scale ranging from "extreme dislike" to "extreme like", similar to the methodology described by Stone and Sidel (1993).

The results of the acceptance test were subjected to an analysis of variance in SISVAR (Ferreira 2002). To visualize the acceptance of the samples, histograms were constructed to display the frequency distribution of the hedonic values obtained for each sample. The histograms enabled the visualization of the grouped hedonic values for each sample, revealing the level of acceptance and rejection to compare the performances of two or more samples (Behrens et al. 1999).

RESULTS AND DISCUSSION

JUST-ABOUT-RIGHT-SCALE

The linear model Y= 0.805837X + 0.381925 (Figure 1) described the relationship between the ideal formulations of rice and seasoning (Table I). The percentage of explained variance (R^2) for the model was satisfactory (R^2 = 99.5%), revealing good agreement between the experimental and modeled data.

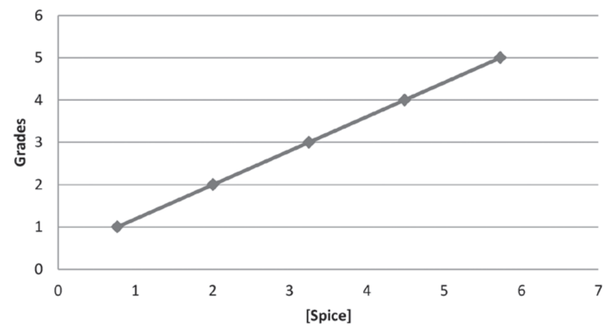

Figure 1 - Regression analysis of the results obtained in the Just-about-right-scale test.

The equation of the line was used to determine that the optimal concentration (Y=3) of spice (3:1) added to rice is 3.25%. Fortes et al. (2008) found that using 3% salt while preparing conventional rice promotes better acceptance.

Therefore, the calculations for the reduced-NaCl seasoning (Table I) were based on their optimal concentration, while maintaining the 3:1 ratio (salt: flavor).

Seasonings 2 and 3 were made with a 25% and 50% NaCl reduction, respectively, while seasoning 1 was the control (0% reduction NaCl). The concentrations of KCl and monosodium glutamate used to replace NaCl were determined during pre-testing.

TIME-INTENSITY

The evaluation of the salty taste of the garlic and salt spice through time-intensity analysis is very important, because the use of other salts to replace NaCl can promote a decreased perception of the salty taste in the product. So through this test it is possible to find what the best substitutes of NaCl are and what the best concentrations of each one are. Figure 2 and Table II show the charts and the parameters obtained for the analysis of the salty taste intensity over time for the rice formulations prepared with garlic and salt spices with varied sodium contents.

The analysis of variance applied to the parameters obtained while analyzing the intensity over time indicated that there was a significant difference ($p > 0.05$) between the maximum saltiness intensity (Imax) and the time needed to achieve the maximum saltiness intensity (TI Max.).

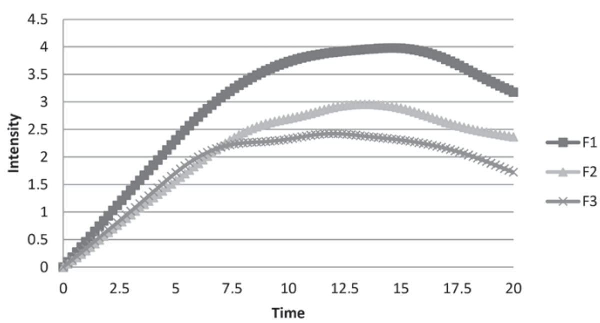

Figure 2 - Graphical representation of the intensity of the salty flavor over time for rice seasoned with reduced sodium formulations (F1: 0% reduction NaCl; F2: 25% reduction NaCl; F3: 50% reduction NaCl).

TABLE II
Parameters obtained while analyzing the intensity over time for the salty taste of the garlic and salt spice.

Samples	Imax *(Maximum of saltiness)*	TI *Max (elapsed time to reach the maximum intensity of saltiness)*
F1	3.98[a]	14.6[a]
F2	2.96[b]	13.4[b]
F3	2.42[c]	12[c]

Values marked with the same letters are not significantly different at a 5% probability when using Tukey's test. (F1: 0% reduction NaCl; F2: 25% reduction NaCl; F3: reduction of 50% NaCl).

