https://doi.org/10.17221/221/2019-CJFS

Reduction in sodium chloride content in saltine crackers through an edible coating

Crislayne Teodoro Vasques, Maiara Pereira Mendes, Denise de Moraes Batista da Silva, Antonio Roberto Giriboni Monteiro*

Food Engineering Department, State University of Maringá (UEM), Maringá, Paraná, Brazil

**Corresponding author: e-mail: crislayne_vasques@hotmail.com*

Citation: Vasques C.T., Mendes M.P., Silva D.M.B., Monteiro A.R.G. (2020): Reduction in sodium chloride content in saltine cracker through an edible coating. Czech J. Food Sci., 38: 237–241.

Abstract: Aiming to reduce the sodium content in saltine crackers, the present study employed a methodology of salt coating that provided an inhomogeneous distribution of salt so that the salt perception was not altered. To this end, three cracker recipes were prepared and compared. Recipe 1 (F1) was the standard, Recipe 2 (F2) had a 33.3% reduction in salt in the dough, and Recipe 3 (F3) had no salt in the dough but instead a salty coating with the same amount of salt as F2. Physicochemical and sensory analyses revealed that F1 and F3 were not statistically different in salt perception, whereas F2 differed from the others. From these results, it was concluded that the methodology of covering crackers with a salty coating with a 42.5% salt reduction could be an alternative to achieving salt reduction.

Keywords: salt reduction; healthy food; biscuit

The annual intake of salt in the world is significantly higher than the level recommended by the World Health Organization (WHO). The current average salt intake is 9–12 g per person per day, whereas the limit proposed by the WHO is 5 g per person per day. Therefore, the current consumption is more than twice the maximum recommended (Brown et al. 2009; WHO 2012: Guideline: Sodium intake for adults and children, Geneva). This excessive use of salt has been associated with adverse health effects, and salt is one of the leading agents responsible for hypertension and cardiovascular diseases (Kloss et al. 2015).

Salt plays an essential role in the quality and properties of food products. However, reducing the salt concentration in diets is a challenge from both the technological and the sensory aspect. A reduction in salt concentration not only decreases the salty taste and accessibility but also it affects the function that this ingredient has in the production and conservation of many kinds of foods (Albarracín et al. 2011; Antúnez et al. 2016; Rodrigues et al. 2016; Silow et al. 2016).

It is estimated that at least 75% of sodium intake occurs through industrialised foods. The most efficient way to reduce sodium is during the manufacturing process before the product reaches the customer (Bobowski et al. 2015). Many strategies for reducing the sodium concentration have been studied, including the method of encapsulated sodium with non-homogeneous distribution, which reduces the taste perception through contrast and allows a reduction in salt levels in bread while maintaining the flavour intensity (Noort et al. 2012; Israr et al. 2016).

Cream cracker cookies have a priority when it comes to a sodium reduction according to the Sodium Reduc-

Supported by the Brazilian public agencies CAPES, Project No. 817627/2015 and CNPq, Scholarships No. 303597/2018-6.

https://doi.org/10.17221/221/2019-CJFS

tion Plan 035/2011 by the Brazilian Health Ministry (ANVISA – Agencia Nacional de Vigilância Sanitária 2011, technical report No. 035/2011), which follows the WHO and advocates that the maximum daily sodium intake should be less than 2 g.

Therefore, in this study, we aimed to develop two recipes with a 40% salt reduction: One recipe reduced the salt content in the dough and the other reduced the amount of salt in the topping. Both recipes were compared with the standard recipe in terms of salt content perception by a sensory test.

MATERIAL AND METHODS

The ingredients used for the recipes were purchased in markets in the city of Maringá, Paraná, Brazil (Coamo wheat flour 9% gluten, Coamo soy fat, Royal Baking Powder, and Cisne Salt). The preparation of the products was carried out in the cereal laboratory of food engineering at the State University of Maringá (UEM).