Figure 2 and Table II indicate that all formulations showed a similar profile and achieved maximum saltiness within 12 to 15 seconds. However, replacing NaCl with KCl and monosodium glutamate generated a less intense salty flavor relative to the control (F1). The same was observed by Souza et al. (2013) and Teodoro et al. (2013) in their experiment with sodium reduction in butter and in cream cheese. However, these studies showed that potassium chloride salt is more similar to NaCl than monosodium glutamate. Therefore, according to Guinee and O'Kennedy (2007), the substitution of up to 40% of the NaCl for KCl is a good alternative to reduce the sodium content and maintain the characteristic flavor of cheeses. Formulation 1 demonstrated a maximum intensity of salty flavor equal to approximately 3.98, while the formulations F2 and F3 had intensities equal to approximately 2.96 and 2.42, respectively.

According to Formaker and Hill (1988) and Mattes (2001), the perception of the salty taste of sodium chloride is attributed to both the cation (70-85%) and the anion (30-15%) due to the passage of ions through a narrow ion channel. According to Mccaughy (2007), these channels are specific for sodium chloride, and it is difficult to find other non-toxic substances with this capability. Therefore, the capacity depends on the types of cations and anions present in the substance (Ye et al. 1991, 1993). Compared to sodium chloride, the flavor perception of other cations such as potassium is less salty (Mooster 1980), as observed in this experiment.

Souza et al. (2013) observed that for sodium chloride substitutes in butter, potassium chloride had similar intensity to that of NaCl, while higher concentrations of monosodium glutamate were required to obtain a similar salty taste. This justifies the lowest salty power observed in the formulation with the 50% less NaCl (F3); this mixture contained more monosodium glutamate and less KCl.

TEMPORAL DOMINANCE OF SENSATIONS

Similar to TI test, the temporal dominance of sensations test is also important to describe the desirable and undesirable sensations of the products with reduced sodium.

The dominant temporal profiles of sensations (TDS) for the 3 rice formulations are plotted in Figure 3, 4 and 5. Each curve represents a particular attribute of dominance over the course of time. In the graphical representation of the TDS analysis, two lines are shown: the 'chance level' and 'significance level'. The 'chance level' is the dominance rate that an attribute can obtain by chance, and the 'significance level' is the minimum value the dominance rate should equal to be considered significant (Pineau et al. 2009).

For the TDS prepared rice seasoned with F1, the salty taste dominated the entire analysis. In the rice seasoned with F2, salty and sweet flavors were dominant, and the salty taste lasted longer (11s) and overwhelmed the sweet taste.

The TDS curves also show that F1 reached a maximum dominance of approximately 0.6 (maximum 60% of the panelists selected this mixture as the saltiest) for salinity, while F2 reached a maximum of 0.35 salinity. Therefore, the duration and the maximum rate salt prepared using a 0% NaCl reduction rather than that prepared with 25% less NaCl because KCl and glutamate are less salty than NaCl (Souza et al. 2013).

In the formulation prepared with 50% less NaCl (F3), we observed a dominant umami taste; this observation is attributed to the higher concentration of monosodium glutamate (Solms 1969, Kawamura and Kare 1987) used to replace NaCl. In addition, a slight sweet taste was detected for approximately 2 s. Although there are many salt substitutes on the market, according to Cruz et al. (2013), sodium chloride is the only one that promotes the manifestation of a pure salty taste.

According to Souza et al. (2013) the salt power of glutamate (31.59%) is well below that of sodium chloride; three times more sodium glutamate is needed to match the salty flavor of NaCl, explaining the absence of perceived saltiness in the F3 tasters. In addition, the same authors found in their work with butter that completely replacing NaCl with monosodium glutamate altered the expression of salty, sweet and umami flavors; the latter two were also reported during the analyses of TDS for the formulations containing 25 and 50% less NaCl, in addition to monosodium glutamate (F2 and F3).

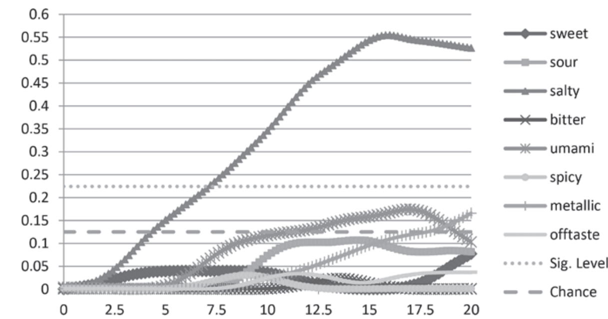

Figure 3 - Graphical representation of the temporal profile of dominance for the sensations generated by the rice seasoned with spice 1 (F1: 0% reduction of NaCl).

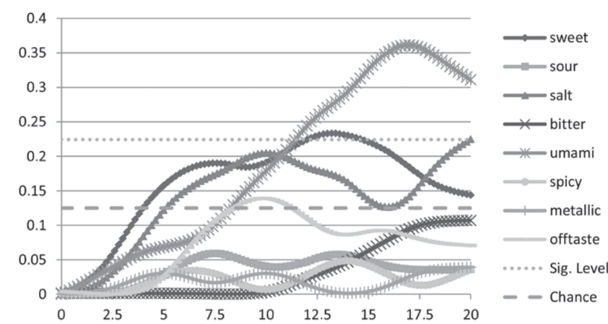

Figure 4 - Graphical representation of the temporal profile of dominance for the sensations generated by the rice seasoned with spice 2 (F2: 25% reduction of NaCl).

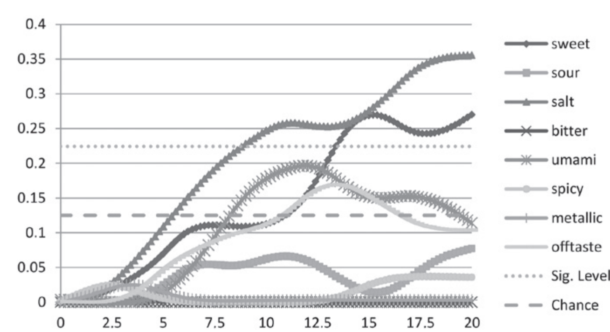

Figure 5 - Graphical representation of the temporal profile of dominance for the sensations generated by the rice seasoned with spice 3 (F3: 50% reduction of NaCl).

Sensory characteristics, functional properties and shelf life are the features most affected by the reduction of salt in food (Guinee and O'Kennedy 2007). Thus, in the development of products with reduced sodium, it is important to consider the nature and composition of the product, the type of treatment and the manufacturing conditions (Ruusunen and Puolanne 2005).

Acceptance Test

The analysis of variance applied to the acceptance testing data indicated that there was no significant difference ($p > 0.05$) in relation to the acceptance of the formulations of mozzarella regarding the attributes. Figure 6 and 7 show histograms obtained from the data for acceptance testing of spices for a better view of the acceptance of the formulations.

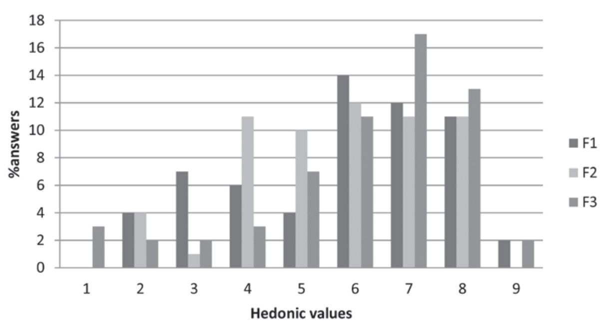

Figure 6 - Histogram displaying the frequencies of the hedonic values for acceptance against the saltiness of the rice seasoned with reduced sodium content formulations (F1: 0% reduction of NaCl; F2: 25% reduction of NaCl; F3: 50% reduction NaCl).

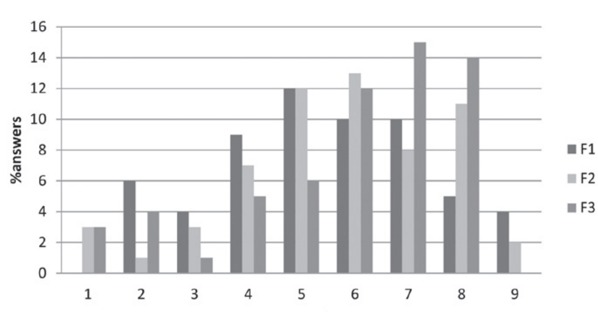

Figure 7 - Histogram displaying the frequencies of the hedonic values for acceptance against the overall impression of the rice seasoned with reduced sodium content formulations (F1: 0% reduction of NaCl; F2: 25% reduction of NaCl; F3: 50% reduction NaCl).