Three saltine cracker recipes were made. Recipe 1 (F1) was the standard one, Recipe 2 (F2) had a 33.3% reduction in salt in the dough, and Recipe 3 (F3) had no salt in the dough, but this was added later through a salt coating with the same amount of salt as in F2.

Recipe and preparation of cracker dough. The ingredients and quantities used in the recipes of the crackers are listed in Table 1. The biscuits were produced in two steps: First, the dough was prepared by manually mixing wheat flour, hydrogenated vegetable fat, and baking powder. Then, warm water was added (32 °C), followed by mixing until complete homogenisation was achieved. The dough remained at rest in a closed container at room temperature (22 °C) for 5 h, forming the "sponge". After this period, the following ingredients were added and blended into the sponge: wheat flour, hydrogenated vegetable fat, warm water, sugar, sodium bicarbonate, soy lecithin, and salt, in the quantities mentioned in Table 1.

Table 1. Ingredients used for making saltine crackers

Ingredients (g)	F1	F2	F3
Phase 1			
Wheat flour	240.48	240.48	240.48
Vegetable fat	25.84	25.84	25.84
Baking powder	1.48	1.48	1.48
Water	112.21	112.21	112.21
Phase 2			
Wheat flour	129.18	129.18	129.18
Vegetable fat	27.84	27.84	27.84
Sugar	7.64	7.64	7.64
Baking soda	2.26	2.26	2.26
Soy lecithin	0.47	0.47	0.47
Water	40.59	40.59	40.59
NaCl	12.0	8.0	0.0

F – standard recipe; F2 – reduction in sodium in the dough; F3 – reduction in sodium through the coating

Subsequently, the recipes remained at rest for over 5 hours. After this period, the dough was put through an electric dough cylinder (TAO 40; Tao, Brazil) until it reached a thickness of 1.75 mm. After that, each dough sheet per recipe was cut into approximately 150 squares (4 × 4 cm). Into each of them around 32 holes were cut so that no bubbles would form during the baking process. The cookies were baked in a preheated gas industrial oven for about 30 min at a temperature of 180 °C.

Recipe of edible coating. The coating was produced with the following ingredients and proportions: 6.0 g of maise starch, 22.4 g of salt, and 71.6 mL of water. The maise starch was dissolved in cold water; then, the salt was added and heated in a water bath while stirring. When the solution reached a temperature of 80 °C, one minute was timed, and then the solution was cooled, obtaining a volume of 65 mL. From this volume, only 22 mL was used for the coating, which means 7.58 g NaCl, to be spread over F3 before the crackers were baked.

The sodium content of the crackers was evaluated by Method 972.29 (AOAC – Association of Official Analytical Chemists, 1990: Official Methods of Analysis. 15th Ed. Arlington), the moisture was determined by Method 930.15 (AOAC 2005: Official Methods of Analysis, 18th Ed. Chapter 9: Metals and other elements at trace levels in foods, Section 9: Multielement methods), the pH was rated by an electrometric procedure with a digital potentiometer (model HI 221; Hanna Instruments, Italy), the water activity was monitored by a portable meter apparatus model Aw 43 (Etec, Brazil), the specific volume was determined by the method of displacement of millet seeds in five repetitions, and the colour was obtained in ten repetitions using the optional Chroma Meter CR400 (Konica Minolta, Japan).

The hardness of the three cracker recipes was determined by the three-point break test according to Gaines (1991), using a texture profile analyser (TA-XT plus; Stable Microsystems, UK) with a load cell of 5 kg, a pre-test speed of 1.0 mm s^{-1}, a test speed of 3.0 mm s^{-1}, a post-test speed of 10.0 mm s^{-1}, a distance of 5 mm, and a shot strength of 50 g.

https://doi.org/10.17221/221/2019-CJFS

Sensory analysis was performed according to the methodology described by Monteiro et al. (2016) in an unstructured range of 7 cm, whose purpose is to evaluate the intensity of salt in each sample. The judges received a portion of each sample (approximately 4 g), and each sample was codified with a three-digit random number. The tasters rated the samples in ascending order of salty flavour, from the least salty one to the saltiest one, with approval of the Ethics Committee in Research of the State University of Maringá (CAAE 18718013.3.0000.0104).