The histograms revealed slight differences in the frequency distribution for the hedonic values assigned to the different rice formulations. Note that in both attributes, the frequency distributions of the responses for all samples skewed toward the region of the highest scores, ranging from "like slightly" (note 6) and "like extremely" (note 9), indicating a good acceptance of the products. Therefore, a replacement of 25% (F2) and 50% (F3) of NaCl by KCl and monosodium glutamate in garlic and salt spice promoted the development of products with the same sensory acceptability as the traditional one. Furthermore, formulation F3 had acceptance notes higher than other products.

According to Brandsma (2006), flavor enhancers are interesting to the food industry because they can help reduce the sodium chloride levels. Similarly, for formulation 3, using a spice with a higher concentration of monosodium glutamate led to higher scores for acceptance attributes among students. In both histograms, the frequency distributions of the responses for all of the samples were displaced to the region of highest scores, indicating good acceptance of products.

Several recent studies have lead to the development of products with less sodium and good acceptability, but in every case, a partial substitution of sodium chloride was enacted using different mixtures of salts (Katsiari et al. 2001, Guinee and O'Kennedy 2007, Horita et al. 2011). The histograms indicated that all samples achieved similar results. Therefore, a reduction of up to 50% of NaCl in seasoning and garlic salt composed of NaCl, KCl and monosodium glutamate did not adversely affect the acceptance of the product, when compared to the control.

Furthermore, through the acceptance results, another alternative to promote the reduction of sodium in garlic and salt spice is the simple reduction of NaCl content used during its preparation. According to Ares et al. (2014), this is possible, since consumers have become increasingly concerned with the concept of "well-being" and the human health risk factors. So, they have sought healthier products with lower salt content (Drake et al. 2011). In addition, salt awareness campaigns are needed (Kenten et al. 2013). Moreover, while some aspects of salt reduction can be globally implemented, local tailoring is required to match levels of interest in salt reduction (Newson et al. 2013). Strategies have been suggested by Mendoza et al. (2014).

CONCLUSION

It is possible to produce a garlic and salt spice with replacement of up to 50% of NaCl by KCl and monosodium glutamate, even though the products result in lower intensities of saltiness and umami taste manifestation.

TDS and TI analyses are important tools in the development of products with reduced sodium intake. Through this analysis it was possible to describe the sensorial profile of the products and to optimize the formulations.

RESUMO

O tempero alho e sal é amplamente utilizado na culinária brasileira, mas possui um alto teor de sódio. Como a alta ingestão de sódio tem sido fortemente correlacionada com a incidência de doenças crônicas, este estudo teve como objetivo desenvolver um tempero alho e sal com teor de sódio reduzido. A avaliação sensorial dos temperos foi conduzida através da aplicação dos mesmos ao arroz cozido. Primeiramente, a concentração ótima de tempero adicionado durante a preparação do arroz foi determinada. Subseqüentemente, temperos (3:1) foram preparadas contendo 0%, 50% e 25% de redução de NaCl, utilizando uma mistura de sais contendo KCl e glutamato monossódico. Um tempero com 0% de redução de NaCl foi estabelecido como controle. Três formulações de arroz elaboradas com os diferentes temperos foram avaliadas pelo teste de aceitação sensorial, tempo-intensidade e domínio temporal das sensações. As proporções de sais utilizadas no tempero alho e sal não geraram gostos estranhos ou ruins aos produtos, mas surtiram em produtos menos salgados. No entanto, os temperos com níveis mais baixos de sódio (F2 e F3) foram melhor aceitos em comparação ao tempero tradicional (F1). Portanto, uma mistura de NaCl , KCl e glutamato monossódico é uma alternativa viável para desenvolver um tempero alho e sal com reduzido teor de sódio.

Palavras-chave: KCl, glutamato monossódico, TDS, TI.

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