The data were subjected to an analysis of variance (ANOVA), and Tukey's test was applied to compare the means to the 5% significance level, using Statistical Assistance software 7,7 (Assistat, Brazil).

RESULTS AND DISCUSSION

Moisture, water activity, pH, and hardness. As seen in Table 2, the recipes did not show any significant differences ($P > 0.05$) in moisture and hardness. The three recipes had a moisture content in accordance with Resolution Number 12 (1978) of the National Health Surveillance Agency (ANVISA 1978, regulation RDC No. 12, 25th July 1978), which prescribes a maximum moisture percentage of 14%. Therefore, the decrease in sodium chloride did not interfere with the texture of the crackers.

Passos et al. (2013) found that the humidity values of cream crackers vary from 2.5% to 4.0%, which presents a pleasant texture. This result is similar to the result of the present study, in which the humidity value was found to range from 2.43% to 3.89%.

In bakery products, salt contributes to protein hydration and enhances binding to fats, promoting the development of the gluten network (Raffo et al. 2018). However, in our study, the sodium chloride reduction did not interfere with the cookies' hardness. Salt is used in products with low humidity levels, such as cookies, to help maintain the texture standards appreciated by costumers.

The recipes presented pH values ranging from 6.95 to 7.25, showing significant differences ($P \leq 0.05$) between recipes.

Regarding water activity (a_w), F1 (0.455 ± 0.001) had a slightly but significantly ($P \leq 0.05$) higher value than F2 (0.451 ± 0.001) and F3 (0.451 ± 0.001). All these values were lower than 0.60, which is considered the limit value for the multiplication of microorganisms.

Specific volume and colour. Specific volume is of great importance in determining food quality because it is usually influenced by the quality of the ingredients used in the recipe. We found no specific volume differences ($P \geq 0.05$) in the recipes.

The colour parameters of the crackers differed statistically. F2 and F3 crackers, with less salt in their recipes, presented a higher luminosity (L^*) value, resulting in a lighter product. In contrast, F1 showed a lower L^* value, resulting in a cracker that was darker than the other crackers. Regarding the yellow chrome (b^*) value, there were no significant differences between F1 and F3. All the recipes showed a lower propensity to a reddish (a^*) tint. This demonstrates that the colour of the crackers is directly related to the presence or absence of ingredients in the recipe: F1 (66.30 ± 2.15) was darker than the two crackers with less salt, F2 (69.86 ± 0.78) and F3 (69.78 ± 2.90).

Sodium content. As shown in Table 3, both recipes with sodium reduction (F2 and F3) had a lower sodium content than the reference limit established by the Brazilian Ministry of Health by Term of Commitment 035/2011 (ANVISA 2011), which sets a national goal of sodium reduction in crackers to 923 mg sodium per 100 g dry weight. It is essential to highlight that in recipes F2 and F3, the term "Reduced in Sodium" can be used on product labelling because of the sodium reduction by more than 25%, as established by the Brazilian legislation in RDC Number 54, from 2012 (ANVISA 2012, regulation RDC No. 54, 12th November 2012)

The salt content was statistically different ($P \leq 0.05$) between F2 and F3 samples, as expected due to the use of different methodologies for reducing sodium. In F2,

Table 2. Moisture, water activity (a_w), pH, and hardness of formulations

Recipes	Moisture (g H_2O/100 g DW)	a_w	pH	Hardness (kgf)
F1	$3.09^a \pm 1.37$	$0.455^a \pm 0.001$	$7.07^b \pm 0.01$	$4.35^a \pm 1.32$
F2	$3.89^a \pm 0.03$	$0.451^b \pm 0.001$	$6.95^c \pm 0.01$	$3.59^a \pm 2.10$
F3	$2.34^a \pm 0.04$	$0.451^b \pm 0.001$	$7.25^a \pm 0.01$	$3.37^a \pm 1.31$

Shown are means ± SD; different letters in the same column indicate a significant difference ($P \leq 0.05$) according to Tukey's test; for F1, F2 and F3 explanation see Table 1; DW – dry weight; kgf – kilogram-force

https://doi.org/10.17221/221/2019-CJFS

Table 3. Sodium content in the crackers

Recipes	Na (mg/100 g DW)	Na reduction in the cracker (%)
F1	1 457.50[a] ± 11.26	0
F2	908.11[b] ± 2.04	37.69
F3	838.40[c] ± 3.00	42.47

The results are shown as the means ± SD; different letters in the same column indicate a significant difference ($P \leq 0.05$) according to Tukey's test; for F1, F2 and F3 explanation see Table 1; DW – dry weight

for which the dough method of salt reduction was used, there was a 37.69% reduction in salt content, a significant difference compared with F1.

Compared with the F1 standard, F3 presented a 42.47% reduction in sodium, which is higher than the initial goal of 33.3%; this may have occurred as a result of salt loss during the coating process.

Sensory analysis. Regarding the reduction in NaCl in F2 and F3 compared with F1, a sensory analysis with 110 untrained testers was performed to compare the perception of salt between the samples. The tasters rated the samples in ascending order of salty flavour, from the least salty one to the saltiest one.

As shown in Table 4, the results of the sensory analysis were as follows: F1 (3.63 ± 0.69) and F3 (3.73 ± 0.97) showed no statistical difference in perception ($P \leq 0.05$), while F2 (1.84 ± 1.07) showed a difference compared to the others. F2 is the cracker that had a 37.69% reduction in salt.

Thus, F3, with a 42.47% reduction in NaCl, showed no difference in salty flavour from F1, demonstrating that the methodology of applying salt in the coating was effective in reducing salt without affecting the salt perception. When we compare F1 and F2, there is a significant difference in salt perception; in other words, when we reduce the amount of salt in the dough by 37.7%, the tasters can perceive the reduction (F2), but when we reduce the salt content by 42.5% through the coating process, the tasters do not notice any difference.

Table 4. Sensory results: sodium intensity in cream cracker cookies from the three recipes

Recipe	Salinity (0–7 scale)
F1	3.63[a] ± 0.69
F2	1.84[b] ± 1.07
F3	3.73[a] ± 0.97

The results are shown as the means ± SD; the same letters in the same column indicate that there was no significant difference according to Tukey's test ($P < 0.05$); for F1, F2 and F3 explanation see Table 1

Several studies have shown that an inhomogeneous distribution of salt plays an essential role in the perception of salt in foods (Noort et al. 2012; Busch et al. 2013; Nguyen et al. 2017). Thus, an inhomogeneous salt distribution may be used to increase the salinity intensity, enabling a salt reduction with no loss in salt perception (Noort et al. 2012). Recent studies have shown similar results, such as an increase in salt perception with the use of coarse-grained salt crystals in pizza dough. This approach may enable a sodium reduction of up to 25% with no adverse effects on the sensory quality (Mueller et al. 2016).

A gradual reduction of salt in bread proposed Antúnez (2016). The obtained results suggest that salt content in bread may be reduced by up to 10% with no effect on the costumer's sensory perception. Such a reduction must be implemented in an adequate way and over an extended time because drastic cuts in a short period usually result in a high risk of costumers migrating to saltier products.

CONCLUSION

Compared with other studies on sodium reduction, this research proposed a different methodology for reducing salt in cracker biscuits. We used a salty coating by which we obtained a 42.47% reduction in salt compared to the standard recipe.

The panel of tasters did not perceive any difference in salt between the standard crackers and the crackers produced with a coating with 42.5% less salt instead of salt addition to the dough. When the same panel compared the control with the sample with a 37.6% salt reduction in the regular process, they perceived a difference in saltiness. Thus, the coating process made a difference in the salt perception of the product.

In conclusion, the coating method of salt can be regarded as a good strategy for reducing the salt concentration in saltine crackers without compromising the product acceptance by consumers. By the application of salt to the outside of the cookie, the coating can contribute to a better interaction of the salt with the consumers' gustatory receptors without reducing the flavour perception of the cracker, resulting in a product that complies with the World Health Organization's recommendations. However, further studies are required to check the applicability of this methodology to other products.

https://doi.org/10.17221/221/2019-CJFS

REFERENCES

Albarracín W., Sánchez I.C., Grau R., Barat J.M. (2011): Salt in food processing, use and reduction: a review. International Journal of Food Science and Technology, 46: 1329–1336.

Antúnez L., Giménez A., Ares G. (2016): A consumer-based approach to salt reduction: Case study with bread. Food Research International, 90: 66–72.

Bobowski N., Rendahl A., Vickers Z. (2015): The preference for salt in a food can be changed without a diet low in sodium. Quality and Food Preference, 39: 40–45.

Brown I.J., Tzoulaki I., Candeias V., Elliott P. (2009): Salt intakes around the world: Implications for public health. International Journal of Epidemiology, 38: 791–819.

Busch J.L.H.C., Goh Y.S.M. (2013): Sodium reduction: Optimising product composition and structure towards increasing saltiness perception. Food Science and Technology, 29: 21–34.

Gaines C. (1991): Objective measurements of the hardness of cookies and crackers. Cereal Foods World, 36: 991–994.

Israr T., Rakha A., Sohail M., Rashid S., Shehzad A. (2016): Salt reduction in baked products: Strategies and constraints. Trends in Food Science & Technology, 51: 98–105.

Kloss L., Meyer J.D., Graeve L., Vetter W. (2015): Sodium intake and its reduction by food reformulation in the European Union: A review. NFS Journal (Official Journal of the Society of Nutrition and Food Science), 1: 9–19.

Monteiro A.R.G., Marques D.R., Benossi L., Chinellato M.M., Berwig K.P., Wolf B. (2016): Eliminating the use of fat in the production of extruded snacks by applying starch coating. Chemical Engineering Transactions: 49, 625–630.

Mueller E., Koehler P., Scherf K.K. (2016): Applicability of salt reduction strategies in pizza dough. Food Chemistry, 192: 1116–1123.

Nguyen Q.C., Wahlgren M.B., Almli V.L., Varela P. (2017): Understanding the role of dynamic texture perception in consumers' expectations of satiety and satiation. a case study on barley bread. Food Quality and Preference, 62: 218–226.

Noort M.W., Bult J.H.F., Stieger M. (2012): Saltiness enhancement by taste contrast in bread prepared. Journal of Cereal Science, 55: 218–225.

Passos M.E.A., Moreira C.F.F., Pacheco M.T.P., Takase I., Lopes M.L.M., Valente-Mesquita V.L. (2013): Proximate and mineral composition of industrialised biscuits. Food Science and Technology, 33: 323–331.

Raffo A., Carcea M., Moneta E., Narducci V., Nicoli S., Peparaio M., Sinesio F., Turfani V. (2018): Influence of different levels of sodium chloride and of a reduced-sodium salt substitute on volatiles formation and sensory quality of wheat bread. Journal of Cereal Science, 79: 518–526.

Rodrigues D.M., Souza V.R., Mendes J.F., Nunes C.A., Pinheiro A.C.M. (2016): Mixing of microparticulate salts: An alternative to reduce sodium in bulk potatoes. LWT – Food Science and Technology, 69: 390–399.

Silow C., Axel C., Zannini E., Arendt E.K. (2016): Current status of salt reduction in bread and bakery products: A review. Journal of Cereal Science, 72: 135–145.

Received: July 25, 2019
Accepted: July 27, 2020